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INTRODUCTION

It is necessary and justified, nowadays, more than ever, to assemble the scientists and entrepreneurs in the field of textile and clothing industry. The Scientific-professional Conference "Textile Science and Economy IV" (TNP2012) is organized with the goal to promote connection between Serbian entrepreneurs and scientists and experts to jointly contribute the development based on knowledge and innovations. We are aware that by establishing these development research institutions and institutions of academic education, very active participants in this process must be included.

It is necessary to keep connections and cooperation based on knowledge and experience because that leads us to sustainability and development of our textile and fashion industry. Therefore, this conference TNP2012 meets the Strategy of Scientific and Technological Development of Serbia for the period from 2010 to 2015. Through the papers of the Conference TNP2012 participants current situation in the textile and fashion industry is to be analyzed, as well as the vision of this industry in Europe up to 2020 from the standpoint of the European Technology Platform (ETP). The European Union has entered the new millennium, setting the strategic goal of achieving extremely competitive and dynamic economic development based on the innovations and technological development. Therefore, this Conference TNP2012 wants to contribute to the development strategy of the Serbian textile and fashion industry in the direction of the dynamic cooperation of science and economy.

The aim of this Conference TNP2012 is to foster the regional cooperation with the scientists, experts, businessmen from the neighboring countries as well as from the other countries, what gives this event international significance and its scientific and professional level. Therefore, it is a great pleasure that such a remarkable number of the scientists and businessmen, mainly from the region and the other countries, responded to our invitation. The submitted papers of our colleagues were published in The Conference Proceedings. Because of economic focus of this event, the business and professional papers and the papers of our graduates, now employed in many companies, have found their place in The Conference Proceedings.

At the plenary lecture we have tried to show you the European experiences related to technology transfer from the University to Economy.

In the part of inviting lectures, we have tried to assemble the leading scientists, experts and professionals from the industry whose working experiences can contribute to the Strategy of Scientific and Technological Development of the Republic of Serbia 2010-2015 (SSTDRS).

In the poster section we wanted to present scientific and professional work at our Faculty.

Technical Faculty "Mihajlo Pupin" is the only scientific institution in Vojvodina in the field of textiles and clothing. The intention of this Conference TNP2012 is to present to the entrepreneurs the Faculty’s previous experiences and competences in the field of education and science. During the Conference TNP2011 and after, the Technical Faculty will promote its openness and acceptance of new ideas of improving cooperation with entrepreneurs and solving their everyday technological issues as well as those in the field of research - development projects.

The Chairman of the Organizing Committee:

Vasilije Petrovic, PhD, Professor

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- **Ministery of Education, Science and Technological Development**
- **Ministry of Economy and Regional Development**
- **Regional Chamber of Commerce Zrenjanin**

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HOW BUSINESS ASSOCIATIONS AND CLUSTERS SUPPORT BUSINESSES IN SOUTH-EAST EUROPE – LESSONS FROM THE GIZ TEXTILE ASSOCIATIONS PROJECT

Peter BOLTON MA (Cantab.)

1. INTRODUCTION: THE PROJECT AND THE ASSOCIATIONS

This paper describes the activities of and issues facing six business membership associations supporting companies in the clothing and textile industry, and the work of a project supporting the associations, funded by GIZ through its Open Regional Funds for South-East Europe (ORF) which since 2007 have sought to build on the bi-lateral projects already developed in South East-Europe by giving the opportunity for organisations to work together on projects with a regional dimension, which seek to encourage integration in the region. The project started in September 2010 and will be completed by the end of February 2013. The project consists of three packages of measures whose activities are closely interconnected:

- Strengthening the service capability of local textile and garment associations within their competencies
- Strengthening the cooperation and services of associations on the regional level
- Providing support to strategic cooperation of the textile and garment sector with industries in Northern Europe .

The planned activities in more detail were as follows:-

Package of measures 1: Strengthening the service capability of associations

- As a basis for strengthening associations, carrying out analyses of structural needs of associations, especially with regards to development and effort made on regional networking.
- Developing strategic plans for further organizational development should be made.
- Support, based on the strategic plan, for associations in the further development of their services focusing on the needs of members/small and medium-sized enterprises.
- Mutual advice by the partners of the countries involved. This package of measures was intended to develop the capacity of the partners to improve their services for member companies and to offer them on a regular basis.

Package of measures 2: Regional cooperation

- The creation of permanent mechanisms (e.g. data base, networked internet pages etc) for information processing and exchange, e.g. with regards to national markets, for sourcing or export data for EU countries and the region
- The establishment of regular exchange on relevant topics (e.g. corporate social responsibility (CSR), purchasing and outsourcing, knowledge transfer and regional marketing)
- Meetings organised by the associations of regional companies and the creation of direct contacts between member companies

Package of measures 3: Strategic co-operations with EU countries

On the European level, the South-East Europe region is still not seen as a recognized partner. Also, business relations which could lead to deeper integration into regional and international value chains and higher production levels are weak. For this purpose meetings with garment associations from Germany and other EU countries were planned.

With the package of measures 2, the strengthened regional cooperation between associations is in further activities used for more intensive joint appearance on the market. Thus, the plan was to develop a joint application with EURATEX (the European Association of national clothing/textile associations) for EU funds.

It was also planned to organize gatherings of companies from the region with importers from the EU.

Project Partners

The project partners are the following organisations:- Bulgarian Association of Apparel and Textile Producers and Exporters (BAPIOT), The Albanian Textile Association (Chamber of Facon of Albania), Association of Textile, Footwear and Leather Goods of Bosnia and Herzegovina (UTOK.), Textile Trade Association/Textile Cluster – Macedonia (TTA/TTC) and the Fashion and Apparel Industry Cluster of Serbia (FACTS).

The Bulgarian Association, which is located outside the SEE region was included as it was originally planned that it would be contributing consultancy expertise to the project. For technical reasons this did not happen.

The project is funded by the German government and is implemented by SEQUA gGmbh, a German consultancy organisation which specialises in working in business associations. The expertise available to the project consists of the project manager from SEQUA, two part time experts, one from UK and one from Bulgaria and a number of days available for experts from the SEE region plus Bulgaria to provide extra inputs.

Details of the individual partner associations are as follows:-

Albania (CFA)

CFA was established in 2008 as an initiative of the industry (i.e. not as a donor project) and has about 100 members. Most production is cut, make and trim (CMT) of fashion apparel, mainly for the Italian market. Membership fees (which are relatively low) are not paid in all cases and CFA has no budget for permanent staff. No donor funding is received. Its President manages the association alongside running his own business. CFA has a relatively high profile because it is represented on government bodies involved in the dialogue with industry, but there are few activities apart from lobbying the government and organising attendance by companies at fairs and exhibitions at home and in Albania. The President believes that there will not be enough income from members to enable CFA to provide traditional association services and has therefore proposed that CFA should function more like a "cluster" by providing facilities that member companies can share, such as a cutting centre and a training centre, but these plans have so far not made any progress.

Bosnia (UTOK)

UTOK was originally founded through the initiative of a donor project but is now self-supporting (including some government funding on a contract basis for export activities). UTOK has one full-time member of staff. It has about 150 members, covering both the Federation and Republika Srpska. Of these about 70% pay the fees. Most companies are engaged in CMT production, including fashion apparel and work wear. Lobbying the government is the most significant and successful of UTOK's activities – it has been especially successful in accessing government finance for companies. Other significant activities are providing information and advice to companies, organising visits to international fairs. Some training has been undertaken but demand has fallen recently.

Bulgaria (BAPIOT)

BAPIOT was established in 1999 and currently has about 150 members. The apparel and textile industry is a significant part of the Bulgarian economy. 90% of it is engaged in CMT production and this is reflected in the membership of BAPIOT. Significant services are training, provided by trainers from universities etc, B2B meetings for members in Bulgaria and abroad and a comprehensive monthly e-mailed newsletter. BAPIOT also develops and manages funded projects on behalf of its members. Until 2010, BAPIOT received significant donor funding and a large amount of income from a textile fair in Sofia which it managed – both sources of funding have now ceased (the fair having fallen victim to the recession), which meant that the organisation with a director and two other full-time staff struggled to maintain itself financially. The director has now left and not been replaced and due to more marketing to increase numbers of members and increase the size of the training programme, BAPIOT is now financially stable.

Kosovo (K-Tex)

K-Tex was established in 2010 as an initiative proposed by the Kosovo Chamber of Commerce. It has contacts with about 50 members, but only a small proportion pay membership fees as it does not have enough resources to provide consistent services. It has no significant sources of finance and no direct donor support – the President, who runs her own company, manages K-Tex on a voluntary basis. Due to recent history, nearly all of the apparel/textile companies are small family businesses, with most production sold on the domestic market or in neighbouring countries. Unusually for the region there is no CMT production and therefore little export to the EU etc. Services consist only of some lobbying and ad hoc advice, but K-Tex recently undertook (with donor support) a survey of apparel/textile companies, which it is hoped will raise the profile of the organisation.

Macedonia (TTA-TTC)

TTA-TTC started in 2003 as an association of individuals and was re-founded as a business association in 2006. It has merged with a textile “cluster” previously supported by USAID, but currently has the characteristics of an association, rather than a cluster. It currently receives considerable direct donor support, which ends during 2012. It currently has one full-time Director and an assistant whose activities are entirely funded by a project. Membership has declined in recent years and is currently about 70. Most of the industry (and the members) are engaged in typical CMT production – a small number of companies are in full package production and a few have or are developing their own brands, mainly sold on the domestic market. Most current services including training, consultancy and B2B meetings in Macedonia and abroad are donor funded. TTA-TTC is also engaged in lobbying, although, on its own account, with little success.

Serbia (FACTS)

FACTS was founded in 2010 as an initiative of GIZ and SIEPA, the Serbian export promotion agency. FACTS as an organisation is fundamentally different from the other associations in that it has a relatively small number of members - 14 companies plus 3 educational institutions. The companies pay much higher fees than in the other association and are all fashion companies with their own brands, and are not therefore representative of the Serbian industry as a whole. There is currently 1 full time director. The services include detailed market research, joint purchase of services (particularly design facilities) and raw materials, export promotion, including research into and visits to new markets, marketing via the website and promotional events, lobbying, supporting members to access government finance (e.g. contribution to costs of export activities), and developing and managing funded projects.

2. PROJECT ACTIVITIES SO FAR

The project activities carried out as follows (under the headings of the three activity areas) can be summarised as follows:-

Strengthening the service capability of associations

The proposed process was to support the associations in developing individual strategic plans which would identify needs for service development and other support. The process of creating a strategic plan with specific objectives which were approved by the association board was completed entirely in Serbia, largely in Kosovo and Bosnia, in Macedonia is still in progress. The process was incomplete in Bulgaria when the Director left office and has not resumed, and did not start at all in Bulgaria. Where this process has made progress, it has helped the association to identify key issues – the priorities of the association in the case of Kosovo, and the need to resolve management issues in Serbia. In all the associations, regardless of progress on the strategy, informal advice and mentoring has been provided, mainly on planning, management, service development and marketing.

Generally there was not a perceived need to use the project to help devise new services, either because of poor market conditions, or because help in service development (as opposed to strategic planning and management) was not required. Some local consultant resources are being used to provide or improve services such as training.

Regional cooperation

Three regional meetings of the associations have been held, in Skopje, Belgrade, and Tirana and the fourth and final one will take place in Tirana on 8 and 9 November 2012. The first meeting was mainly devoted to creating a detailed plan of activities and subsequent ones have included short training inputs on relevant topics such as lobbying/advocacy and e-business and presentations from individual associations on their own activities as a means of sharing best practice. In addition the contacts made at the meetings have enabled associations to develop business contacts between their members, thus developing trade in the region (This will be formally reported on at the final meeting in Tirana).

Other activities under this heading have been:

- A survey of member companies and training/education providers in all six countries covered by the project on the effect of skills shortages in the industry, which all participants agreed is a serious problem for the industry. The survey is still being conducted. (The issue of gender within the textile industry was included in the survey)
- The design of a regional brochure and website promoting the clothing/textile industry in the six countries included in the project. This was commissioned because the 6 partners believed that the image of the industry in the region was poor and indeed that awareness of it in Europe as a whole was very low. The brochure is now complete and work on a basic website is ongoing.
- Regional B2B (Business-to-Business) meetings were proposed to take place in Sofia and Tirana. The former took place in June 2012 and the latter is in the final stage of preparation. The aim of these was to enable businesses from different countries in the region to start to do business with each other and if possible attract EU businesses to attend the meetings. So far success has been limited, mainly because the associations are principally associations of producers, who generally want to meet buyers rather than other producers at B2B meetings.
- It was agreed that a key need was the exchange of information between association on e.g. laws and government incentives, business conditions etc in the other countries and the creation of a regional calendar of events. In addition it was agreed to create a regional database of training providers. This issue was dealt with thanks to the support of an EU funded project (TEXWEB) which included an element of information sharing via a dedicated website and the databases of

shared information and data on training providers provided by project partners has been hosted on the TEXWEB website.

Strategic co-operations with EU countries

There were two activities under this heading – the first being the creation of a joint bid for EU funding for a development project in the region. The project supported the development and the submission of a project application, which was in the event, unsuccessful. The second was a meeting between the partner associations and clothing/textile associations in the EU, to be held under the auspices of EURATEX. This is planned to be held near the end of the project, in January or February 2013.

3. ISSUES RAISED BY THE PROJECT

The work done so far with the partner associations raises questions and issues both about the design and implementation of the project and also about the operation of the business associations themselves.

Issues about the Project Itself

The process of implementing the project raises the following issues about the design of the project:-

- A relatively large amount of project expert resource was devoted to providing support to associations in developing new services. In fact, the range of services that can be offered by business associations is limited by the interests and ambitions and the skills and experience of the staff – the latter is more problematic in organisations where there is only one member of staff. The potential for developing entirely new services is limited – there is more potential for doing what the project has tried to do, to work on the management and planning processes in order to make the delivery of services easier to achieve.
- A major emphasis was placed on staging B2B meetings as an opportunity for companies from the 6 different countries to meet each other. This was a good concept in principle, but was difficult to implement mainly because the 6 partners were mainly representing manufacturers who would normally be interested in meeting buyers (and buyers in their own countries would not normally be among the contacts of the associations), rather than manufacturers from another country – although some interest was shown by companies wanting to learn from manufacturers elsewhere. The fact that there was no financial support for the companies' travel costs also had a deterrent effect on participation by companies in the B2B meetings

Overall however, the project design should be regarded positively – it focussed on building capacity within the associations, based on an initial analysis and strategic planning process, rather than direct subsidy of association activities, which rarely leads to sustainability. Moreover, the different components within the project and the flexible approach of the donor meant that issues of concern to the associations and the industry, such as the image of the industry in the region and the importance of skills shortages were tackled at the request of the participants after the project had formally started.

Issues about the business associations

Typology of Associations

One of the clearest issues identified during project implementation has been the different types of associations supported. Among the 6 associations, there are two distinct types of association:-

The first is the traditional voluntary business association model, in which there are a relatively large number of member companies, relatively low membership fees and a relatively large number of low value services – this model is typical for most European business associations, including the chambers of commerce in UK Scandinavia and national sectoral associations. It is usually effective if there is a large enough target group of member companies to provide adequate income from membership fees and additional services, as for example with UK chambers of commerce which on average have over 1750 members – in this situation a relatively low fee level combined with low value (but useful) services such as business information, contacts with other businesses, information on foreign markets, discounts on extra services such as training enables the association to employ enough staff to provide adequate services, and once this point is reached, the organisation can easily expand through recruiting more members (particularly for a non-sectoral association with a large potential market of member companies) as the cost of maintaining each new member is far outweighed by the income received.

The second model is the "cluster" model – which is represented in this group only by FACTS (Serbia) – this typically has a small number of members (14 companies) in the case of FACTS which pay relatively high membership fees (an average figure of €1440 per member per year) for a smaller number of high value services – the advantage of this model is that the "cluster" can provide services to a group of companies for a fraction of the price the individual companies would have to pay for the same services. This works only if the members are the same type of company who need the same type of high value services – in the case of FACTS, this is fashion companies producing their own collections. The small number of companies means that the staff are aware of and can respond to the needs of individual companies – which is not possible when dealing with 150 members. It should be noted that the term "cluster" is used with inverted commas, to indicate that the concept is not the same as the traditional cluster described in the literature in the work for example of Professor Porter – this type of cluster refers to an organic grouping of businesses in the same geographical area which develop productive relationships with each other spontaneously. This is different from business organisations such as FACTS, whose members are not in the same geographical area and were brought together by an external initiative. Most "clusters" of this type in the SEE region are in origin donor projects which try to create a "cluster" which provides services to companies in the same industry. Generally, these "clusters" fail to escape from dependence on donors and struggle to become autonomous business associations – FACTS is an exception in this respect, at least partly because it was founded not as a donor project but through government agencies working with a group of businesses.

The traditional business association model does not work effectively for all of the 5 project partners – that is all the associations except the Serbian association. The potential market is limited more or less to apparel manufacturers, of which the very small companies can be discounted as they will not normally be prepared to pay associations for services. In the case of Kosovo and Albania, the number of member companies does not provide enough income to employ staff, and CFA (Albania) has been exploring the possibility of turning itself into the alternative "cluster" model in order to increase income, while TTA/TTC (Macedonia), which has experienced falling membership, is exploring the possibility of creating a "cluster within an association" – whereby a small number of companies which want to move away from CMT production might be offered a higher level of service for a higher membership fee. The Bosnian association (UTOK), appears to have reached equilibrium with about 150 members (including footwear and leather producers) and no dependency on donors, while BAPIOT in Bulgaria, having struggled with loss of income from donors and other sources, is reaching financial viability by reducing staff and increasing membership through more aggressive marketing.

The cluster model appears to work for FACTS – with its 14 members, and high value services which are marketed as saving more money than the company pays in the annual membership fee, it is financially viable, and effective in providing services for its members. One of the reasons for its success is that the cluster manager has long experience in marketing in the fashion industry – this means in effect that FACTS is providing services such as marketing and purchasing to its members jointly, which would normally be performed by managers within the individual companies – in a sense FACTS is the joint marketing operation for its members. The level of activity has now expanded to the extent that the organisation is now considering recruiting additional staff, to be funded out of further increases in numbers of members and service activity.

The above discussion raises the question as to whether the "cluster" or association model is best for business associations in the textile sector. There is no simple answer – the advantage of the association model is that it can provide services to a far larger number of companies than the "cluster" model, but there is clearly a minimum number of members below which the association struggles for financial viable. The "cluster" model requires there to be a sufficient number of companies in the same area of business which are willing to co-operate – which is potentially problematic and requires a high level of industry specific expertise in its staff, which is not necessary for traditional associations.

Success Factors

The contrasting types of association and different levels of activity also raises the question – what are the success factors for sectoral business associations? What characteristics should they exhibit to be successful? The following are some tentative proposals:-

Advocacy and Lobbying

All the associations involved in the project (including representatives of member companies) agreed that lobbying and advocacy – directed mainly to the government – in order to improve conditions in the clothing/textile industry was the most important activity carried out by the association, because members expect it to be done. With one exception, all the associations (even some with no permanent staff) reported that lobbying had achieved some success. The fundamental importance of lobbying/advocacy is that it gives identity and image to a business association – without it, the association would be indistinguishable from a company providing services to businesses, and thus would have no distinctive identity – or influence. The paradox is that nobody pays for lobbying and non-members receive the advantage of it, but it is still essential.

Marketing – Businesslike approach

Another success factor is whether the association takes a marketing oriented approach – that is understanding and responding to members needs in a proactive way, and in fact running the association as if it were a business. Success in this area partly depends on the experience of the director, but the critical point is that the key actors in the organisation, the board, the President and the Director, understand that the association, while it is not a business (because it does not distribute profits to shareholders) must be run like a business if it is to succeed. A constantly recurrent problem in business associations is that the members fail to understand the business issues facing the association because they are radically different from the member's own business – a clothing manufacturing company is conceptually much simpler than an association which is a mix of lobbyist, training provider, consultant, export adviser etc. This causes the risk that wrong decisions will be taken about the direction of the association.

Critical Mass

As suggested above, associations need to reach a "critical mass" in terms of numbers of members. Whether the association can reach this depends on a number of factors, the state of the economy, the interest by companies in the future development of their own business (which in the case of many CMT companies appears to be limited as they see no future for this type of business), the marketing approach of the association and the commitment and understanding of the board.

Supportive Board members

Finally, a key success factor for associations of this type which will always have limited staff resources, is the commitment to the association of board members. Not only do they need to understand the ambiguous nature of a business association (as pointed out above under "Marketing – businesslike approach), but also they need to provide practical input to compensate for the lack of staff resources and to provide additional skills and experience. This support is usually provided by board members organising themselves into working groups to tackle particular issues. (Generally speaking, according to the partner associations in this project, this process has insufficient practical result.)

4. CONCLUSIONS

This paper has described the recent activities of a group of associations supporting the garment/textile industry in the SEE region (plus Bulgaria) in the context of project support provided by GIZ. The overall conclusion is that the project support has been useful to the partners, but that more important elements of success are a focus on lobbying and advocacy, a marketing approach, the ability of the association to reach a "critical mass" of members and the importance of support and understanding of the association's activities by the members of its board. Two models of business association were identified, which both have their strengths and weaknesses – perhaps sectoral associations of this kind need in future to develop the characteristics both of "clusters" and traditional associations.

TEXTILE ELECTRONICS, SENSORS

Xuyuan TAO, Cédric COCHRANE, Ludivine MEUNIER, Fern M KELLY and Vladan KONCAR

Abstract: *The fibre form transistor has become one of the most interesting topics in the field of smart textiles. The use of PEDOT:PSS to realize a parallel wire electrochemical textile transistor has been reported. A novel geometry pattern makes the transistor easier to insert into textile fabric making the large-scale production possible. The length of transistor can be up to several centimeters. The On/Off ratio reached up to 103. The switch time is near 15s. An inverter circuit and an amplifier were fabricated by using one transistor as well in order to demonstrate the feasibility of fully textile electronic circuits.*
On the other side chromic materials have the ability to change their colour reversibly according to external environmental conditions. They are categorised by the stimulus that triggers the colour change. For example, thermochromic materials can be defined as those in which a colour change is induced by a change in temperature and electrochromic materials are those in which a colour change is induced when an electrical current is applied. Thermochromism is already a well-known application within the textile field, however electrochromism is not as common. In this paper, an overview of the field of electrochromic devices is provided and the successful development of a first generation flexible textile electrochromic device, achieved by ourselves, is discussed. The flexible electrochromic textile display consists of a novel 4-layer sandwich structure containing a thin spacer fabric with electrochromic compound (Prussian blue), a conductive layer and two electrodes; bottom and upper (transparent). If powered with a low voltage battery, this structure is able to generate a reversible colour change. The switching times have been measured at ~ 5 s and 4.5 V. The colour changes are monitored via CIE L, a*, b* values.*

Keywords: *(e-textile, electrochemical transistor, PEDOT:PSS, Textile flexible display, Conducting polymer, Prussian blue*

1. INTRODUCTION

Interest in textile transistors has been growing rapidly in recent decade. According to articles published until now, fibre transistors can be divided into two families: wire thin film transistors (WTFTs) [1-3] and wire electrochemical transistors (WECTs) [4-5]. The advantage of WTFTs is the short response time (<1 µs), meanwhile the magnitude of the voltage required to control the gate is as high as several tens of volts. On the other hand, the required control voltage for WECTs is only 2~3 V. However, the large switch time, more than several tens of seconds, scales down WECTs technology to quasi-static applications. The difference between proprieties of WTFTs and WECTs result from different insulating materials between the gate and semiconductor layers. For conventional organic field-effect transistors, the insulating material is obtained from inorganic oxide (i.e.SiO2) or polymer dielectrics (~10 nF/cm2). Meanwhile for electrochemical transistors, the insulating layer is realized by the liquid or gel electrolyte (>10 µF/cm2) [6]. The excellent high capacitance of electrolytes results from the formation of electric double layers (EDLs) at interfaces, which can be exploited to induce a very large charge carrier density (>1014 cm2) in the channel of an OFET at low applied voltages [7].
In terms of the geometry pattern of wire transistors, WTFTs integrate the dielectric layer, the semiconductor layer and three electrodes (gate, source and drain) in one wire filament [1-2] (Figure 1a). As a result, the possibility and processability of integration of such transistors into textile fabric is easy to realize by simple physical contacts between different yarns. However, in order to guarantee the width-length ratio of the channel as large as possible, the deposited layer should cover the filament all around. Therefore, the filament should be continually rotated during the evaporation process. Furthermore, in order to assure the electrical performance, the thickness of different layers should be carefully controlled. Sometimes, the mask of deposition is also necessary. Hence, this complicated multiple layers deposition makes WTFTs unsuitable for the large-scale production.

In the case of WECTs, the gate is on one yarn and other parts of transistor are on another yarn. These two separated yarns are glued to each other via an electrolyte solid which can be ion gel [7-9], poly ion liquid [10-11] or the combination of these two electrolytes [12] (Figure 1b). WECTs need neither multiple deposition nor mask, which simplifies the manufacturing process. In fact, the coating process

in solution can be used to realize semiconductive or conductive layers on the yarn surface. Furthermore, because of the insensitivity of the electrolyte thickness between the channel and the gate electrode, the geometry of the transistor does not have a major impact on electrical performance. The need for precise positioning is not necessary any more. In order to make a textile electronic circuit, it is necessary to create first the fabric with the gate filament and the source-drain filament in weft and warp directions. Then, a post processing is necessary to bring the electrolyte to the cross section of these filaments and to realize finally the WECT. This post processing after the integration of the yarns into the fabric makes WECTs unsuitable for the textile application, because the electrolyte liquid may be easily absorbed into the textile fabric by the capillarity force. As a result, an inflexible spot will be left in the textile structure, which may influence its hand feel.

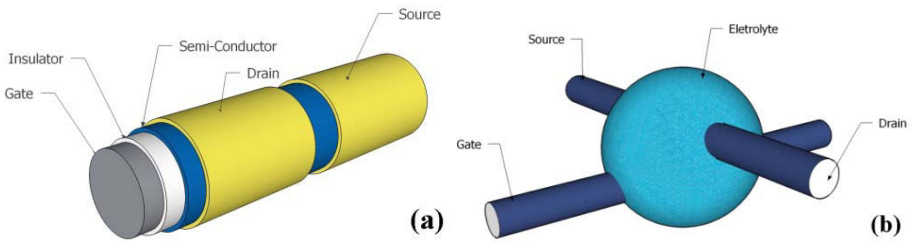


Figure 1. The topologies for WTFTs (a) and WECTs (b)

In this article, a novel geometry pattern of WECTs has been reported. Two parallel filaments are twisted together like a thread. One of them is used for the gate electrode and the other is used for drain and source electrodes. The PEDOT:PSS is used as thin-film electrodes in the WECT. The ON and OFF states of transistor are realized by the redox reaction of the PEDOT film.

PEDOT+PSS- +M+ + e- PEDOT0 +M+PSS- [1]

where M+ represents metal ions transported inside the electrolyte polymer, i.e. Ca2+, Na+ and K+. The electron e– is transported inside the PEDOT:PSS film. The redox potential is in -0.2~-0.4 V [13], which is convenient to make a low-voltage electrochemical transistor.
The advantage of our novel pattern is that the transistor may be realized before the integration into the textile fabric in order to make a fully textile electronic circuit. The novel pattern WECT was inserted into a cotton fabric and the numerical and analog circuit were realized.

2. MATERIALS AND MEASUREMENTS

The high-conductivity PEDOT:PSS solution (CLEVIOS™ F DDP 105) was purchased from H.C. Starck, Germany. The electrolyte solution consists of 33 wt.% poly(styrenesulfonate) (PSS) (Aldrich), 12 wt.% glycol (Sigma-Aldrich), 8 wt.% D-sorbitol (Aldrich), water and 0.1M NaClO4 (Sigma-Aldrich). The electrolyte solution was mixed up in an ultrasonic bath and can be conserved in fridge for several months. The CYCLOTENE™ 3022-35 resin (BCB35) is used as received from the Dow Chemical Company without further purifying.
All electrical measurements were carried out at ambient atmosphere (20-22°C temperature and 37-40% relative on a scope (Agilent humidity). Transistor electrical measurements were realized on the Agilent 4156C Semiconductor Parameter Analyzer. Electrical circuit measurements were carried out 54622A 2-Channel) and a waveform generator (Tabor PM8571). The textural properties of conducting layers surfaces were then investigated by Scanning Electron Microscopy (ZEISS ULTRA 55).

3. EXPERIMENTAL

The PEDOT:PSS coating was continually carried out by a Coatema® coating machine with a solution vat and a hot air heating system (Figure 2). This device can realize a roll-to-roll coating with controllable coating speed and heating temperature (> 100°C). One bobbin of Kevlar multifilament with PEDOT:PSS coating was obtained using this process. The running speed of the Kevlar filament was as fast as 0.5 m/min. The Kevlar filament was heated by passing through the one meter large oven under 90°C. The coated bobbin can be kept under the ambient atmosphere for several months without changing the conductivity.

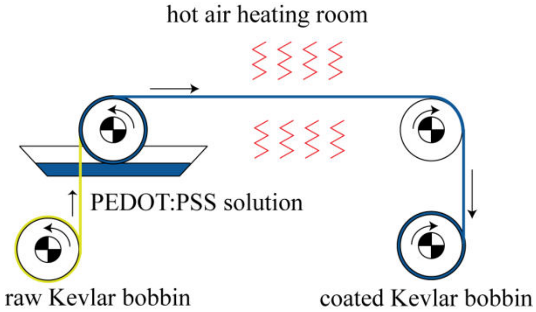


Figure 2. The scheme of the coating system

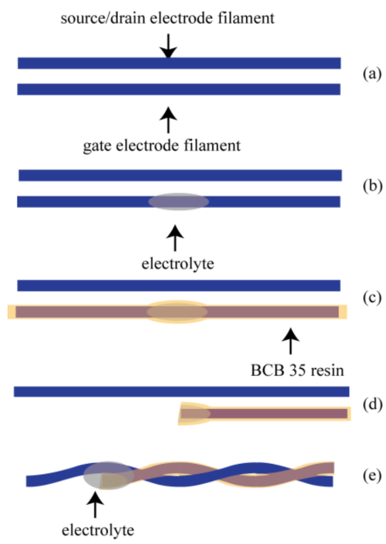


Figure 3. The scheme of WECT construction in form of a thread

Two 50 cm coated filaments were cut from the bobbin for gate electrode filament and source/drain electrode filament (Figure 3a). A drop of electrolyte solution was dripped in the middle of gate electrode filament. This filament was heated in an oven at 55°C for 10 mins (Figure 3b). The length of coated electrolyte polymer was about 6 mm. After taken out of the oven, the gate electrode filament was coated with BCB35 resin by dip-coating (10 cm/min) by an automatic machine and then directly heated in a tubular oven at 250°C for 15 mins in ambient atmosphere (Figure 3c). The BCB35 coating was used as an insulator layer to avoid the electrical contact between two parallel multifilaments, when the gate electrode filament and the source/drain electrode filament were twisted together. After the resin layer was dried, the gate filament was snipped in the middle of electrolyte (Figure 3d). Finally, the gate electrode filament and the source/drain electrode filament were twisted together and the end of gate electrode filament with pre-coated electrolyte was glued again to the source/drain electrode filament by a drop of electrolyte (about 1mm long). (Figure 4)

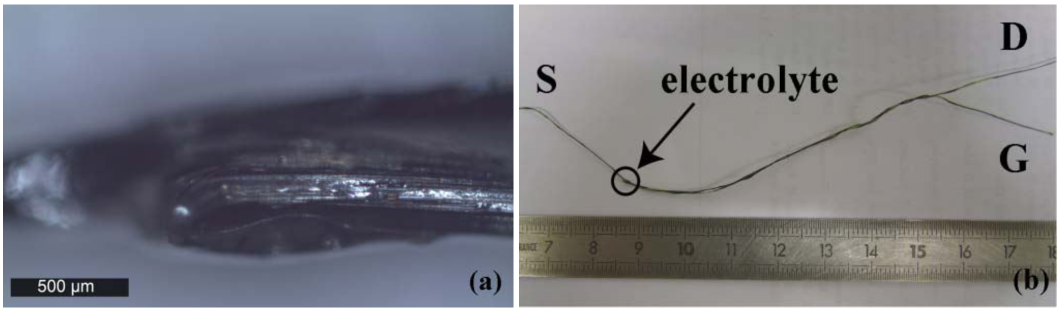


Figure 4. (a) The microscope image of the joint electrolyte. (Magnification X10); (b) the image of twisted wire electrochemical transistor

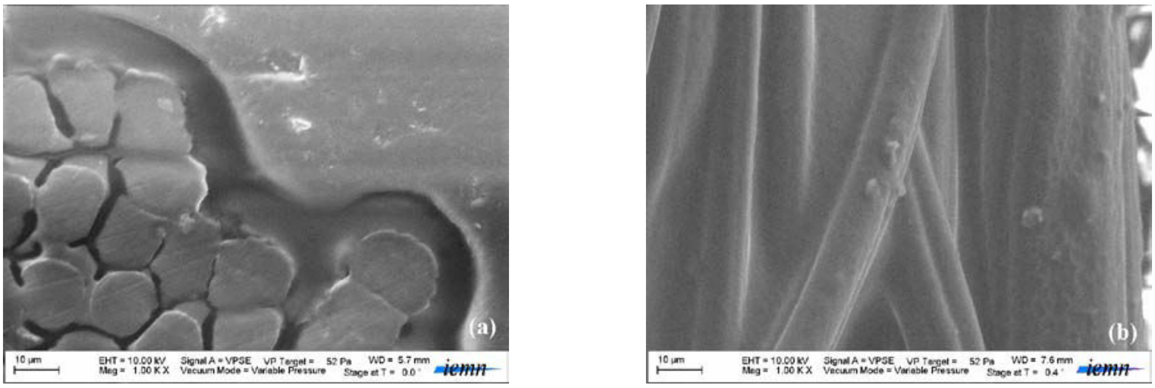


Figure 5. (a) The cross section SEM image of the Kevlar multifilament coated with PEDOT:PSS; (b) the surface SEM image of the Kevlar multifilament coated with PEDOT:PSS

4. RESULTS AND DISCUSSION

This novel geometry pattern configuration makes the post-processing unnecessary. The thread (WECT) can be inserted into a textile fabric without any difficulty. The conductivity of the PEDOT:PSS coated Kevlar multifilament is simply measured as 3~4×10-3 S/cm by two-point method for a predefined fixed length. Figure 5a shows the cross section SEM image of the Kevlar multifilament coated with PEDOT:PSS. This material was coated around the multifilament and penetrated interstices among filaments as well (the dark parts are conductive material). The thickness of the PEDOT:PSS layer is about 3~5 µm observed by SEM. From Figure 5b, a smooth conductive layer is clearly observed. The conductive material may also be observed in interstices among monofilaments making a continuous conductive network.

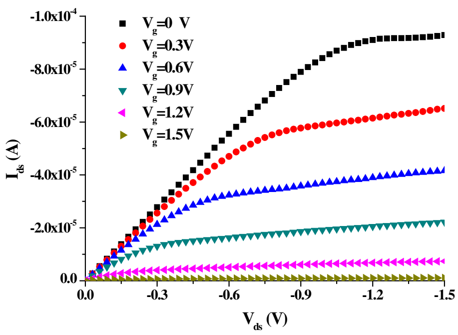


Figure 6. Typical Ids vs. Vds characteristics at various gate voltages for the sweep rate of 3 mV/s

Figure 6 shows the output characteristics of Ids vs. Vds of the twisted wire electrochemical transistor at sweep rate of 3 mV/s. For different Vg, with the decrease of the Vds, the current in the channel, Ids, was saturated when Vds arrived to the value corresponding to the beginning of the “pinch off” phenomenon. Even if the Vg=0V, the source/drain electrode filament does not behave as a pure impedance but has saturation region. This phenomenon can be explained by the existence of the electrolyte. When Vds arrives to a negative value, cations of the electrolyte diffuse to the negatively biased side of the channel. As a result, the reduction of the PEDOT occurs at the drain side. Notice that above the pinch-off, Ids does not saturate completely and increases linearly with Vds. This part of current comes both from the existence of the difficultly reduced PEDOT:PSS interstices among monofilaments, which can be considered as the pure resistor, and from the leakage of the gate electrolyte. Another explanation for this incomplete saturation can be stand from the imperfect alignment of the electrolyte and the gate electrode [14].

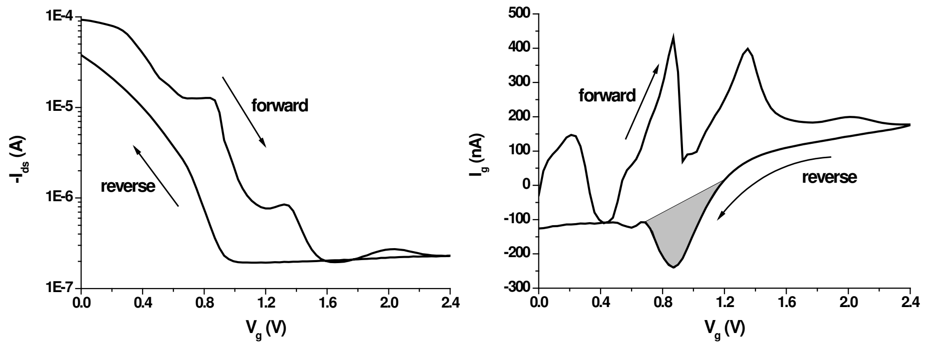
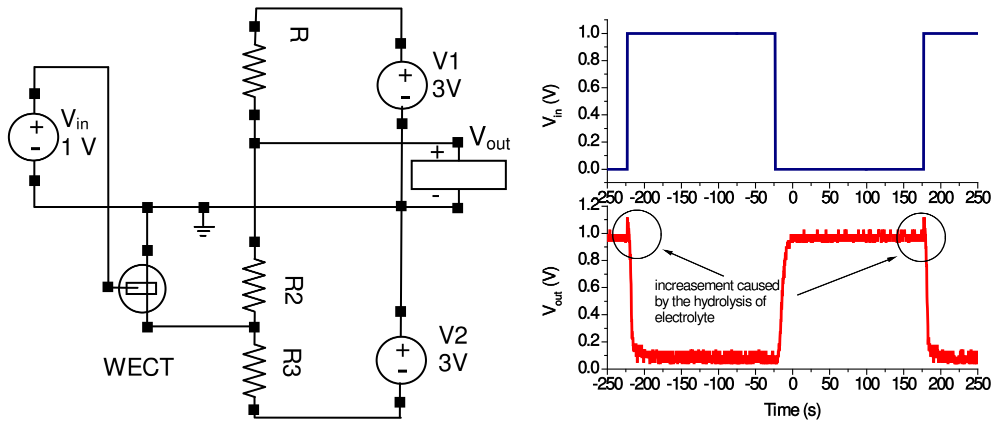


Figure 7. Ids-Vg and Ig-Vg characteristics measured simultaneously for WECT. The drain voltage was -1.5V. The gate voltage was swept at a rate of 3m/V

The Figure 7 shows the Ids-Vg transfer curve and Ig-Vg curve. The Ig-Vg data reflect an apparent "three-step injection" process during the forward sweep. First, a positive peak is observed around Vg=0.2V, corresponding to the first Ids decrease. Second, the following two important peaks are observed around Vg=0.9V and Vg=1.3V, corresponding to the significant decrease of Ids. A possible explanation for this behavior is that sodium cations easily diffuse to the channel surface but difficultly penetrate into PEDOT:PSS interstices among coated filaments, which makes two following peaks.

By integrating the displacement current versus time data, we can calculate the total injected 2D charge carrier density (Q'), like the analysis of a cyclic voltammogram [15]. The shaded area under the reverse sweeps of the Ig-Vg curve corresponds to sodium cation density of ~3×1015 charge/cm2 (~474 µC/cm2). Because the parallel pattern of WECT, the surface of electrolyte/gate is three or more times larger than those of electrolyte/channel. This structure gives an Ion/Ioff as large as 103. The ratio of these two surfaces decides the ratio of Ion/Ioff [16]. This value can be easily modified by the fabrication process of the WECT.



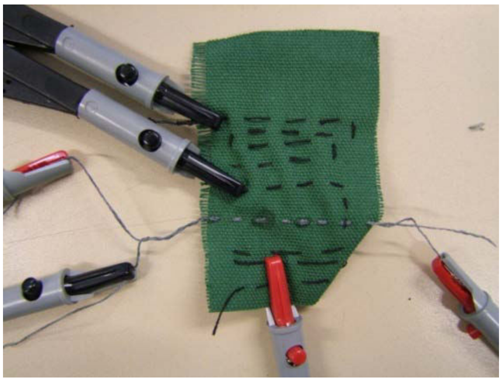
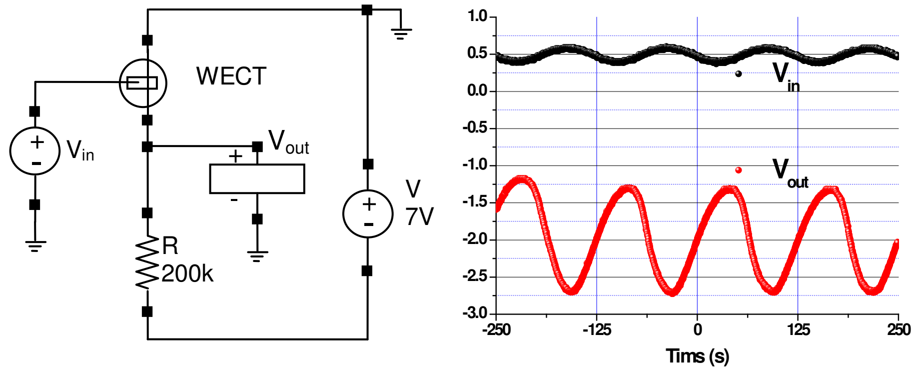


Figure 8. (Left) the circuit of logic inverter including a depletion mode transistor and (right) its associated input-output characteristics (below) textile circuit

The circuit of logical inverter realized with the twisted WECT in a textile structure (cotton fabric) is shown in Figure 8. The values of resistors were R1=R2+R3 and R3=2XR2. The value of R2 can be estimated as twenty times of the resistance of WECT in a conductive state. The period of pulse was 400s and the duty cycle was 50%. When the gate receives an input voltage of 0 or 1V, the transistor will turn ON or OFF. Figure 8 also shows the input–output characteristics when the input signal is changing gradually between 0 and 1V. The switch time ON-to-OFF was about 15~16s and the switch time OFF-to-ON was about 17~18s. The same characteristics were obtained when the period of pulse was decreased to 100s. A short temporary increase of the Vout before the decrease when the Vin switch from 0V to 1V can be explained by the hydrolysis of electrolyte [17].



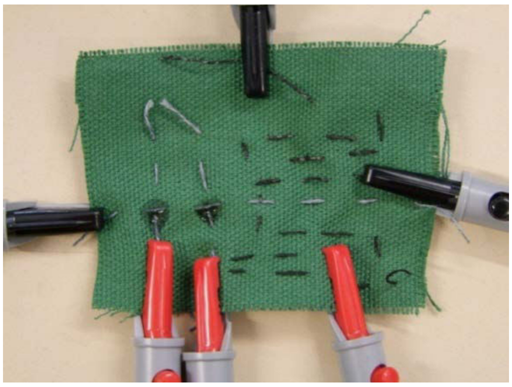


Figure 9. (Left) the circuit of one-transistor amplifier with (right) the associated amplification characteristics (below) textile circuit

Besides the digital circuit, WECTs can also be used to realize analog circuits such as an amplifying one. These circuits open up the possibility to implement sensor amplifiers, comparators, frequency-selective filters, oscillators, timers, feedback-control systems, etc [18] directly into textile structures. Figure 9 displays the basic one-transistor amplifier. The load resistor gives the amplification. With a resistor of ~200kΩ, the estimated amplification is about 7.5 times for small input signals (Figure 9), provided that the input DC-level is set in order to correctly bias.

5. CONCLUSION

In this work, a novel geometry pattern of twisted wire electrochemical transistor has been reported. Two Kevlar multifilaments were coated with PEDOT:PSS as electrodes. One of them was coated with the electrolyte in the middle of filament. After being coated with the resin and cut off, this filament was glued with the other one by the electrolyte, and then twisted together. A post-processing is not necessary for this geometry pattern for textile applications. The transistor filament can be as long as tens of centimeters. The output and transfer measurements have shown the same characteristics as the traditional wire electrochemical transistor. The On/Off ratio reached up to 103.

A one-transistor inverter circuit and an analog amplifier have been fabricated as well. The amplification reached up to 7.5. The new twisted WECT opens a promising perspective of designing electronic circuits directly into textile structures. By changing the electrolyte, it would be possible to create textile sensors as well. In combination with other conductive yarns, the complex smart textile circuit will be realized in near future.

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Researches related to the COLOR REMOVAL FROM WASTEWATERS USING OZONE TECHOLOGIES

Moga Ioana Corina, Drambei Petronela, Pricop Floarea, Scarlat Razvan

***Abstract**: More and more textile producers use as wastewater treatment processes advanced techniques of color removal. In many cases the ozone is used because it is a stronger oxidant offering good results in color removal. In the present study are proposed methods based on mathematical modeling and numerical simulations for the ozone processes inside a wastewater treatment plant from a textile company. As it is known from the specialty literature the ozone treatment stage can be placed after the biological treatment or after the chemical stage.*
The wastewater treatment plant that was studied is equipped with 2 reactors inside which the ozone is introduced in the wastewater mass using porous diffusers, made form elastomer materials which are very resistant. From numerical simulations resulted that the best contact between the ozone particles and the water molecules is reached near the bottom close to the diffuser. It is presented the ozone dispersion inside the wastewater mass and the dependence between the ozone consumption and wastewater load.

***Key words**: ozone, mathematical modeling, numerical simulation, wastewater, textile industry*

1. INTRODUCTION

Ozone contains three oxygen atoms, instead of two atoms like the molecule of oxygen, which confers stability. The ozone is considered the second powerful sterilizer in the world, from the bacteria, viruses and odors destruction point of view. The third atom ½O_2 (active oxygen) is quickly released, conferring a powerful oxidation character in the aqueous environment. As a result it searches to constitute stabile associations of molecules, by attaching to the avid substances of oxygen. In this way it is obtain a swift oxidation of organic matters with different molecular structures.

The studies and researches effectuated in our country and worldwide have demonstrated the powerful oxidation character of the ozone. Especially, in the textile industry, are discharged wastewaters that contain organic matters (dyes etc.) which cannot be destroyed using the classical biological treatment, fact that imposes the development of researches regarding the production and efficient utilization of ozone. The complexity of physical-chemical–biological phenomena that appears in aerated bioreactors makes that the methods based on analytical solutions, for the oxygen mass transfer and diffusion in aqueous environment, to be different from the one that is used in general. In the present paper, the authors tried to obtain the oxygen repartition inside the biological ozonization reactor using the integral numerical methods, for a concrete case of industrial installations.

The introduction of ozone in the studied wastewater treatment plant (WWTP) from textile industry is made into two cylindrical reactors. The first reactor is destined to bio-chemical reactions and the second, the final one, is destined to disinfection. In the first stage is difficult to determine whether the shape and capacity were correct adopted to answer to the proposed aim. So, it appears the necessity of mathematical modeling and numerical simulation of oxygen transfer process from the ozonized air in correlation with ozone consumption inside the bioreactor. The principal aim of mathematical modeling and numerical simulation was to determine the variation of dissolved oxygen concentration in the aqueous environment and determination of hydrodynamic regime that is realized through the gas-lift effect, generated by vertical rising of air bubbles. Knowing the wastewater flow rate (900 m^3/day) and the reactor sizes, the wastewater velocity inside the basin can be calculated. With this value, mathematical modeling and numerical simulation will be possible, for the wastewater flow inside the reactor.

2. THEORY

In the hypothesis of perfect mixture, a balance between the oxygen consumption and gas diffusion is established. From this balance results the profiles of oxygen concentration inside the biological reactor. Taking into account a factor that reflects the oxygen consumption from the biochemical oxidation of organic matter, equilibrium will be obtained between consumption and ozonization (Hvala, N., Vrecko, D., Burica, O., Strazar, M., Levstek, M., 2002). A cylindrical biological reactor it is considered (see also Figure 1), which is placed in a WWTP from textile industry.

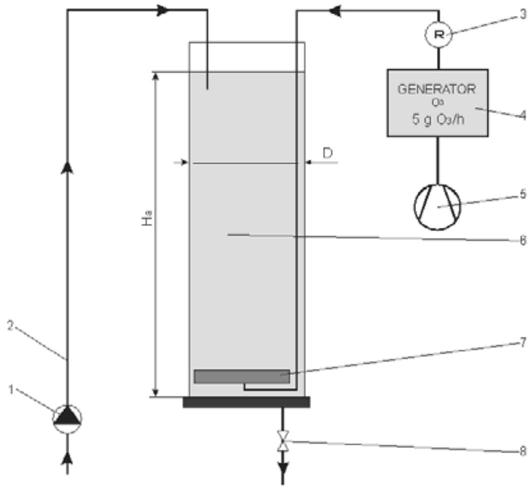

Figure 1: Biological reactor with device for ozone injection
1 - feed pump; 2 - feed pipe system; 3 - rotameter; 4 - ozone generator, 5 - air compressor;
6 - biological reactor; 7 - diffuser; 8 - drain tap.

On the apron of the cylindrical rector is placed the device used for ozone dispersion. This device will assure the mass of gas bubbles inside the aqueous environment. The operational system af the diffusers is based on the fine distribution of ozone in wastewater mass.

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Modeling water oxygenation process will take into account the following hypothesis (Mandis I.C., Robescu D., Pricop F., 2009): Hydraulically permanent motion; Unidirectional horizontal motion – on the positive sense of Ox axes; No stationary system as to mass transfer; Perfect mixing in biological tank; The motion regime is turbulent creating a perfect mixture in biological tank.

Dissolved oxygen concentration in water is the result of two processes - oxygen mass transfer from air into the water because of the air bubbles motion in water and oxygen consumption because of biochemical process for organic matter mineralization. Accordingly, consider the ozone dispersion equation, general form, in tri-orthogonal Cartesian (Mandis I.C., Robescu D., Pricop F., 2009):

$$\frac{\partial \overline{C}}{\partial t}+\frac{\partial}{\partial x}\left(\overline{u}\,\overline{C}\right)+\frac{\partial}{\partial y}\left(\overline{v}\,\overline{C}\right)+\frac{\partial}{\partial z}\left(\overline{w}\,\overline{C}\right)=\frac{\partial}{\partial x}\left(\varepsilon_x\frac{\partial \overline{C}}{\partial x}\right)+\frac{\partial}{\partial y}\left(\varepsilon_y\frac{\partial \overline{C}}{\partial y}\right)+\frac{\partial}{\partial z}\left(\varepsilon_z\frac{\partial \overline{C}}{\partial z}\right)+ \qquad (1)$$

$$+D_m\left(\frac{\partial^2 \overline{C}}{\partial x^2}+\frac{\partial^2 \overline{C}}{\partial y^2}+\frac{\partial^2 \overline{C}}{\partial z^2}\right)+S(x,y,z,t)$$

where:

ε_x, ε_y, ε_z represents the dispersion coefficients, on the three direction of fluid current; because of the turbulent regime are considered the average values for these coefficients;

u, v, w - velocity components on the thee axes taken in consideration;

D_m - molecular diffusion constant of oxygen in water;

S (x, y, z, t) - the source of ozone which contributes to a forced entering of ozone into the biological reactor; at biological processes with oxygen consumption this term will express the consumption intensity and has the form of *-kCC*.

A complete solution of this equation, whereupon had to be attached the motion and continuity equations, is impossible to obtain because a numerous aspects such as: the dependency of the dispersion coefficients of the flow regime, the nature, form and dimension of dispersed particles as well as the physic properties of the agents. For this reason the solution is obtained using models with a high degree of simplicity that are reflecting the physic reality (Morgenroth, E., Kommedal, R., Harremoes, P., 2002).

3. METHODS

The dispersion equation is simplified taking into account the following hypotheses: the system is bidimensional O_x, O_z, with longitudinal water flow and with gas bubbles arising from the bottom; the vertical motion is identically; molecular diffusion is negligible as intensity in account with turbulent convective diffusion; turbulent convective dispersion and diffusion on the transversal direction to the motion direction are neglected, because of their little values in account with the similar phenomenons that appears on longitudinal O_x and vertical Oy directions; the gas bubbles formed in the water will arise through the blank surface resulting a high variation through vertical direction of the flow, obviously, a gas-lift effect appears, because of the gas bubbles movement, that will contribute to the mix of the phases from the aqueous environment and will intensify the ozone transfer; the fluid movement speed v through vertical direction will be replace in equation with the ozone bubbles arise speed w; the longitudinal dispersion appears because of water flow on the direction of O_x axis, and the vertical gas bubbles movement assure the perfect and total mix of the polyphasic mixture.
As results of the upper hypotheses equation (1) is reduced at equation:

$$\frac{\partial \overline{C}}{\partial t} + \frac{\partial}{\partial x}\left(\overline{u}\,\overline{C}\right) + \frac{\partial}{\partial y}\left(\overline{w}\,\overline{C}\right) = \frac{\partial}{\partial x}\left(\varepsilon_x \frac{\partial \overline{C}}{\partial x}\right) + \frac{\partial}{\partial y}\left(\varepsilon_y \frac{\partial \overline{C}}{\partial y}\right) - k\,C\,C \qquad (2)$$

The ozone is introduced through the bottom of the aeration tank, dispersed through equipments with fine bubbles resulting the relation between the dispersion coefficients $\varepsilon_x < \varepsilon_y$.

4. FINDINGS

Using a simulation program the direction of the current lines and the flow of the fluid through the ozonization reactor were determined. Thus, in Figure 2 and Figure 3 are presented the direction of transit current lines through aeration tank. As it can be seen the input is made through the top of the tank (upper right) and the water evacuation is made through the bottom of the tank (left part, under the diffuser). Water flux is in contraflow with ozone bubbles movement sense.

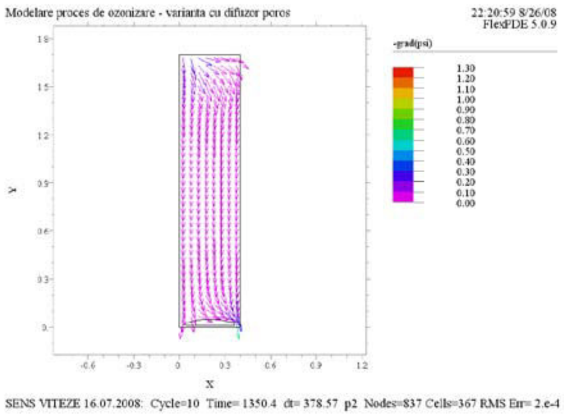


Figure 2: Flow inside the biological reactor

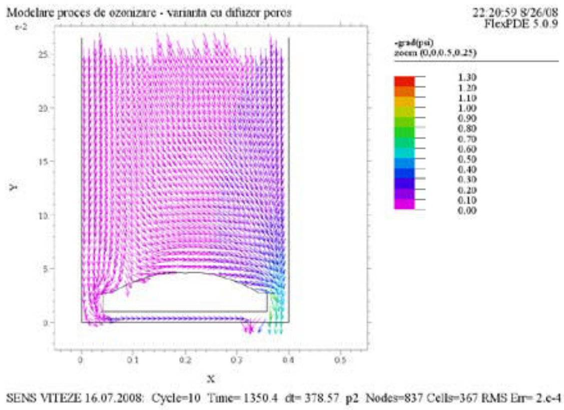


Figure 3: Flow inside the biological reactor (zoom at the bottom part of reactor)

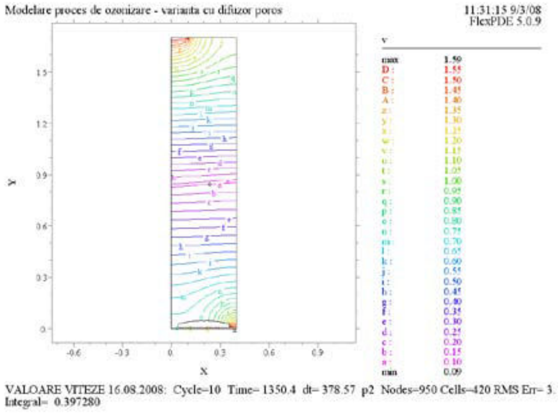


Figure 4: Velocity values for wastewater that passes through biological reactor

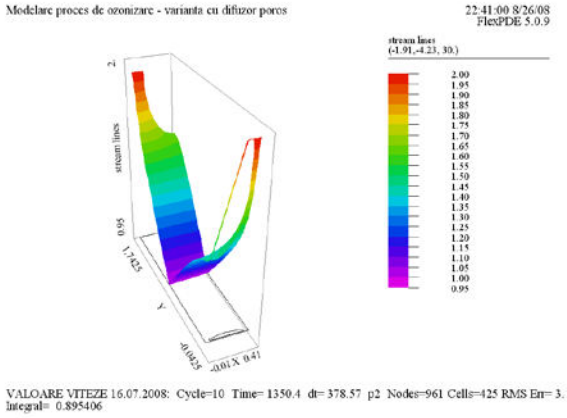


Figure 5: Tridimensional representation of velocity modulus inside the biological tank

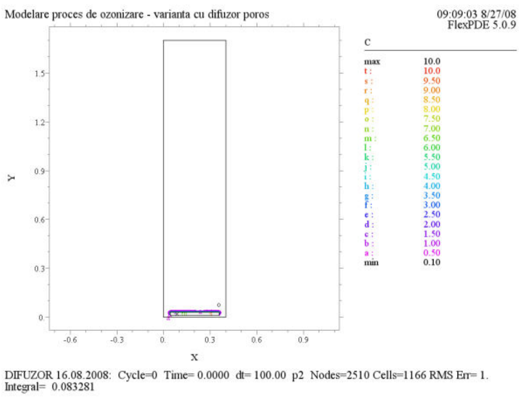
For determination of the water velocity inside the tank has been made simulation using the same program (see also Figure 4 and Figure 5).

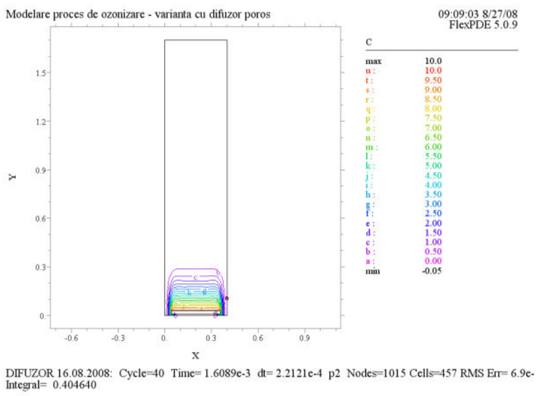
The velocity has the maximum value at the entrance and at the end of reaction tank because of the little sections in those areas. After the entrance the velocity begins to decrease, reaches the minimal value, and then begins to arise till reaches the maximum value at the end of the tank.

The development of transient regime of the wave front in the evolution of dissolved oxygen concentration in the water is very important because in many installations the equipment that produces oxygen stops for a short period of time. At the starting of the dispersion installation the main scope is the realization and the development of the oxygen concentration wave front that obviously is correlated with the hydrodynamic movement generated and induced by the equipment in water mass. The simulations (Figure 6) present the development of the wave front when the installation starts.

In the right bottom corner is presented the ozone dispersion in the water mass during normal operation.
After that have been made simulations taking into account variation of *k* coefficient (the coefficient express the ozone consumption). The results of the simulation have shown that once the coefficient increases the ozone concentration from the water decrease. The dependency between these two measures is presented in the Figure 8.

Beside variation of coefficient *k*, can vary the ozone flowrate that is introduced in the reaction tank. In Figure 8 are presented the results obtained in the simulation process for different values of the ozone debit introduced in the tank.





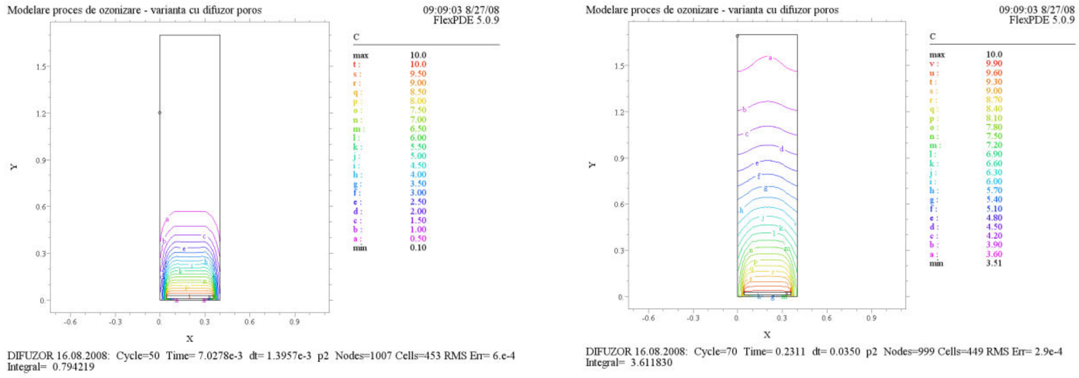
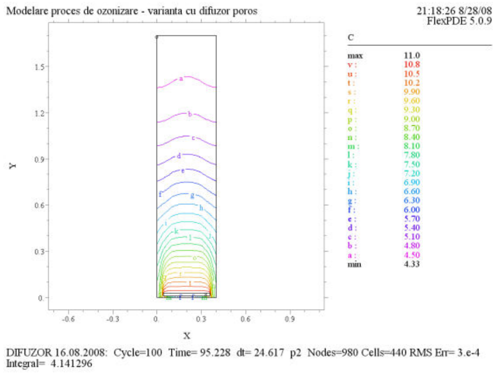
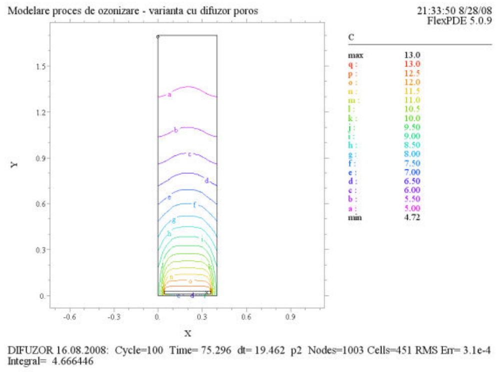


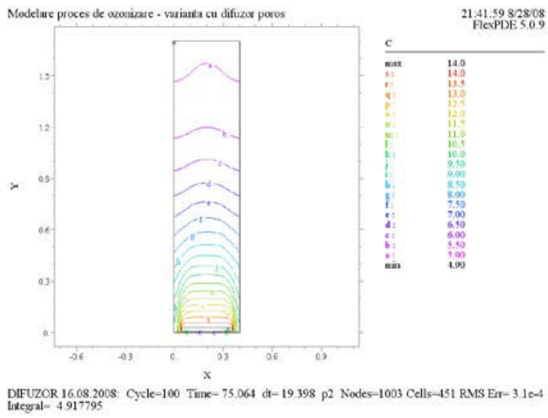
Figure 6: Development of wave front at the starting of the ozone generator

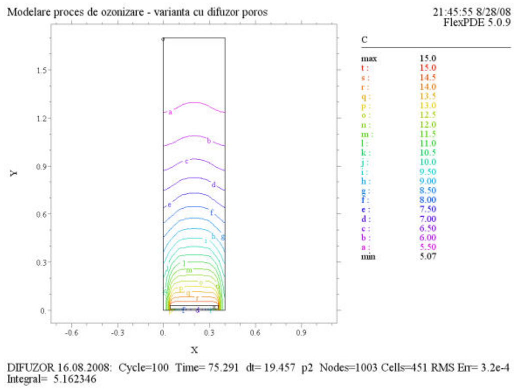




C_s = 6 mgO_2/l

C_s = 7 mgO_2/l





C_s = 8 mgO_2/l

C_s = 9 mgO_2/l

Figure 7: Ozone dispersion in wastewater for different values of ozone concentration at saturation

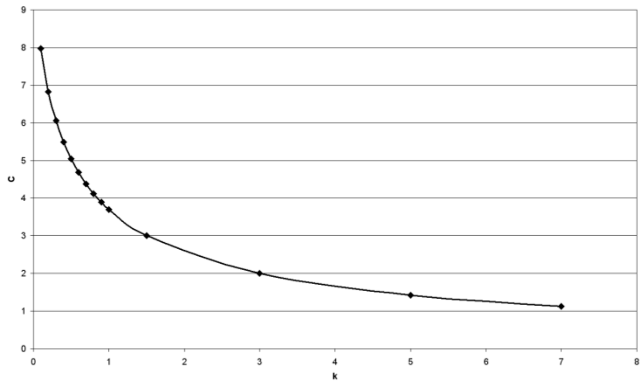


Figure 8: Concentration variation depending on k

5. DISCUSSION

The hydrodynamic movement is induced in the water mass of the ozonization tank through gas-lift effect generated by the ascending movement of gas bubbles. The intensity of this movements is very important because it has to assure the mixation and the omogenization effect of the stages from polyphasic environment as well as the transfer of the oxygen from gas bubble into aqueous environment. More intense is the hydrodynamic turbulent regime more homogeneous is the mix obtained and the transfer rate of the oxygen from the ozone bubble to the aqueous environment has higher values. The attainment of an intense turbulent regime imposes higher injection energy consumption and a higher debit of air lard with oxygen.

6. CONCLUSIONS

The results obtained through the modeling and the simulations of oxygen repartition from aqueous environment confirm the importance of the researches realized in this domain. The oxygen consumption variation form the aqueous environment, through biochemical reaction, is reflected by coefficient k from the dispersion equation. The modification of this factor, by increasing it, conducts to another repartition of oxygen concentration in wastewater. Mathematical modeling and numerical simulation of oxygen transfer from ozonized air reflect the real phenomenon of oxygenation and consumption. From the analysis of figures resulted from numerical simulations resulted that the maximum values for oxygen concentration are obtained in the adjacent area of the diffuser, from the bottom of the biological reactor. In this area it will be obtained a transfer process of high intensity, because of the renewal contact area between gas and liquid, where the gas bubble are formed and detach from the elastomer membrane. While the gas bubbles are rising inside the water column from the biological reactor, the value of dissolved oxygen is decreasing because of: oxygen consumption needed at organic matters biochemical oxidation; the oxygen concentration from the ozonized air bubble is reduced, due to the transfer effect near the diffuser.

AKNOWLEDGEMENTS

The work has been co-funded by the Sectorial Operational Programme Human Resources Development 2007-2013 of the Romanian Ministry of Labour, Family and Social Protection through the Financial Agreement POSDRU/89/1.5/S/62557.

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EFFECT OF HYDROLYSED COLLAGEN IN THE OPTICAL BRIGHTENING OF COTTON

Marolda Brouta-Agnésa, Helena Esteve, Sandra Balsells and Roshan Paul

Abstract: *Optical brightening agents (OBAs) are dyes that absorb light in the ultraviolet region of the electromagnetic spectrum and re-emit in the visible blue region. This results in a fluorescent effect on the whiteness in daylight masking the inherent yellowness of the substrate. The main objective of this study was to determine the effect of hydrolysed collagen once incorpoaarated in the optical brightening process. First of all, the compatibility of four different optical brighteners with hydrolysed collagen was studied at different pHs. Further application studies were carried out at various concentrations of hydrolysed collagen and at different pHs. The results indicate that there is a synergistic effect of hydrolysed collagen in the optical brightening of cotton.*

Key words: *Hydrolysed Collagen, Optical Brighteners, Cotton*

1. INTRODUCTION

In recent years, the textile industry intends to develop high quality processes in a cleaner environment. The collagen is an extracellular fibrillar protein that is present in all the organs and tissues of a living organism, having a predominant role in the maintenance of the skin, bones, tendons and cartilages. The source of every collagen is of animal origin and there is no collagen of vegetable origin.

Cotton is normally bleached to produce white coloured goods. This chemical whitening may sometimes lead to a yellowish tone. Thus optical brightening is an important process in the whitening of cotton. This process may load the effluents with unfixed products and it is always desirable to enhance its efficiency on economical and ecological grounds. In this context, it is interesting to know whether the efficiency of this process may be enhanced by incorporating hydrolysed collagen. Practically no references are found on the application of hydrolysed collagen in the optical brightening of cotton.

2. EXPERIMENTAL

In this study, bleached cotton fabric was used as the substrate. The optical brightening agents (OBAs) used differ in the number of sulphonic groups. Sera White C-EBN (1) and C-EBB (2) are derivatives of diamino-stilbene with two sulphonic groups. The Sera White C-MBN (3) is a derivative of diamino-stilbene with four sulphonic groups and the Sera White C-LBN (4) is a derivative of diamino-stilbene with six sulphonic groups. The complete fraction of the hydrolysed collagen, without any fractional separation, was used for the study.

1.1. Compatibility study

Study was carried out by preparing several proportions of hydrolysed collagen in water (water:collagen) at various pHs 3, 5, 7 and 9, and mixing with 1% o.w.f. of various OBAs.

- 100:0: A solution without hydrolysed collagen to determine the capacity of fixation of the optical brightener on cotton.
- 95:05: This proportion has allowed to determine whether the fixation of the optical brightener is better with a very small concentration of hydrolysed collagen.
- 90:10 and 80:20: These proportions have allowed to determine whether the fixation of the optical brightener is better with higher concentration of the hydrolysed collagen.

The samples were kept for 24 hours and observed the compatibility visually and spectrophotometrically.

1.2. Optical brightening

The cotton samples were pretreated with various proportions of water/collagen and the pH was adjusted to 4 using hydrochloric acid. The treatment was done in an Ugolini dyeing machine for 20 minutes at 60ºC with a speed of 40 rpm and the liquor ratio was fixed at M:L: 1:20. Once the pre-treatment with collagen was finished, the pH of the solution raised to 7, and 1% o.w.f. optical brightener and 3 g/L of sodium sulphate were added under agitation. The OBA treatment was carried out according to the process shown in Figure 1.

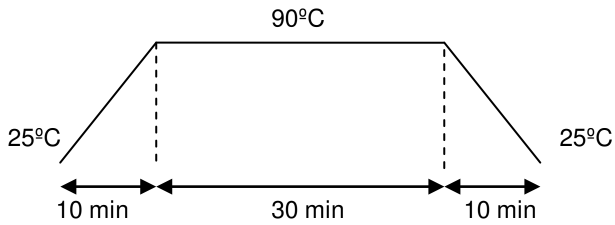

Figure 1: Optical brightening process

1.3. Characterisation

The optically brightened samples were subjected to 5 cycles of domestic washing using a detergent without containing optical brightener, as per UNE-EN ISO 6330:2001. The samples were analysed spectrophotometrically to measure the Whiteness Index as per ASTM E313 - 1996 in a Minolta spectrophotometer.

2. RESULTS AND DISCUSSION

First of all, the compatibility of the hydrolysed collagen was studied with various OBAs at different pHs (Table 1). A blank study was also carried out without the hydrolysed collagen, in order to compare the results.

Table 1: Compatibility study of hydrolysed collagen with various OBAs

Process 1: Without hydrolysed collagen						**Process 2: With hydrolysed collagen**					
	Product	pH-3	pH-5	pH-7	pH-9		Product	pH-3	pH-5	pH-7	pH-9
A	OBA 1	X	X	X	X	E	OBA 1	X	X	X	X
B	OBA 2	X	X	X	X	F	OBA 2	X	X	X	X
C	OBA 3	X	X	X	X	G	OBA 3	X	X	X	X
D	OBA 4	X	X	X	X	H	OBA 4	X	X	X	X

Further, all the samples were analysed visually (Table 2) in order to determine the effect of the concentration of hydrolysed collagen and pH on its compatibility with various OBAs. The samples were analysed using the following scale: x: without significant change; 1: transparent solution, but little darker; 2: transparent solution, but darker; 3: turbid; 4: very turbid.

Table 2: Visual analysis of hydrolysed collagen with various OBAs

	A3	A5	A7	A9	E3	E5	E7	E9	B3	B5	B7	B9	F3	F5	F7	F9
No change			x	x			x	x				x				x
Precipitation					x	x										
Sedimentation											x					
Agglomeration																
Phase separation									x				x	x		
Colour change	2	1			2	3			4	3	1		4	3	2	

	C3	C5	C7	C9	G3	G5	G7	G9	D3	D5	D7	D9	H3	H5	H7	H9
No change		x	x	x		x	x	x				x			x	x
Precipitation					x											
Sedimentation																
Agglomeration																
Phase separation									x	x			x	x		
Colour change	1								4	3	1					

As observed from Table 2, the sample E5 has resulted in a precipitation, which showed yellow fluorescence, where as the samples B3, F3 and F5 have separated into two phases. The G3 has showed a white precipitation at the bottom and, D5 and H5 has separated into two phases. The sample D3 has also separated into two phases, but more than that observed for D5. Interestingly the sample H3 separated into three phases.

The spectrophotometric analysis showed that each of these OBAs behaves differently with hydrolysed collagen. The collagen increases the absorbance of Sera White C-MBN. The absorbance of Sera White C-EBN increases in basic pHs while it gets reduced in acidic pHs. Interestingly, Sera White C-LBN behaves in the just opposite manner as that of C-EBN. The OBAs Sera White C-EBN and C-EBB behaves in a very similar manner as both are having similar structure.

Table 3: Possible mechanism of the effect of hydrolysed collagen on cotton

	pH <5	pH 5.0-7.0	pH > 7
Collagen Isoelectric point 5.2	Cationic NH_3^+- R-COOH	anionic NH_2-COO^-	anionic NH_2-COO^-
Cotton	anionic	anionic	anionic
Union of hydrolysed collagen to cotton	COORDINATION The hydrolysed collagen gets fixed electrostatically, reducing the negative charge of cotton	ABSORPTION The hydrolysed collagen is absorbed physically over cotton. There is repulsion of charges, but something can be absorbed	Repulsion of charges

Table 3 shows the possible mechanism of the effect of hydrolysed collagen on cotton. Depending on the pH, the hydrolysed collagen can improve or reduce the affinity of OBAs.

Table 4: Whiteness Index of various cotton samples before washing

Cotton Whiteness Index – 0 washing				
Proportions	OBA 1	OBA 2	OBA 3	OBA 4
NT=67.63	-	-	-	-
100:0	126.21	134.03	122.8	110.47
95:05	128	132.12	122.75	111.54
90:10	**131.6**	**137.53**	125.42	112
80:20	127.05	136.78	125.66	113.3

Table 5: Whiteness Index of various cotton samples after washing

Cotton Whiteness Index – 5 washings				
Proportions	OBA 1	OBA 2	OBA 3	OBA 4
NT=92.3	-	-	-	-
100:0	136.97	**146.06**	125.18	122.48
95:05	139.56	145.76	130.04	117.98
90:10	**139.4**	**145.33**	132.99	113.45
80:20	136.41	144.88	131.61	117.39

Tables 4 and 5 show the Whiteness Index of different cotton samples containing varying proportions of hydrolysed collagen, before and after 5 cycles of domestic washings. As observed the OBA, Sera White C-EBB showed the highest level of whiteness at 90:10 proportion of hydrolysed collagen, before washing. On the other hand the Sera White C-EBN showed a similar synergistic increase in the whiteness value, before washing.

As observed from Table 5, in general, the whiteness value increased for all the cotton samples after washing. It is interesting to note that C-EBN continued to have a superior value than the control sample after the washing. But the C-EBB lost the synergistic effect after washing and the control sample resulted in a higher whiteness value after washing.

3. CONCLUSION

The OBA Sera White C-EBB showed the highest level of whiteness at 90:10 proportion of hydrolysed collagen, before washing. Sera White C-EBN also showed a similar synergistic increase in the whiteness value, before washing. But it is interesting to note that C-EBN continued to have a superior value than the control sample even after the washing.

ACKNOWLEDGEMENTS

The authors wish to thank the financial support from the Spanish Government under the programme- *Programa Nacional de Proyectos de Investigación Aplicada 2008* and also the project partners AIICA, CEC-FECUR and AITPA for their support. The authors wish to thank also Dystar Hispania for kindly supplying the required optical brighteners.

TEXTILE ELECTRONICS, DISPLAYS

Xuyuan TAO, Cédric COCHRANE, Ludivine MEUNIER, Fern M KELLY and Vladan KONCAR

Abstract: *The fibre form transistor has become one of the most interesting topics in the field of smart textiles. The use of PEDOT:PSS to realize a parallel wire electrochemical textile transistor has been reported. A novel geometry pattern makes the transistor easier to insert into textile fabric making the large-scale production possible. The length of transistor can be up to several centimeters. The On/Off ratio reached up to 103. The switch time is near 15s. An inverter circuit and an amplifier were fabricated by using one transistor as well in order to demonstrate the feasibility of fully textile electronic circuits.*
On the other side chromic materials have the ability to change their colour reversibly according to external environmental conditions. They are categorised by the stimulus that triggers the colour change. For example, thermochromic materials can be defined as those in which a colour change is induced by a change in temperature and electrochromic materials are those in which a colour change is induced when an electrical current is applied. Thermochromism is already a well-known application within the textile field, however electrochromism is not as common. In this paper, an overview of the field of electrochromic devices is provided and the successful development of a first generation flexible textile electrochromic device, achieved by ourselves, is discussed. The flexible electrochromic textile display consists of a novel 4-layer sandwich structure containing a thin spacer fabric with electrochromic compound (Prussian blue), a conductive layer and two electrodes; bottom and upper (transparent). If powered with a low voltage battery, this structure is able to generate a reversible colour change. The switching times have been measured at ~ 5 s and 4.5 V. The colour changes are monitored via CIE L, a*, b* values..*

Keywords: *(e-textile, electrochemical transistor, PEDOT:PSS, Textile flexible display, Conducting polymer, Prussian blue*

1. INTRODUCTION

Any change in the colour of an object, whether from white to black, colourless to coloured or from one colour to another, can be easily detected by the human eye, or by simple spectrophotometric instruments. Such changes in colour provide important visual signals that can be used to convey information to an observer, the most obvious being traffic control signals. Consequently, research into substances that undergo reversible colour changes upon the application of an external stimulus has been extensive.[1] Materials of this type are known as chromic materials. The ability to combine chromic materials with textiles therefore provides the opportunity to create a flexible communicative display for clothing, principally for protection and safety or for added fashion.

Chromic materials are classified based on the type of stimulus that induces their colour change. For example, an “electrochromic” material is one in which a reversible colour change is observed when an external voltage is applied. This phenomenon is an analogy to “photochromic” and “thermochromic” materials, whereby the change in colour is observed by a change in light or a change in heat respectively. [2-4] Articles of clothing treated with photochromic materials were first introduced in the market in 1989, with the application intended for added fashion. However, the ability also exists to be applied in solar protection, by monitoring UV radiation. Photochromics are generally organic molecules that can reversibly change their molecular configuration with the influence of UV radiation. The molecular arrangement of the material affects the absorption spectra and hence its colour.[5]

Two types of thermochromic systems have been used successfully in textiles. These are the liquid crystal type and the molecular arrangement type. In both cases, the dyes are entrapped in microcapsules and applied to fabric like a pigment in a resin binder. Toray Industries commercially released in 1987, a line of clothing made from temperature sensitive chameleonic fabric, known by the

name of “Sway”. The change of colour with temperature of these fabrics was designed to match the application. For example, ski-wear 11°–14°C, women’s clothing 13°-22°C and ‘temperature shades’ 24°-32°C.[6] More recently, thermochromic materials have been implemented in fashionable flu-masks to monitor the body temperature of a person (Fig. 1a) [7]. Thermochromic paints also allow textiles to have a particular motif painted on them that will change colour. A wallpaper painted with green plants in thermochromic paint, starts to blossom as soon as your room heater turns on, spreading wonderful roses all over your wall like magic (Fig. 1b) [8].

In addition to photochromic and thermochromic materials, electrochromics are also currently attracting much interest in academia and industry for both their fascinating spectroelectrochemical properties and their commercial applications. However, unlike the photo- and thermo- analogues, clothing or interior textiles treated with electrochomics are not readily available on the market. Devices consisting of electrochromic materials, that are available, include glass windows of buildings which darken reversibly at the flip of a switch,[9] and for anti-glare car windows; including the sun-roof and the rear-vision mirrors[10]. Other proposed applications include re-usable price labels, devices for frozen-food monitoring, camouflage materials and controllable light reflective or light-transmissive displays for optical information and storage [11]. Developments are also being undertaken into electrochromically operated billboards, large-scale traffic direction boards, and rail and airport departure boards [12, 13].

However, the products listed above are rigid in their structure due to glass commonly being applied as the base substrate [12,14-17]. An opportunity therefore exists to alternatively combine the desired spectrochemical properties of electrochromic materials with a flexible textile substrate, in order to achieve a display that is flexible. This would give rise to a technology that could be applied to a suite of products that would have the ability to change its pattern or print. Not only could communicative clothing be created, but also communicative flags and interior furnishings, including upholstery and drapery.

Many materials express these chromic properties, and can be assigned to one of three general categories [18, 19]. Type I materials are soluble in a given electrolyte solution in both reduced and oxidised states, e.g. 1,1’-di-methyl-4,4’-bipyridilium (‘methyl viologen’). Type II materials are soluble in one redox state, but form a solid film on the surface of an electrode following electron transfer, e.g. 1,1'diheptyl-4,4'bipyridilium dication in water. Type III materials, in both the reduced and oxidised states, are solids. All-solid systems are the most common for electrochromic displays. They include all conducting polymer systems, metal oxides, Prussian blue and its analogues, and rare earth phthalocyanines.

Electrochromic devices (ECDs) themselves may have one of many alternative compositions3. The traditional structure of an ECD, however, is that of a seven-layer electrochemical cell with the rigid sandwich structure (Fig. 2). An electrochromic material is coupled to both a suitable solid or liquid electrolyte (ionic conductor) and an ionic storage layer. These three layers are sandwiched between two conductors (electrodes), with at least one of these, also requiring transparency. These are then sandwiched between two substrates, typically glass, completing the device. Colour changes observed in ECDs occur by charging and discharging the electrochemical cell with an applied potential of a few volts (typically 1 - 5 V) [20]. After the resulting current has decayed, the colour change will be effected with the simultaneous redox reaction. The new redox state (and colour) remains due to the so-called “memory” effect, without the requirement of further electrical input [3].

(a)

(b)

Figure 1. Thermochromic textiles that change colour with temperature (a) fashionable flu-masks and (b) blossoming wallpaper

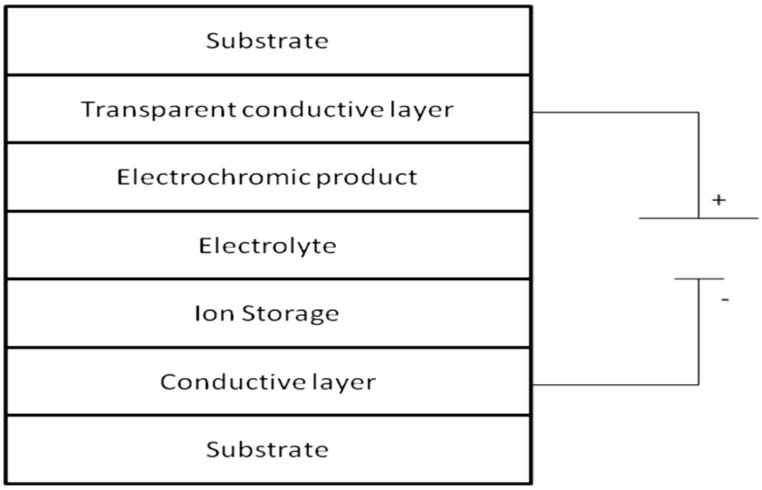

Figure 2. An ECD with a seven-layer sandwich structure

A number of academic and commercial research groups, including the engineering conglomerate (Siemens), are currently working on the development of ECDs that are flexible (Fig. 3) [4, 21-30]. The Siemens display consists of a layer of electrochromic material sandwiched between two electrode layers. The ECD structure or the electrochromic mixture used by Siemens, which enables the screen to work so rapidly, however has not been disclosed. Moreover, Mecerreyes et.al. [26] have proposed a simplified alternative to that of the seven-layer structure described above. By using a plastic substrate, they have successfully created a flexible all-polymer ECD. Poly(3,4-ethylenedioxythiophene) (PEDOT) has been utilized, demonstrating that conducting polymers can act simultaneously as both the electrode and the electrochromic material. The transparent conducting layer of the classical configuration is therefore eliminated, resulting in a device requiring only five-layers (Fig. 4).

Figure 3. A flexible electrochromic display, as developed by Siemens

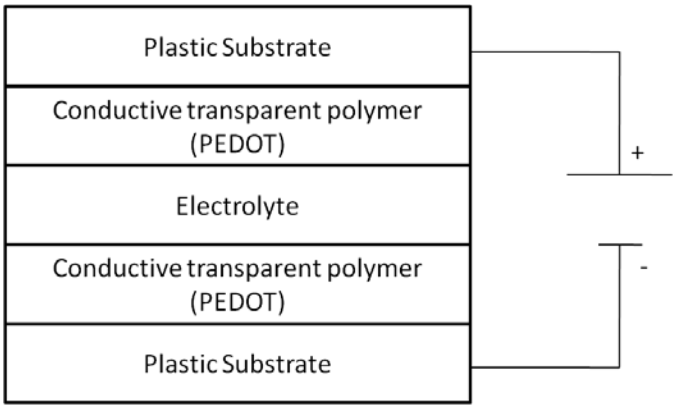

Figure 4. An ECD with a five-layer sandwich structure

This article discusses the preparation of a flexible electrochromic display for application in smart clothing. The five-layer electrochromic device, considered above, has been simplified further to a four-layer device, by suspending a solution of an inorganic Type III electrochromic material (Prussian Blue) within a spacer fabric. The pros and cons of this device are discussed and the ways in which it may be improved are proposed.

2. MATERIALS AND METHODS

Iron (III) chloride hexahydrate ($FeCl_3.6H_2O$, 97 %) and potassium ferricyanide ($K_3Fe(CN)_6$, 98 %) of analytical grade were purchased from Sigma-Aldrich Chemicals. Carbon black and silver were purchased from Dupont de Nemours. PET/ITO films were purchased from Sigma-Aldrich. Polyurethane-coated polyester was provided by Mediama. The specific spacer employed, consisted of 100 % polyester, was prepared in the GEMTEX laboratory of ENSAIT.
As previously described, a sandwich structure is the desired structure for the formation of an electrochromic device. The five-layer structure, developed by Mecerreyes et.al.26 (Fig. 4), has been adapted to prepare the flexible electrochromic device, giving rise to a simplified four-layer structure (Fig. 5). Figure 6 outlines the step-by-step preparation of the display. Polyester, pre-coated with polyurethane to provide a waterproof surface, was used as the textile substrate. The first conductive layer typically used is carbon black or silver. Prussian blue, $K_4[Fe(CN)_6]$, has been selected as the electrochromic compound for the prototype due to its availability and its ease of synthesis via electrochemical reaction. The preparation includes combining two precursors, namely $FeCl_3.6H_2O$ (10 cm^{-3}, 0.05 $mol.dm^{-3}$) and $K_3Fe(CN)_6$ (10 cm^{-3}, 0.05 $mol.dm^{-3}$). An oxidation-reduction reaction ensues and $K_4[Fe(CN)_6]$ is formed. The colour of the $K_4[Fe(CN)_6]$ solution is orange-red. When the solution is introduced to the white spacer fabric, the fabric becomes orange-yellow in colour. The

thickness of the spacer can be set between 0.5 mm and 1 mm. The device is sealed by joining the upper electrode (transparent and flexible PET/ITO) to the textile substrate using neoprene glue. A 4.5 V power supply is utilised to initiate the redox cycling of the electrochromic material.
To characterize the colour change, a spectrophotometer by Data Color International, Spectraflash SF600 Plus, was employed, and L*, a*, b* co-ordinates obtained. To compare results, the CIELab colour space was implemented (Fig. 7).

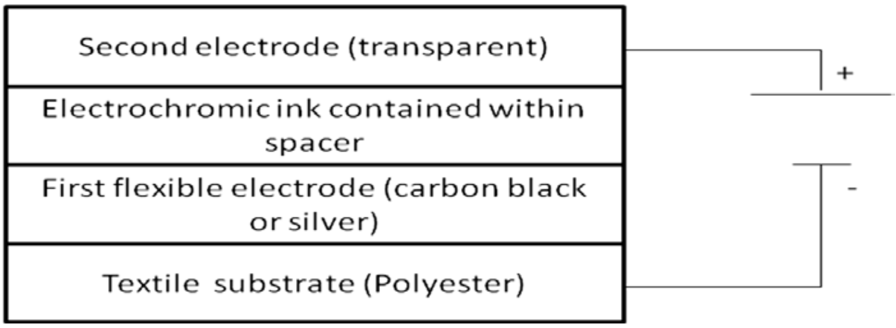

Figure 5. Four-layer sandwich structure of the flexible electrochromic display prototype

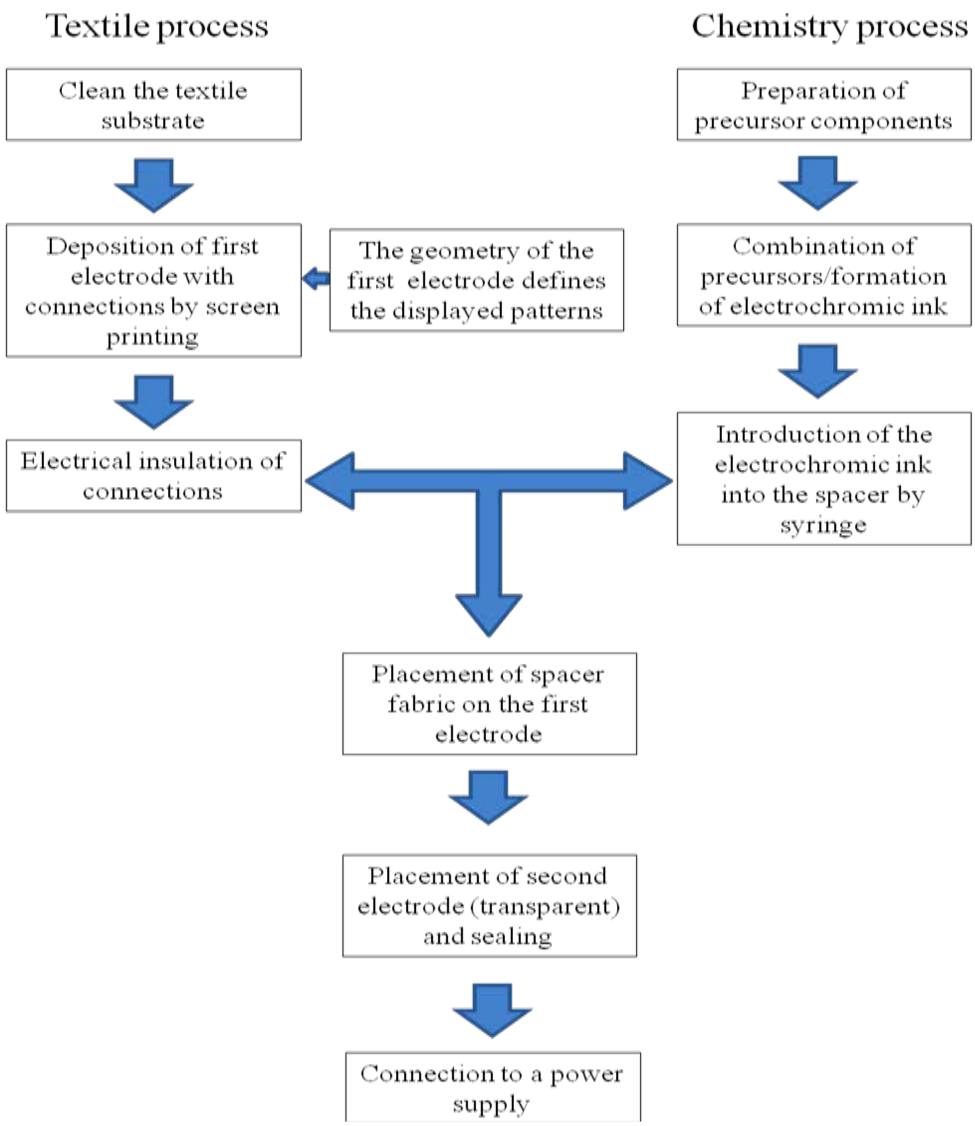

Figure 6. Steps for flexible display preparation

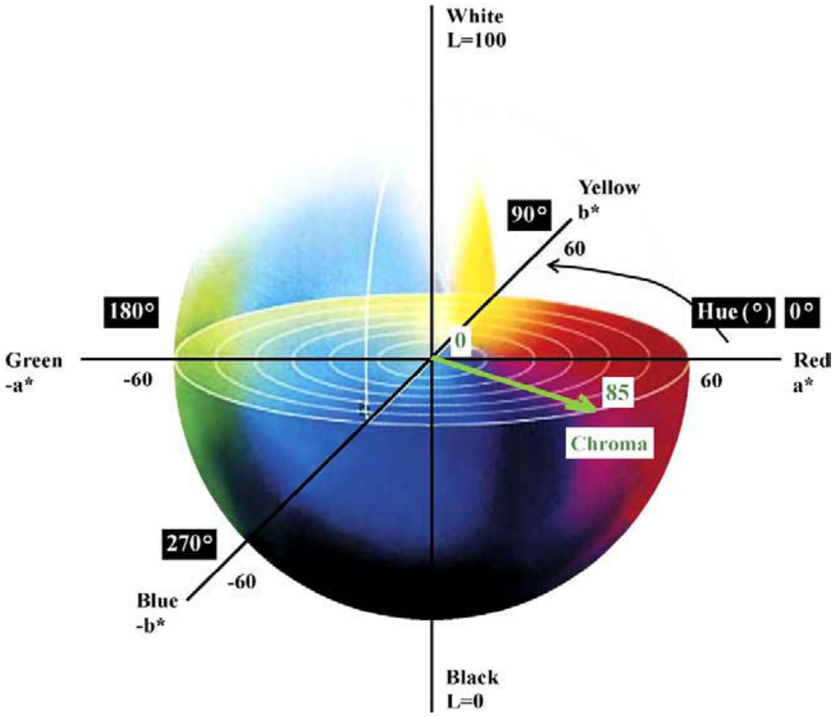

Figure 7. CIELab colour space

3. RESULTS AND DISCUSSION

The flexible electrochromic display developed is a four-layer sandwich structure (Fig. 5). The flexible textile substrate employed, and the first layer of the device, is a polyurethane coated polyester fabric. Deposited on this fabric, via screen printing, is the first flexible electrode of carbon black or silver. The third layer consists of the electrochromic ink (Prussian blue), dispersed within a spacer fabric. The second electrode (PET/ITO) and final layer of the device is transparent, so that the colour-switching of the electrochromic ink may be observed, and completes the device as the fourth layer. On sealing of the device, the PET/ITO layer also acts in protecting the electrochromic material from the atmosphere and thus slows the oxidation process. The solution of Prussian blue employed is both electrochromic ink and electrolyte. As it is in liquid form, it is mobile within the spacer. For this reason the two electrochromic layers, divided by an electrolyte, that are present in the five-layer device developed by Mecerreyes et.al. [26] (Fig. 4), may be combined and the structure can be simplified to the proposed four-layer structure.

Following the successful construction of a flexible electrochromic device in the shape of the letter X (Figs 8 and 9), an electrical current was applied. A colour change from orange/yellow (Fig. 8a) to blue (Fig. 8b) is observed in less than one minute. The CIE L*, a*, b* results, characterising the change in colour, are provided in Table 1. Of particular interest is the measured b* coordinates, as these values describe the colour hue of the material between pure yellow (90°) and pure blue (270°). Before an electrical current was pulsed through the flexible display the X was yellow/orange, confirmed by a measured b* value of 68.86°. The consequent change in colour to blue after the passage of electricity is noted from the b* value changing to 243.84°.

(a) (b)

Figure 8. The flexible electrochromic device (a) before and (b) after an electrical current has been applied

Prussian blue is widely used in ECDs, either as the sole electrochrome or as an auxiliary electrode3, [31-34]. However, in the literature they are typically applied in the form of solid films or solutions on a rigid electrode and substrate. Retention of a solid film or solution of Prussian blue on a flexible substrate is a very difficult task, due to the movement of the fabric. Thus, dispersing a liquid Prussian blue suspension in a spacer fabric is a novel idea. However, a number of challenges exist when using a solution phase electrochromic material in a flexible display. Due to the nature of the spacer fabric and the EC compound being a solution, the exact volume required by the spacer is difficult to determine. Additionally, when pressure is applied to seal the device, retaining the entirety of the dispersed solution within the structure is challenging. In the device discussed above, the Prussian blue solution has a tendency to leak with tilting and flexing of the display. Therefore, adequate sealing of the device by means of selecting the correct adhesive and sufficient contact between upper electrode and substrate is of utmost importance. A complete seal is also required as atmospheric exposure leads to oxidation of the inorganic electrochromic material Prussian blue, hence decreasing the life cycle duration of the device. Neoprene glue was applied to the four-layer device discussed above and it is found to be a valid choice due to its contact properties and flexibility. It takes about 10 min to successfully connect and seal the upper electrode to the lower substrate using the yellow coloured glue. The requirement is there for a ransparent glue with immediate sealing properties. Future tests look towards using a fine line of epoxy resin. Sealing of the device by means of ultrasonic thermowelding is another option. This would essentially create a sealed pixel that could be manipulated in an individual manner.

Alternatively, a solid electrochromic material could replace the Prussian blue suspension within the spacer. Grafting a conducting polymer to the spacer fabric would be a favourable substitute. In comparison to Prussian blue, by using solid conducting polymers, the issues with the loss of electrochromic material during device formation, i.e. leaking of the electrochromic would be removed. Also, conducting polymers, in particular the polythiophene family, are known for their high cycle lifetime. Poly(3,4-ethylenedioxythiophene) or PEDOT, for example, shows no significant loss in performance after more than 5000 cycles26.

Although the colours produced by Prussian blue are limited (either yellow or blue), the use of conjugated polymers in ECDs allows the possibility of developing other desirable colours. Subtle modifications to the monomer in the preparation of the conducting polymer can significantly alter the spectral properties of the material20, and for this reason the conducting polymers have become the most commonly used materials for ECD applications. Polythiophene and the family of polythiophene-derived polymers are a good example of how by tailoring the thiophene monomer, a rainbow of colours can be achieved. Polythiophene is blue in its oxidised state and red in its reduced state. However, by manipulating the monomer a large number of substituted thiophenes have been synthesized, leading to materials varying along a broad spectrum. Figure 10 presents a series of neutral EDOT and B-arylene EDOT electrochromic polymer films on ITO/glass illustrating the range of colors available [35].

Polypyrrole (PPy) and polyaniline (PAni) are two more examples of conducting polymers subject to wide investigation. PAni is polyelectrochromic, showing several colours for the various redox states in which it may exist. The redox states include leucoemeraldine (yellow), emeraldine salt (green), emeraldine base (blue) and pernagraniline (dark purple) [36, 37]. PPy is blue/violet in colour in its oxidized state and yellow when reduced37. As with thiophenes, by altering the monomer prior to polymerization, the colour of the pyrrole-derived polymer can also be manipulated. For example, poly(3,4-ethylenedioxypyrrole) (PEDOP) is pink when reduced and transparent light blue when oxidized. However, because PPy presents lower cycle lifetimes, its use in ECDs, as a reliable medium, is not as common as that for the thiophene family2.

It is proposed to develop a second generation of flexible ECDs. These would be prepared by grafting conducting polymers, such as those listed above, to a spacer fabric in an analogous 4-layer structure to that described. This will remove issues relating to the solution phase and open the door to flexible ECDs capable of showing an array of colours.

Figure 9. Showing the flexible nature of the electrochromic device

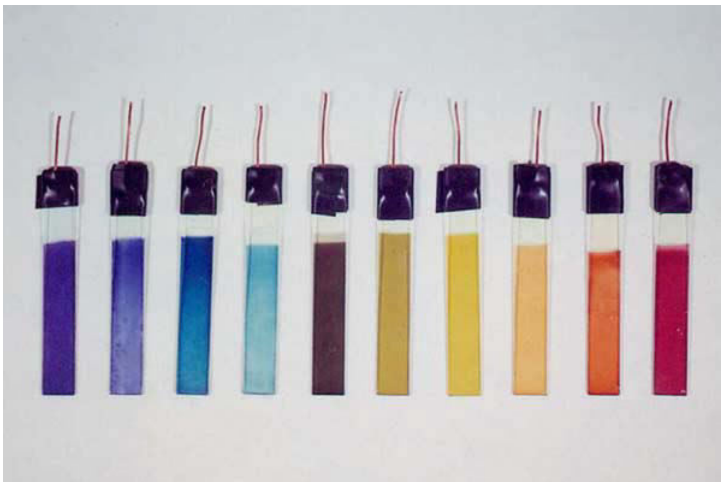

Figure 10. EDOT and B-arylene EDOT electrochromic polymer films on ITO/glass

Table 1 : Characterisation of the colour of electrochomic device, via CIE L*, a*, b* values, before and after application of a current

State	Colour	L* d65/10	a*	b*
Before current	Yellow	64.06°	43.1°	68.86°
After current	Blue	30.12°	36.52°	243.84°

4. CONCLUSION

The structure of a classical electrochromic device and a summary of electrochromic materials have been described. The process of creating an ECD whereby the substrate is a flexible textile is a challenging task, but a first generation device, consisting of four-layers, has been successfully prepared on a t-shirt. The four layers are: a pre-coated textile substrate, the first electrode of carbon black, a Prussian blue solution dispersed within a spacer fabric and finally a second electrode of PET/ITO. The solution phase electrochromic dye has not proved to be the best solution for the preparation of a flexible ECD. However, ways in which the device can be improved, relating to sealing processes have been proposed. The second generation of flexible ECDs will look towards using solid organic conducting polymers, replacing the Prussian blue, so as to overcome the drawbacks of inorganic electrochromics.

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ASSESSMENT OF TURKISH APPAREL RETAIL INDUSTRY WITH PORTER'S DIAMOND MODEL

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Abstract: *Turkish textile and apparel industry had a great contribution on the Turkish economy and growth being a significant player of the global competition. Having such an influential textile and apparel industry and a large population composed of high number of young consumers, the apparel retail industry in Turkey entered a growing phase with an increasing rate of competition. That forced the apparel retail industry to transform its traditional structure and behave in a more organized way. In this study, the competitiveness level of the current apparel retail industry is analyzed using the Porter's Diamond Model. To this aim, first an overview of the apparel retail industry is given with a current structure of the distribution channels, the quantitative data and statistical facts gathered from secondary resources. The information are then organized to form the Porter's diamond which includes the categories entitled with the factor conditions, demand conditions, related and supporting industries and firms strategy, structure and rivalry, the effects of the government and finally the chances for increasing the competitiveness. Finally, the apparel retail industry is given some suggestions for increasing its performance.*

Key words*: Apparel, Retail industry, Porter, Diamond model*

1. INTRODUCTION

Turkey became a significant player for textile and apparel industries in the world. Turkey got the 7th rank in terms of textile export values and 4th rank in terms of apparel export values in 2008 (WTO, 2010, 2009, 2006, 2001). The value of the total textile and apparel exports has become 21,1 billion dollar in 2010, whereas 6,5 billion dollar was belonged to the textile and 14,6 billion dollar was belonged to the apparel industry, causing the textile and apparel industry to be ranked as the top exporting industry (ITKIBa, ITKIBb). The textile and clothing sector has 11 to 12% contribution on the GDP, which constitutes almost 30% of total exports and 12% of total employment of Turkey (Ozben et al, 2004). There are 40,000 companies in the sector, 96% of them are small and medium enterprises and one fourth of them are acting in the export business (Atilgan, 2006).

Although, the textile and apparel industry is export oriented, there is a large consumption within the country itself. Turkey has a large and young population of around 73 million people. Thus, Turkey is a big market which contributes on the growth and expansion of the textile and apparel retail industry.

Retailing; is a set of activities which provides buying necessary product or selling services to meet the personal or family needs of consumers and retail store takes place at the end stage of distribution process (Misirli,2009). Misirli (2009) summarizes the tasks of retailers as : Presenting location utility to consumers; Presenting possession utility to consumers; Presenting time utility to consumers; Presenting products with varieties; Dividing total and large volumes of products separating into small pieces; Maintaining inventory; Presenting support services to consumers and; Sharing information. All these tasks are important for maintaining sustainability in the fast changing economical conditions in which the competitiveness level is required to be evaluated constantly and increased continuously.

A competitive advantage was defined by Berdine et al (2008) as the condition that enables a country or an organization to act in more efficient and quality level than its competitors increasing the benefits. Porter's diamond model established a framework for analyzing why some industries or nation in concern are more competitive that the others and for determining factors of national advantage. This model suggests that the national home base of an organization plays an important role in shaping the success or the failure of the organization on a global scale.

In this study, the newly growing apparel industry is overviewed with a purpose of assessing its level of competitiveness. To this aim, Porter's diamond model is employed including the determination of factor conditions, demand conditions; firm strategy, structure and rivalry; related and supporting industries.

2. LITERATURE REVIEW

Porter's influential study published in The Competitive Advantage of Nations (1990) has undoubtedly enhanced the understanding of competitive advantage (Oz, 2002). Sultan (2007) states that, the competitiveness included more than just macroeconomic issues such as deficit, interest rate and political stability according to Porter.

Oz underlines the Porter's claim that exploring the underlying reasons behind the competitive structure, should be turned to the 'diamond' in order to see how each determinant functions interact with and influence on each other (Oz, 2002). Because, it is not the comparative advantage, factor proportions or technology that determined the competitiveness but the presence or absence of particular attributes instead (Berdine et al, 2008).

There are numerous studies in literature that applied Porter's diamond model in order to measure the level of competitiveness. Berdine et al (2008) measured the competitive advantage of US textile and apparel industry in order to identify current competitive advantages, how they can be leveraged to enhance the performances of the companies, to find out the key components that are driving the competitiveness of the top textile and apparel exporting regions and finally to carry out how these components can be adapted in order to increase global competitiveness. Mann and Byun (2011) applied Porter's diamond model within the purpose of assessing the competitiveness of Indian apparel retail industry and carrying out the opportunities and challenges raised because of the retail trade liberalization. Sultan (2007) used Porter's diamond model to investigate the competitive advantage of small and medium sized enterprises within the case of Jordan's natural stone industry. In the study entitled with Assessing Porter's framework for national advantage: the case of Turkey, Oz (2002) aimed to describe the competitive structure and major sources of competitive advantages of Turkish industry. Jin and Moon (2006) employed two competitiveness models which are Porter's diamond model and generalized double diamond model in order to explore what constitutes a country's competitiveness in the global apparel market after losing its labor competitiveness and the authors made some suggestion to effectively achieve an increase in the competitiveness level. Yilmaz et al (2007) used the Porter's theory of competitive advantage of nations in order to review the competitive advantage of Turkish towel market within the global market. Selwan and Younan (2008) attempted to describe what role the competitive advantage of nations play when the European companies such as H&M and Zara choose to establish in the Middle East with an objective of describing the market strategies.

3. METHOD

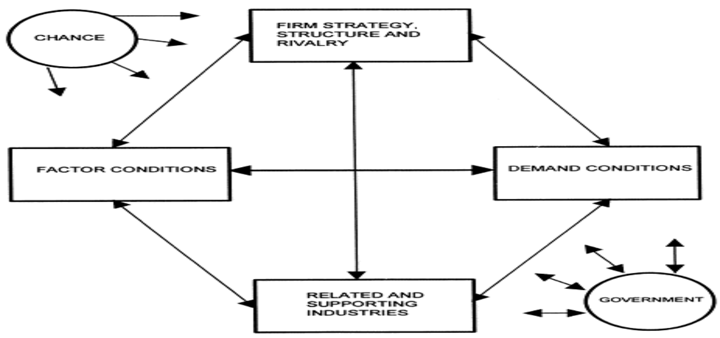

Figure 1. The structure of Porter's Diamond Model

For the study the qualitative data and secondary resources were employed with some common facts and statistical data.

This study was established in 3 parts. In the first part the overview of the apparel retail market was given with some numerical and statistical facts. In the Second part, the components of the Porter's diamond whose structure given in Figure 1, were determined based on facts and previous studies. Finally, some suggestions were made for the apparel industry to improve the competitiveness level.

4. RESULTS

4.1. The overview of Turkish Apparel Retail Industry

According to the data taken from AMPD (Shopping center and retailers association), the retail sector has 22.108.148.419 TL revenue whereas the apparel retail sector covers 2.369.883.648 having around 11% of the total revenue in 2006. In the same report, it is stated that, the selling area of the apparel retailers in terms of square meter is equal to 448.480 m^2 and the share of the number of the stores in total retailers is highest with the percentage of 48,2.

According to the A.T. Kearney Global Retail Development Index 2010, Turkey got the 10th rank with a score of 51,8 composed of 83.8 in market attractiveness (25%); 65,5 in country risk (25%), 45in market saturation (25%), 37 in time pressure (25%) .

4.2. The Competitiveness of the Turkish Apparel Retail Industry

Factor Conditions: Factor conditions are defined as the nation's position in factors of production, such as skilled labor or infrastructure, necessary to compete in a given industry. Factor conditions can be advantageous items that serve to increase the competitiveness levels or the can be disadvantageous items such as workforce shortages.

The employment in the apparel retail sector, comes at the third place within the general retail industy in Turkey with 21282 people and 19% share after the home improvement markets (33%) and supermarkets (29%). The ratio of the women employed in the retail industry is 47% in general and 50,8% in the apparel retail industry. But the only 8,3% of the women are the employers (Turkishtime, 2009). The productivity of the retailing industry was stated to be 75 in 2000 for fast consuming market compared with the India and USA taking the scores of 20 and 103 respectively (McKinsey,&Company, 2003). The main reason for this may be the lower educated personel working in this industry. Although there are some highschools giving vocational education within this field, the number of the educated personel is low or the number of the schools are insufficient.

Demand Conditions: Demand conditions are defined as the nature of home demand for the industry's product and service.

Turkey has a young population of 73639596 according to data taken from Turkish Statistical Institute in 2011 whose distribution within the years, 2000, 2005 and 2010 is given with the expectations for the years 2015 and 2020 in terms of age groups as in Table 1. According to data, the share of the people aged between 15-60, who are expected to consume more than the other age groups, is above 60% in all the years investigated (AMPD,2012).

Table 1 :The population distribution within years

Age	2000	2005	2010	2015	2020
0-14	29,97%	28,44%	26,56%	24,43%	23,19%
15-30	29,26%	27,25%	25,56%	24,84%	24,08%
30-44	20,62%	22,18%	23,61%	24,01%	22,86%
45-60	11,97%	13,48%	15,02%	16,31%	17,98%
60+	8,19%	8,65%	9,25%	10,41%	11,88%

Parallel with these results, the number of consumers visiting the apparel retailer became 63123725 making the apparel retail sector third popular retailer type after malls and supermarkets (AMPD,2012). According to the data taken from Pricewaterhousecoopers (2007), average per capita income in Turkey is around 5000 US dollar and the rate of gross national product growth became 7,4 in the year 2005. Turkish Statistical Institute reports that the expenditure on the shoes and apparel is 110TL in average with a share of 5,2% in total household expenditure of 2120 TL in 2011 (TUIK,2011).

Regarding these data, there is a large potential demand for the apparel retail industry but the consumption on apparel is not as high as expected.

Related and supporting industries: The dimension of related and supporting industries is defined as the presence or absence in the nation of supplier industries and related industries that are internationally competitive.

As stated previously, Turkey has a well developed textile and apparel industry concentrated on the export production. Nonetheless, the companies began to make investments in Turkey realizing the consumption potential. The growth of the retail industry increases the investments on the infrastructure, safety, facility management, logistics, food industry as well. For instance, the banking sector facilitates the payment for the retail industry, according to 2010 December data taken from BKM (Interbank Card Center) 838,45 million TL from the debit cards and 20115,01 million TL from the debit cards were made to companies whereas the clothing and accessorize companies received 122,60 and 1680,43 million TL respectively.

Firm Strategy, structure and rivalry: The dimension of firm strategy, structure and rivalry is defined as the conditions in the nation governing how companies are created, organized and managed as well as the nature of domestic rivalry.

The retailing industry in Turkey includes both the traditional and organized retailing activities. Based on the data from the report of Pricewaterhousecoopers, although the organized retailing activities increased in recent years, its share is still 35 % with total 10000 selling points. One of the important factor shaping the retail industry is the presence of the shopping malls. The number of shopping malls was 99 in 2005, 200 in 2007 and 225 in 2008(Turkishtime, 2009).The increase in the number of shopping malls brings the increase in number of store together. There were averagely 109 stores in 2005; 118 stores in 2006 and 118 stores in 2007 per shopping mall. But, that value was affected from the crises and it became 86 in 2008 (Turkishtime, 2009). In 2009, the retail industry reached a speed of opening 13 stores a day, thus the modern retailing industry invests around 100-120 million dollar per month (Pricewaterhouseccoopers, 2010)

According to data taken from Turkish Time magazine (2009), the organized retailing is still very young for Turkey and the average age of the apparel retail industry became 21 in 2008 whereas 23 in 2007 which meant that the number of apparel retailers are increasing everyday. The increase in the number of stores increases the competition enabling the retailer to get very close revenues.

The companies adepting the modern retailing plans to review the inventory policy and to make necesarry changes required by the human resources educations and customer focused researches and surveys (Turkishtime, 2009). Transformation within the industry increases the employment ratio, efficiency performance thanks to the scale economy, the penetration into the foreign markets and the usage of knowledge in management (Pricewaterhousecoopers,2007). Besides, the effort of presenting high quality garments at lower prices improved the modern trade. The retailers usually focus on the price competition whereas medium and large manufacturers focuses on the brands and featured products.

Chance:

Fashion Goods retailers are counted among the most global of the product groups. According to the Reports of "Global Powers of Retailing 2012" (Deloitte,2012), in 2010, more than three quarters of the fashion goods retailer operated outside their home country and served the customers of 19,3 countries in an average receiving a larger shares of sales from the foreign operations which is 27,7% than the other product sectors such as fast moving cunsumer goods and hardlines &Leisure goods. In the same report, Turkey was counted among the emerging markets like India, Brazil, Indonesia, the Andean region of South America and much of Sub-Saharan Africa with the possibility of growth and new opportunities for the leading retailers. This situation influenced the investments made in Turkey. While the foreign investment decrease 14% in 2009 compared to 2008; the direct foreign investment increased 12% within the same period (Pricewaterhousecoopers, 2010).

Technology brings many opportunies in way of doing business. The young population having the interest of fashion and technology makes the retailing industry more modernized and dynamic and inspires the foreign investments(Pricewaterhousecoopers, 2010). In Turkey, the number of Internet Users in Turkey increased from 293000 to 14000000 between the years 1998 and 2005 whereas the internet use ratio was over 80% for the young professional people (Nikbay,2006). The retail industry should renew itself as the consumers are especially GenY consumers instead of Babyboomers who will interact with the retailers as never established before via the internet Access and Networks(Pricewaterhousecoopers, 2010).

Government:

The government prepares to make a legal arrangement fort he shopping center which are the mst important distribution channels fort he retailers (Dunyagazetesi, 2012). Besides, the government support the local investors for establishment of the shopping centers in order to enhance the brand activities

Some Suggestions:

Considering the Porter's diamond, the strength of the Apparel industry lies beneath its chance of having well developed textile and apparel industry and having high number of young consumers. Within this case, the industry is strongly suggested to focus on increasing its knowledge about its customers analyzing their shopping behaviors. Besides, it the industry should improve the education level of its workers in order to increase the productivity and better servet he customers who are more technology focused and eager for being interactive in the marketing environment thanks to the increasing internet usage.

5. CONCLUSION

This study analyzed the competitiveness level apparel retail industry benefiting the systematic analyzing nature of the Porter's diamond model and identifying the factor and demand conditions, firms' strategy, structure and rivalry and the interactions or the influences from the related and supporting industries considering the chances and government factor.

It was found out that there are many opportunities for the newly developing apparel retail industry in Turkey in case that modern retailing is activated and the technology is employed. Within this context, the study provided an initial point for determination of the competitiveness. The analyzes can be more detailed for the future studies with a comparison with the well developed retail markets in the other countries in order to take their activities as references for improvements.

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APPLICATION OF EXTERNAL BENCHMARKING FOR AN APPAREL RETAIL COMPANY

Canan SARICAM, Fatma KALAOGLU, Gulsum CAKICI, Gulcin BAYSAL

Abstract: *Business success in a competitive environment lies beneath the capability of the identification of the customer requirements, understanding the strengths of the competitors' applications and the discovery of the accomplishments which best serve the meeting of customer requirements. Benchmarking is a valuable tool for the companies to assess their image and position in regard of their customers. It allows determining the strength and weaknesses, the comparative advantages of the competitors and provides alternative ways to overcome the problems by enabling the companies to reach the best practices. In this study, the external benchmarking study was explained with an application in a Turkish apparel retailer company using the quality function deployment technique. To this aim, a survey was conducted in a sample composed of 50 young working women and they were required to rank the company in terms of meeting 20 customer requirements grouped under 5 major titles considering the other apparel retail companies which are mainly the foreign brands having the same customer profile with the company. The customer requirements were matched with the technical procedures required for running the retail company and the evaluations were established in order to position the Turkish company among the foreigners and to determine the problematic areas providing the key solution points.*

Key words*: External, Benchmarking, Apparel, Retailer*

1. INTRODUCTION

Global competitiveness is increasing everyday in textile and apparel trade. Serving customers' changing needs and requirements is a challenging issue in a fast fashion environment. They demand from the products to be stylistic, fashionable, and comfortable as well as having identity and providing image for themselves. Besides, the technology influenced the customers' demands in both ways. On one hand, they deserve the products to be made of technological and well qualified materials; they require to be interactively shopping in the market on the other hand. The technology reshaped the lifestyles enabling an easy access all over the world and increasing the consciousness of the customers socially, economically and environmentally via the internet usage and globalization. Internet access increased the availability of the products, expanded the variability, and improved the price knowledge and awareness.

The changes of the customer requirements and needs as described above put a high pressure on the suppliers, manufacturers and the retailer at the end. All the stakeholders in textile and apparel business were forced to better understand the customer requirements and well serve to meet these demands. They even have to be better forecasters in order to anticipate the demands before they were voiced or put into words. Moreover, they have to achieve all these, at the lowest cost they could. Because, globalization followed by the trade liberalization opened the doors for all the countries creating one common market instead of regional existing markets.

Within this regard, the companies acting in the textile and apparel market should be more competitive than before. They should continuously inspect their competitors. They should pay careful attention in order to position themselves among the competitors and give effort in discovering the strengths and weaknesses.

Besides, the companies should continuously benchmark themselves with their competitors. Not just because of the following trends but also for discovering the points the competitors are successful in. With a benchmarking process, the companies can analyze the factors beneath their competitors' success and relate this success with the procedure they applied. They can find alternative solutions for the same or similar problems. It is only in this case that the successful accomplishment can be discovered, modified and adopted. Thus, the benchmarking activities are very important for the companies that are eager to maintain their sustainability and increase the profitability.

Nonetheless, the benefits of the benchmarking applications can be increased if a useful tool is applied as a framework for the benchmarking application. And the structure of quality function deployment well suits for the integrating the customer requirements with the precautions that should be taken with the usage of the relations matrix.

In this study, the application of the external benchmarking process is explained with a given case for a Turkish apparel retailer company using the quality function deployment technique. The relationship matrix of the quality function deployment technique is benefited for the matching of the customer requirements with the technical procedures. The company in the concern is positioned among the competitors that are generally the foreign companies and the company specific reasons are given for the weaknesses and strengths.

2. LITERATURE REVIEW

The definition of the benchmarking is given by Drew (1997) as “the art of finding out in a perfectly legal and above board way, how others do something beter than you do - so you can imitate and perhaps improve upon their techniques”. Tezel defines benchmarking as a continuous process of measuring products, services and practices against the challenging competitors or industry leaders (Tezel, 2007). According to Gonzalez et al (2008) benchmarking is a process of comparison of some measure of actual performance against a reference and the performance of the benchmark in which the aspect of the performance may be efficiency productivity or quality. Fernandez et al (2001) describes the benchmarking as a learning and understanding process. Min and Min (1996) claim that benchmarking is continuous quality improvement process for an organization that desires to assess its internal strengths and weaknesses and it allows discovering the comparative advantages of the competitors and best practices in the industry (Min and Min, 1996).

There are mainly three types of benchmarking process which are internal, external and best practice respectively (Cocks, 2012). The internal benchmarking process is comparing between the groups or units within the same organization whereas external benchmarking deals with the comparison of the key metrics against competitors in the same industry. Finally the best practice is related with the comparison against the best that can be found world-wide even from the different industry.

The main goals of the benchmarking are given by the Furey (1987) as: identification of the key performance measures for business operations, evaluation of the one’s own internal performance level, comparison of the performance levels and identifications of the fields providing comparative advantages, implementation of the programs to narrow the performance gaps between the competitors and the company itself. The advantages of the benchmarking is given by: its ability to draw on the existing knowledge and tools for strategic planning, competitive analysis, process analysis and improvement, team building, data collection and organizational development (Fernandez et al,2001). It is also pointed out by the Daniels (1996) that, when the benchmarking process is linked with the strategic planning framework, it improves the quality, productivity and customer satisfaction.

The benchmarking process is claimed to have the capability of increasing the customer satisfaction level when used in conjunction with the quality function deployment technique (Kumar et al, 2006). There are various studies in the literature in which these two method was combined with each other in different fields such as spare parts logistic (Pfohl et at, 1999), telecommunications (Sanson and Singer, 1993), white goods (Tezel, 2007), education (Cohen,2007).

3. METHOD

The study was established for an apparel retailer company which has three brands, one of which has the customer profile of young educated working women.

The procedure was established in three steps. First of all, technical procedures executed in an apparel retailer company were determined and the customer requirements were listed subsequently working with a focus group from the company. Secondly, using the relationship matrix of the house of quality in quality function deployment technique, the descriptions for both the technical and customer requirements were purified by eliminating any type of collapses. In this way, 19 customer requirements were corresponded with 20 technical procedures. In the final step, a questionnaire was established among 50 young educated working women and the participants were required to evaluate the company's performance against the closest competitors in terms of satisfying the requirements established using the 5 points likert scale.

The findings were assessed to determine the strong and weak points of the company with some suggestions to the company to improve its situation.

4. RESULTS

Working with a focus group, the technical procedures established in the company were listed as in Table 1. A care was given in case that each technical procedure followed a sequence in the establishment of retailing business and was separated exactly from the others.

Table 1: *The descriptions for the technical procedures*

TP1: Price determination	TP11: Identification of trends in season models
TP2: Cost evaluation	TP12: Identification of trends in season colors
TP3: Production pursuit	TP13: Preparation of body sizes
TP4: Raw material endorsement	TP14: Preparation of patterns
TP5: In line quality control	TP15: Planning for collection number
TP6: Inspection	TP16: Shipping plan between warehouse and store
TP7: Shipment	TP17: Product planning
TP8: Competative analyses	TP18: Promotion planning
TP9: Sales period collection preparation	TP19: After sales servies planning
TP10: Preparation of combines for catalogs	TP20: Window design

In parallel with these, the customer requirements from an apparel retailer company were listed based on the past experiences and experts' opinions. The descriptions of the customer requirements were reviewed and any collapse within the descriptions was eliminated in the selection of the accurate definitions. Besides, the customer requirements were grouped under categories such as performance, price, time, fashion design variability and service. Finally, the customer requirements were matched with the technical procedures in case that a direct relation could be established with the answers given by the participants and the capability of the company in terms of application of these technical procedures. Table 2 depicts the relationship between the technical procedures and the customer requirements whose definitions were given in Table 3.

In Table 2, each customer requirement was seen to correspond with at least one technical procedure. Nonetheless, 8 customer requirements were matched with only 1 technical procedure whereas 5 customer requirements were matched with 3 technical procedures. This meant that some customer requirements such as durability, color fastness, prints and accessorizes' quality and price attractiveness required the well establishment of many procedures.

Table 2: *The relation matrix between the technical procedures and the customer requirements*

Customer requirement	TP1	TP2	TP3	TP4	TP5	TP6	TP7	TP8	TP9	TP10	TP11	TP12	TP13	TP14	TP15	TP16	TP17	TP18	TP19	TP20
CR1				x	x	x														
CR2				x	x	x														
CR3				x	x	x														
CR4	x	x																		
CR5	x							x	x											
CR6	x								x											
CR7																		x		
CR8																x				
CR9			x				x													
CR10													x							
CR11														x						
CR12											x				x		x			
CR13												x								
CR14											x	x								
CR15															x					
CR16										x						x				
CR17													x							
CR18										x										x
CR19																			x	

After the relationships were established with the technical procedures, a questionnaire composed of 19 questions where each question corresponded to a customer requirement was prepared and the participants assessed the performance of the company in satisfying these demands using the 5 point likert scale. The scores obtained were summarized in Table 3.

According to Table 3, the company obtained scores between 2 and 4 which meant that, it satisfied the customer requirements at a medium level compared with its competitors.

The highest score obtained became the "credibility of the catalog infos" which was followed by "Return of changeover after sales" and "discount price interval appropriateness". Thus the highest scores belonged to the customer requirements grouped under the service category.

The lowest scores on the other hand, were obtained in terms of "Promotional activities", "Colour fastness" and the "Correct settlement of the products and accurate combines". As each weak point belonged to different category of customer requirements, nothing could be said that about the weakness of the customer satisfaction. Nonetheless, when the averages and the standard deviation were evaluated for the customer requirements under each category it was seen that the lowest average score belonged to the category performance followed by the category Time. This explained that the company was regarded to be producing at lower quality and launching the products in longer periods than it was supposed to be. The service category, on the other hand, got the highest average score that was equal to 3,24. The category "Fashion, design and variability" followed that category. That category also reported the lowest standard deviation in terms of scores which were all above 3 enabling to think that the customers trusted the company's stability within the category in concern.

Table 3: *The scores obtained by the external benchmarking process*

Groups	Customer requirements	Scores
Performance	CR1:Durability	2,97
	CR2:Colour fastness	2,64
	CR3:Print and accessorizes quality	3,02
Price	CR4:Quality-price balance	3,13
	CR5:Price attractiveness	3,18
	CR6:Discount price interval appropriateness	3,56
	CR7:Promotional activities qualification (buy 2 pay 1,etc)	2,56
Time	CR8:Shipment to store on demand	3,13
	CR9:Availability of brandnew product at the beginning of the seasons	2,95
Fashion-design-variability	CR10:Fitness of patterns	3,19
	CR11:Fitness of patterns sizes	3,18
	CR12:Style options variety	3,13
	CR13:Color options variety	3,35
	CR14:Harmony with fashion and trends	3,26
	CR15:Annual divergences in collection	3,08
Service	CR16:Accessibility to catalog producs at store	2,98
	CR17:Credibility of catalog infos	3,67
	CR18:Correct settlement of products and accurate combines	2,74
	CR19:Return or changeover after sales	3,59

When the scores obtained were evaluated with Table 2 that depicts the relationship between the technical procedures and the customer requirements, the company was found to achieve well in "Price determination", "Sales period collection preparation", "Preparation of body sizes" and "Shipping plan between warehouse and store". On the other hand, it needed some improvements with the technical procedures that were "Raw material endorsement", "In line quality control", "Inspection", "Preparation of combines for catalogs" and "Promotion planning". In this context, the company was found to be in the need of improvement of its quality control activities by increasing the final product quality in the end. Besides, it should develop alternative ways to present and promote its products in a way that more attractive combinations can be created in order to increase the network effect.

5. CONCLUSION

That study provided a framework for establishment of external benchmarking for an apparel retailer. In the end of the study, the strong and the weak points of the company were determined and it enabled the company to position the company itself among the competitors.

The originality of the framework lied beneath its ability to directly link the feedback from the customers with the technical procedures established in the company thanks to the usage of the relation matrix within the quality function deployment technique.

The framework can be benefited more if the importance given by the customers to these requirements. In this way, it can be possible to determine the prior issues for getting an immediate impact.

Besides, the performance scores can be evaluated for each competitor separately if all the competitors are willing to share their experiences and best practices.

Nonetheless, the study showed the advantages of the application of the external benchmarking process and the usage of systematic procedure in benchmarking in conjunction with the quality function deployment technique. With the external benchmarking process, the companies can easily evaluate their performance, find the possible solution and solve their problems by adopting the best practices applied by their competitor or benchmarks.

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ASSESSMENT OF THE INFLUENCE OF BRAND POSITIONING IN PRIVATE SHOPPING APPAREL INDUSTRY

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Abstract: *Internet shopping had an incredible growth in recent years enabling the private shopping sites increase in number and gain popularity. For the apparel industry, brand name and brand positioning has an impact on the customer preferences whereas the age group has a substantial importance on private purchasing behavior. In this study, the influence of the brand positioning on the private shopping behavior was investigated. To this aim, 12 Turkish casual wear brands and 3 product types were grouped under three segments of brands which were specified as low price-no name, middle price–known, high price-well known. The data was collected for a specific period of time from one of the top three apparel B2C e-commerce website with over 2,5 million customers in different age groups. The sales performance both in quantity and revenue and the campaign frequency of the select product types and brands were evaluated using statistical data. The results revealed that the pool formed of less priced-less known and high price-well known brands were in a competition. Nonetheless, both less price-less known and high price-well known brands were favored by the new generation which was explained as the internet use habit that intensified in the age groups of 18-24 and caused the age group of 26-34 to become main customers with the main internet shopping interest for today.*

Key words: *E-commerce, brand positioning, private shopping, apparel industry*

1. INTRODUCTION

The electronic commerce market which is buying and selling activities of information, products and services via computer networks, was founded in the late 1990s in parallel with the usage of the internet (Yen and Ng, 2003). Although apparel was stated to be purchased at the least as the consumers did not have the capability of evaluating the quality of the products online, internet sales in apparel continued to increase over the past years (Kwon and Lee, 2003) increasing the competition for the companies acting in ecommerce arena. Park and Stoel (2005) reports that, US apparel sales online during 2002 holiday season increased 35 % over 2000; online sales in Europe were gaining even faster than in the US enabling the apparel sales to have filled up more than 25 percent online shopping cart in the UK, Canada and Australia (Park and Stoel,2005). More than half of online retailers (56 percent) reported profitable results for 2001, an increase from 43 percent in 2000 (Jang and Burns, 2004).

The internet usage ratio is higher for the young and educated people and more internet sales are made to Gen Y generation as stated by Sullivan and Heltmeyer (2008). Hence, according to the data taken from 2005 Turkey Internet Report of TIMNET Internet Media Marketing, the number of Internet Users in Turkey increased from 293000 to 14000000 between the years 1998 and 2005 whereas the internet use ratio was over 80% for the young professional people (Nikbay,2006) which can be explained by the preferences of Gen Y consumers.

According to report of Retail Renaissance, 8 consumers among 10 consumers are searching via internet before doing the shopping whereas 42% of the consumers do the online shopping. This is because of the advantages provided by the ecommerce. In the mentioned report, the consumers stated the advantages of online shopping as the ease of use, the ability of keeping track of the other users, transparent pricing, infinite choices. Besides, online shopping offers the customers, price competition, customization of products, expanded information on goods and services, increased choice of products, and greater shopping convenience such as decreased time spent on shopping, flexibility in shopping time, saving the physical effort of visiting stores, search effort and impulsive buying behavior (Nikbay, 2006). Within the respect of the companies, e-procurement increases the control and flexibility within the cost savings, and present the suppliers the easiness of being more proactive while they are doing business(Yen and Ng, 2003). Regarding the advantages, the internet shopping is expected to grow at a faster pace.

Nonetheless, the are some risks and drawbacks within the usage of online shopping such as privacy protection, online payment security, trustworhtiness of internet retailers and the intangible nature of online shopping. The latter factor is very important for the apparel products' online sales as it states the customer's inability to touch, feel and handle the items to be purchased. Besides these, the online apparel shoppers have many concerns about the sizes, fit and quality characteristics of the products. That problems orient the consumer to purchase specific type of products and to prefer common brands. Therefore, it is critical to understand the influence of brand positioning in private shopping considering the product type and the relation of it with the age groups.

The purpose of this study is to investigate the influence of the brand positioning in the private shopping for the apparel products. To this aim, the statistical data from a well known private shopping company was analysed for different brand groups and common product types considering the purchasing preferences of different age groups.

2. LITERATURE REVIEW

According the report of Textile Consumer (1999) that there is a non-linear relation between the clothing purchase and the age and the middle aged consumers spending more on clothing that the younger and the older consumer. Sullivan and Heitmeyer (2008) investigated the shopping preferences and intentions of Gen Y who are the consumers between 14 and 31 years old in 2008 and expected to consume more than the previous generations. Gen Y is defined to be the technologically advanced, entertainment driven and shop online. Their use of internet is 15% of their spending whereas males' spending is 1.7 times of female's spending.

An important aspect of a brand'sposition in product category is how similar or different the brand is perceived to be in comparison with other brands in the product category (Sujan and Bettman, 1989).
Park and Stoel (2005) investigated the effect of brand familiarity that can be defined as the number of brand related direct or indirect experienceof the consumer, experience and information on online apparel purchase. The consumers were stated to purchase products from the web sites of the well known names and brands whose shopping formatsa re known (Park and Stoel, 2005). Citing Kent and Allen (1994), Park and Stoel(2005) state that well known brands might achieve beter recall than less familiar brands and they could be protected from competitive advertising interference. Moreover, well known brans might have an advantage of being more liked than less familiar brands (Colombo and Morrison, 1989).According to Park and Stoel, the internet purchasers might use a brand as a core internal source of information for judging and evaluating the quality of the apparel sold on the internet.

3. METHOD

One of three major e-commerce sites in the ready to wear private shopping sector was conducted for this study. The selected private shopping company is about 1.5 years old with a total of 2,6 million current customers, 62% women and 38% men.

For the study, three group of categories, each consisting of four brands, were selected based on average unit price levels and brand acquiantance. Three product groups were compared among the selected brands to analyze the customer tendency in private shopping. Product group 1 consisted of top pieces; product group 2 consisted of bottom pieces and product group 3 consisted of other products like full pieces (dresses, suits) and all sort of accessories. The age segments were determined to be the same with the general customer portfolio of the selected e-commerce company. As the current customer age group in general for this website in percentage was as 7,5% for age 0-17, 30% for age 18-24, 23% for age 25-29, 17% for age 30-34, 11% for age 35-39, 6% for age 40-44, 3% for age 45-49, 1,5% for age 50-54 and %1 for age 55+, the age groups were taken as 0-17; 18-24; 25-29; 30-34;35-39; 40-44;45+.

The results were established in three parts which investigates the effect of product groups on sales; the effect of the age groups on the sales performance and the sales performance in revenue and quantity regarding the brand groups.

4. RESULTS

In this study, the data for 12 brands were investigated for whom the number of campaigns, average campaign price in Turkish Liras (TL), average sales quantity, total quantity and total revenue in TL were listed for the period between 1st of March and 15th of July 2012 as in Table 1. The grouping process was established considering the average unit price levels and brand acquaintance.

Table 1: Brand Sales Figures for 12 brands between 1st of March-15th of July

Category	Brand Name	Number of Campaigns	Average Campaign Price-TL	Average Sales Quantity	Total Quantity	Total Revenue-TL
A	A1	9	9,11	266	2.391	21.791
	A2	8	9,51	477	3.815	36.263
	A3	9	9,61	234	2.102	20.204
	A4	6	19,35	295	1.771	34.266
B	B1	5	29,01	125	623	18.075
	B2	7	30,89	329	2.300	71.042
	B3	10	33,40	70	700	23.377
	B4	8	35,35	316	2.530	89.425
C	C1	13	56,93	888	11.538	656.906
	C2	37	57,69	371	13.726	791.833
	C3	9	62,89	167	1.500	94.342
	C4	13	80,42	712	9.251	743.991

Within this regard, three groups of brands were established as Category A, B and C that corresponded to LowPrice-Less Known, Middle Price-Known, High Price-Well Known respectively. Sales reports reflecting campaign sales figures from Category A consisted of low price (9,11-19,35 TL) these being classed as lesser known; Category B consists of middle price (29,01-35,35 TL) reasonably known and Category C consists of high price (56,93-80,42 TL) well known group of brands. The averages and the cumulative values for each category were summarized in Table 2.

Table 2: Category Sales Figures between 1st of March-15th of July

Category	Status	Average Sales Quantity	Average Campaign Price-TL	Total Quantity	Total Revenue-TL	Campaign Frequency (%)
A	Low Price-Less Known	318	11,90	10.079	112.524	24
B	Middle Price-Known	210	32,16	6.153	201.920	22
C	High Price-Well Known	535	64,48	36.015	2.287.071	54

Assessment of the relationship between the brands and the product groups

Figure 1 shows the distribution of the sales quantities of each product groups and each brands. It was observed that the Category C brands had sales quantities in all product groups whereas the sales of Category A and B brands intensified in some product types. In Table 3, the numerical values for each product type and brands were given.

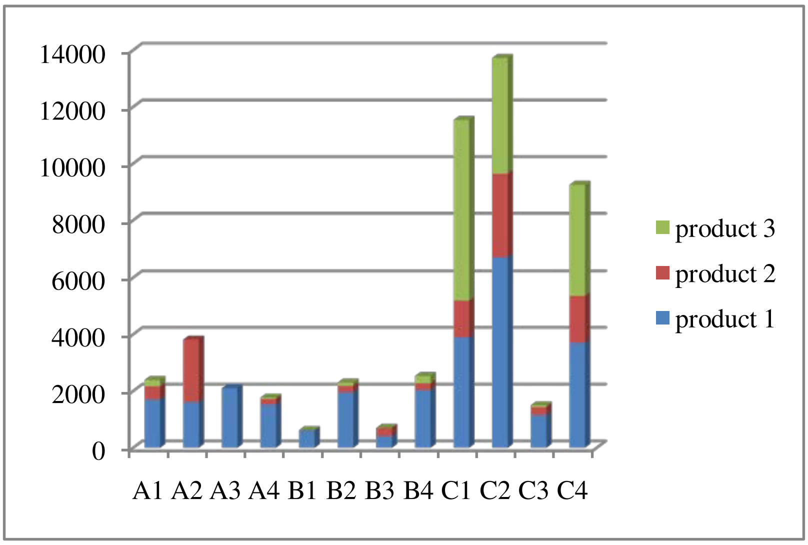


Figure 1: Total Product Group Sales Figures for the Brands

Table 3 and Figure 1 together depicted that the top piece products were generally the main product group in private shopping sales. The reason for the bottom wear product sales being less than the top wear product sales is the risky fit issue. Therefore, the brands should have clear understanding on their own fits for an increased target of product sales as people are expected to make more private shopping.

Table 3: Product Group Sales Figures for the Brands (number of sales quantities)

	A1	A2	A3	A4	B1	B2	B3	B4	C1	C2	C3	C4
product 1	1703	1613	2102	1528	619	1955	406	2031	3889	6717	1146	3701
product 2	468	2202	0	195	4	232	294	244	1303	2928	289	1656
product 3	220	0	0	48	0	113	0	255	6346	4081	65	3894

Nonetheless when the sales figures were evaluated for product 3 category which are full pieces and accessories,highest sales scores belonged to C category brands. This meant that well known brands had the advantage of selling more accessorized products compared to known or lesser known brands. Presently, well known brands can use the advantage of selling more high value added products in private shopping.

Assessment of the relationship between the sales and the age groups

Figure 2 shows the age portfolio of each groups in terms of sales quantities whereas Table 4 gives the numerical values.

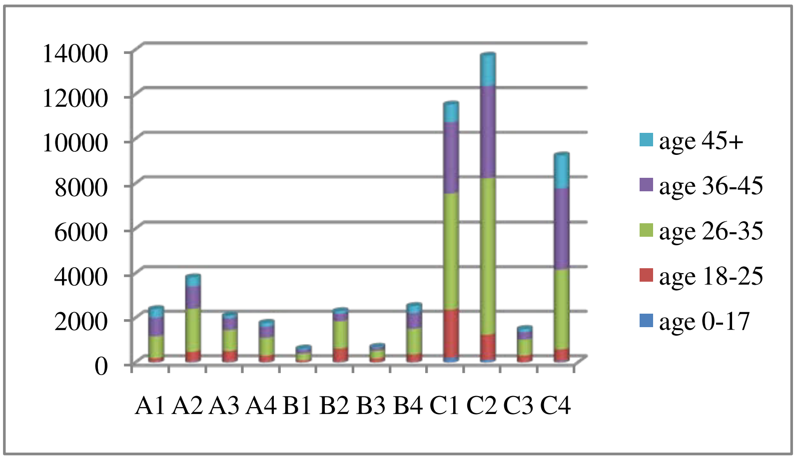


Figure 2. Total Age Group Sales Figures for the Brands

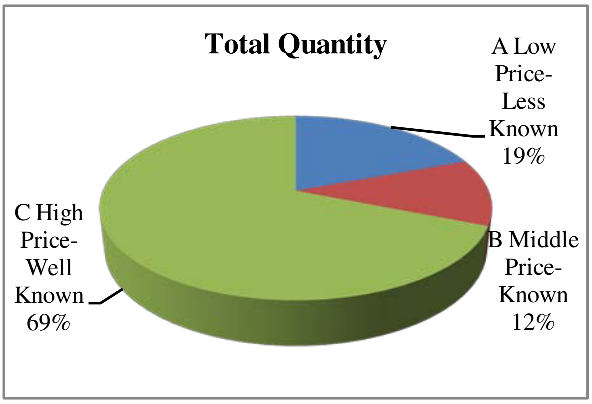
Table 4. Age Group Sales Figures for the Brands (number of sales quantities)

	A1	A2	A3	A4	B1	B2	B3	B4	C1	C2	C3	C4
age 0-17	22	32	29	17	3	24	8	22	201	114	9	50
age 18-25	167	447	479	283	87	595	167	338	2164	1122	294	533
age 26-35	980	1921	939	801	304	1229	344	1144	5178	6992	722	3576
age 36-45	835	1000	530	498	172	338	147	703	3195	4140	332	3614
age 45+	387	415	125	172	57	114	34	323	800	1358	143	1478

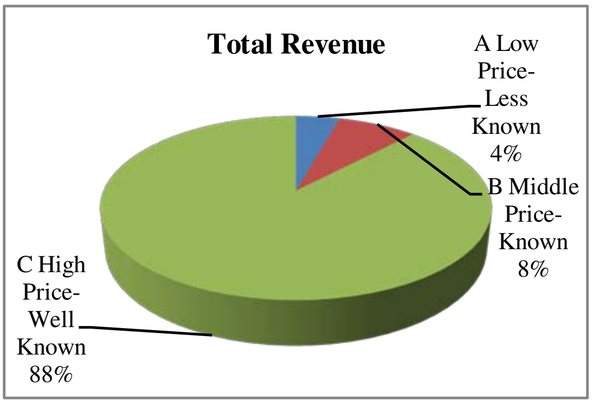
From Table 4 and Figure. 2, the age percentage ranking is the same in descending order which is age 26-35, age 36-45, age 18-25, age 45+ and age 0-17 for all categories. Private shoppers between ages 26-35 are almost 50% for all categories and age 36-45 has the highest sales scores for C category brands compared to other two brand categories. The technology users are more in young ages, but they only have very limited portion in total sales as they are not earning their own money.

Assessment of the relationship between the brand groups and the total sale quantity and revenues

As shown by Figure. 3 (a), the total sales quantity was mainly driven by well known brands (69%), however the lesser known brands had higher sales quantity percentage (19%) compared to known brands (12%). Private shopping offers many advantages for less known brands. The fast access to the customers without any marketing investment is an advantage for them, and if well managed, less known brands would have more the advantage of revenue share than known brands, as presently they already hit the bigger sales quantity compared to known brands.



(a)



(b)

Figure 3. Total Quantity & Total Revenue for Brand Groups

According to Figure. 3 (b), the company's total revenue had the biggest portion of 88% with well known brands, followed by 8% with known brands and 4% with lesser known brands. Table 2 results give one of the main reasons of C category brands making the biggest share which is the company's offering more opportunity with higher number of campaigns to well known brands. The campaign frequency percentage is almost double of the other two categories with 54% as stated in Table 2.

5. CONCLUSION

Private shopping will certainly have an increase with the ease of technology use, easy access to products without spending shopping time or carriage difficulties, and the comparison advantage between products. The day by day increase in sales figures confirms private shopping's big potential. This study provided a framework for establishment of brand positioning in private shopping and benchmarking for these brands.

The originality of the framework lied beneath its accurate, close positioned brands' selection and ability to access and evaluate the actual sales reports. As the amount of available data was high in terms of sales and the data covers diversed range of age groups, the reliability of the data was increased. For a future study, more details can be included regarding the product types and other social and demographic issues can be covered for better detemination of customers' tastes and preferences. Besides, the brands groups can be evaluated for tighter scale average prices and more closely positioned brands.

Nonetheless, the study proved the advantages of evaluating the influence of the brand positioning in private shopping. With this kind of benchmarking, the private shopping companies can easily evaluate the brands' performance for closely positioned brands, see which brand to invest more and find out which brand positions are needed to be fulfilled without any possible revenue loss.

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PRIPERTEIS OF ENZYMATIC HYDROLYSED LYOCELL FABRICS

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Abstract: *Properties of lyocell fibers in twill weave fabrics are studied before and after industrial treatments of mechanical fibrillation in alkaline media and enzymatic defibrillation. Structural properties as fabric weight, warp and weft densities and thickness, mechanical and esthetic properties of each fabric before and after defibrillation were studied and compared. There are no significant changes in the warp and weft densities, colour differences, but a decrease of fabric weight and increase of the thickness was found. Both treatments significantly decreased the fabric tensile strength and stiffness and increased the drape behavior. But as the lyocell fibers have high tensile strength and stiffness in the wet state, the decrease of the tensile strength and stiffness after finishing was tolerant and prevented the crease formation during washing processes.*

Key words: *lyocell, fabrics, cellulases, defibrillation, properties*

1. INTRODUCTION

Tencel Courtaulds-England) or Lyocell (Lenzing AG-Austria) is a cellulosic fiber produced from wool pulp via a novel solvent-spinning process designed to minimize environmental impact. It has a high modulus, leading to low laundering shrinkage, and shows higher strength in both wet and dry states than viscose rayon. Its dry strength is comparable to that of some polyester (Lenz J. et al., 1994). Other qualities of lyocell include excellent drape, stability, dye ability and hand (Carrillo F. et al., 2003).

The structure and properties of lyocell fibers are considerably different from other natural and man-made cellulose fibers. Lyocell fibers exhibit a highly crystalline and amorphous orientation of their elementary fibrils (Lenz J. et al., 1992). This structure of lyocell fibers is the reason for fibrillation when subjected to abrasion in both wet and dry states, and a peculiar tendency to fibrillate, which is particularly interesting to the fashion industry for the special hand effect it produces. When lyocell is suspended in an alkaline solution, and subjected to mechanical abrasion, the so-called irregular primary fibrillation takes place, resulting in the formation of macrofibrils and in a special aged look. Fibrillation consists of the longitudinal disruption of a single fiber into microfibrils, with a diameter of a few microns. Microfibrils obtained through mechanical abrasion are dishomogeneous and produce an undesired pilling effect. In the second step the fabric is treated with an enzymes formulation, and macrofibrils are removed (Lo Nostro P. et al., 2001). Finally, the fabric produces new, shorter, and more homogeneous microfibrils through a uniform secondary fibrillation. This step results in a more precious hand effect (peach skin), in addition to an improved softness.

Cellulases have been applied to improve hand and appearance of cellulosic fabrics (Tanida O. 1994). Multicomponent cellulase products consists of three major types of enzymes: Endogluconases that attacks β-1,4 bonds randomly within the cellulose chains, exogluconases that consecutively remove cellobiose units form free chain ends and β-glucosidases that break these cellobiose up into glucose units. The efficiency of enzymatic hydrolysis of cellulosic fibers using cellulase enzymes is governed by the synergetic actions of these three types of enzymes. Hydrolysis by cellulase involves the adsorption of cellulase protein onto the fiber surface and following breakdown of molecular chains in cellulose. This process is influenced by cellulose properties and working variables such as the enzyme concentration, liquor ratio, treating time and temperature, processing pH and agitation level (Jordanov I. et al., 2001, 2002). The physical form of substrate such as the degree of swelling, the cross-linking of molecules, the existing of various dyes and surfactants, the tightness of the yarn twist, the hairiness of the fabric surface, the fabric structure and the hydrophilic/hydrophobic properties of fabric surface, will affect the adsorption and activity of cellulase on lyocell and in the same time the different degree of interaction (Mangovska B. et al., 1996, 1996). The different degree of interaction will have influence on the degree of reduced dye strength, mechanical, comfort and esthetic properties (Mangovska B. et al., 2010, 2012).

Worldwide, the fashion-related industry is more and more interested in new and versatile fabrics, characterized by specific mechanical and physicochemical properties, for the production of clothing with highly specific properties, such as the so-call “hand effect”, “drape effect”, shrink resistance and so forth.
Staple lyocell fibers are manly used in apparel items such as denim, chino, underwear and other casual wear clothing, even in bath towels. Filament fibers are used in items that have a silkier appearance such as women’s clothing and men’s dress shirts. Lyocell can be blended with a variety of other fibers such as silk, cotton, rayon, polyester, linen, nylon, wool.
In this paper, we reported the effects of two industrial finishing treatments-mechanical fibrillation and enzymatic defibrillation-on the structural, mechanical, esthetic and comfort properties of fabrics made of lyocell and linen/lyocell fibers. Primary fibrillation was done in alkaline conditions by control mechanic action which stimulated the appearance of the fibrils on the fiber surface, as well as some defibrillation during this action. In the second step defibrillation was done, with the cellulases enzymes, which removes the fibrils and clean the fiber surface. At the end refibrillation was done during the drying process in tumbler.

2. EXPERIMENTAL

The experiments were done in V.I.T. Shtip, Macedonia, in the industrial process of fibrillation by mechanical and enzymatic action in rotary drum washer and on Faculty of Technology and Metallurgy in Skopje. Samples 1, 3, 4, and 5 are made of fabrics dyed by continuous process while sample 2 is denim fabric woven of brown dyed warp and black dyed weft with reactive dyes. Sample 2 is desised and fibrillated in the rotary drum washer in the same bath with liquor ratio 15:1 in the presence of 1 g/l crease preventing agent Biavin BPA (Bezema), 1 g/l Kemonecer NI nonionic surfactant (Kemo-Croatia), 1.5 ml/l Aquazym, amylases enzymes at 60^{o}C, during 15 min. The free swelling of Lyocell in alkaline conditions is very high. This means that alkaline treatment can open up even greater internal space within the fabric structure. As the alkaline conditions results in much grater swelling than with water, the potential for fabric shrinkage, stiffness and creasing is increased during this treatment, so it is very important crease preventing agent Biavin BPa to be added in the bath, before the garments made of denim fabric, to prevent crease formation. If crease preventing agent can not be added in the beginning of the process, it is very important to rotate the garments before the agent is added. Samples 1, 3, 4 and 5 are treated only in solution of Na_2CO_3 pH 9.5, 1 g/l Kemonecer NI, 1 g/l in Biavin BPa. After alkaline finishing, fabrics were neutralized with acetic acid solution, following by rinsing with water and fibrillated again in the rotary drum washer in a bath with liquor ratio 15:1 containing 1 g/l Kemonecer NI, 0.7% Cellusoft L cellulases enzymes at pH 4.5 buffered with CH_3COOH/CH_3COONa during 45 to 70 min depending of the fabric construction. If the degree of defibrillation was not succeeded, the defibrillation process was continued. After defibrillation process is finished, to terminate the enzymatic reaction, the fabrics were treated with hot water (80^{o}C) for 10 min and then rinsed twice with warm water (40^{o}C) for 10 min.
After defibrillation process refibrillation was done in the acid bath with silicon softener at 40^{o}C during 15 to 30 min and the fabrics were dried in tumbler as long as the defined effect was not received.
The characteristics of the tested samples are given in the table 1.

Table 1. Characteristics of the tested fabrics made of lyocell fibers

Fabric code	*Composition (%)*	*Weave*	*Thickness (mm)*	*Density (dm^{-1})*		*Fabric weight (g/m^2)*
				warp	*weft*	
1	100 CLY	twill	0.4	280	267	191.0
2	100 CLY	twill	0.4	416	252	201.1
3	100 CLY	twill	0.3	510	310	131.9
4	100 CLY	twill	0.3	510	310	121.3
5	51/49 Linen/CLY	twill	0.4	270	204	241.9

In the experiment following parameters were analyzed:

- Shrinkage during finishing was tested according to MK F2.020.
- Fabric weight was tested according to MKS EN ISO 3801:2011
- Fabric thickness (mm) was tested according to MKS EN ISO 5084:2011on Mesdan LAM
- Warp and weft density (dm^{-1}) were tested according to MKS EN ISO 1049-2011
- Tensile strength (N) was tested according to MKS EN ISO 13934-1:2010 test method on Tinus Olsen (SDLATLAS) using test speed 100 mm/min and gauge length 200 mm.
- Fabric stiffness (N) was measured on in warp and weft direction according ASTM D2646
- Drape behavior expressed as drape coefficient (%) was measured according BS 5058:1973. A measure of fabric drape behavior is expressed via drape coefficient which represents the ratio of surface of draped fabric to the surface of flat fabric and obtains values from 0-100 %. A low drape coefficient indicates easy deformation of a fabric, while high value indicates lesser deformation.
- Abrasion resistance was measured according to MKS EN ISO 12947-2:2010
- Water retention value (%) was tested according to ASTM D 2401-02 on dry processed samples which were allowed to swell in water at room temperature for 2 h before squeezing by padding. After squeezed samples were transferred into tarred weighing bottles and weighed before drying in an air over for 4 h at 105 ºC and reweighed. Water retention value was calculated using the following equation:

$$WRV = \frac{(m_2 - m_1)}{m_1} \cdot 100\ (\%)$$

Were m_2 is the weight of squeezed wet sample and m_1, the weight of dried sample.

- CIE Lab coordinates and Colour differences were measured on X-Rite spectrophotometer with Colour Match colour formulation software v7.0 (D65/10°) and evaluated according to the *CIE Lab* colour coordinates.

3. RESULTS AND DISCUSSION

Structural characteristics of the lyocell and linen/lyocell fabrics before and after finishing are given in table 2.

Tabel 2. Structural characteristics of fabrics made of lyocell and linen/ lyocell before and after finishing

Fabric code	*Description of finishing techniques*	*Shrinkage (%)*		*Thickness (mm)*	*Density (dm^{-1})*		*Fabric Weight (g/m^2)*
		warp	*weft*		*Warp*	*weft*	
1				0.40	280	167	119.0
1ES	Enzyme, silicon	1.6	0	0.47	283.3	266.7	188.0
2				0.40	416	252	201.1
2ES	Enzyme, silicon	2	-3	0.50	420	248	200.3
3				0.30	510	310	131.9
3ES	Enzyme, silicon	-1	-1	0.35	510	310	125.2
4				0.30	510	310	121.3
4ES	Enzyme silicon	-1	-1	0.35	510	310	120.2
5				0.40	270	204	241.9
5ES	Enzyme silicon	2	2	0.47	270	210	223.6

As was previously mention lyocell fibers have high modulus due to the highly crystalline and amorphous orientation of their elementary fibrils leading to low laundering shrinkage. The results from table 2 confirmed the previously mentioned conclusions. Very low shrinkage or even increase in the lengths in warp or weft direction was noticed on the samples 1, 2, 3 and 4. Higher shrinkage was noticed only on the sample 5 composed of linen/lyocell mixture that was expatiated taking in consideration the properties of linen fiber. Weight loss noticed on all samples is attributed to the removal of surface fibrils produced during mechanical fibrillation in alkaline condition and cellulase chain scission followed by extraction of short molecular chains form amorphous region.

Tensile strengths in warp and weft directions are given on figures 1 and 2. The results from the figures 1 and 2 showed on the remarkable decrease of the tensile strengths in both directions. The lost of the tensile strengths in warp direction are 25% on all samples except on sample 2, and 20 to 60% in weft direction. The mechanical difference observed after fibrillation is mostly likely associated with the extensive formation of fibrils along the surface of lyocell fibers, causing macrostructural and morphological changes. In contrast, the enzymatic defibrillation treatment causes microstructural degradation in which the macromolecules of cellulose are directly affected. Cellulase catalytically splits the 1,4-glucosidic bonds, reducing the cellulose polymer chain length. A consequence of this hydrolytic reaction is a significant decrease of the mechanical properties. As lyocell fibers have very high tensile strengths the lost in tensile strengths is acceptable.

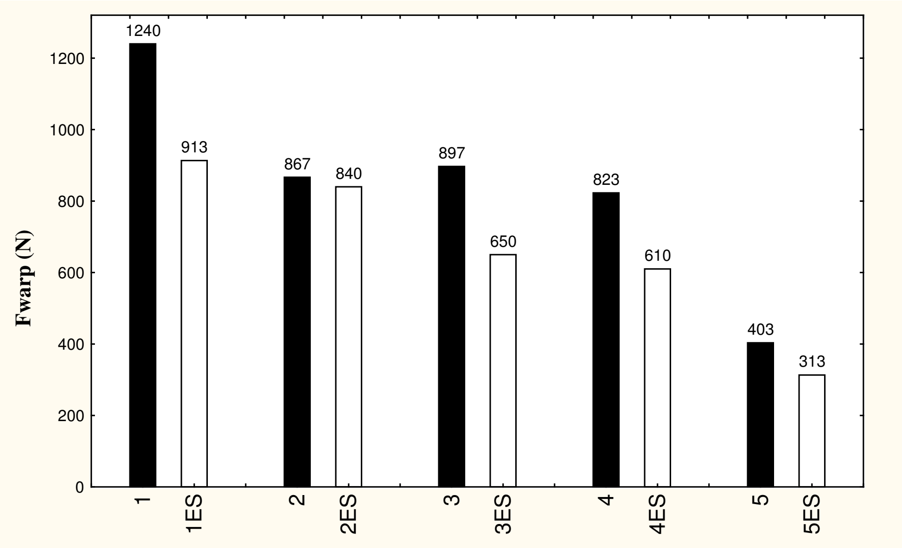

Figure 1. Tensile strength in warp direction of fabrics before and after finishing

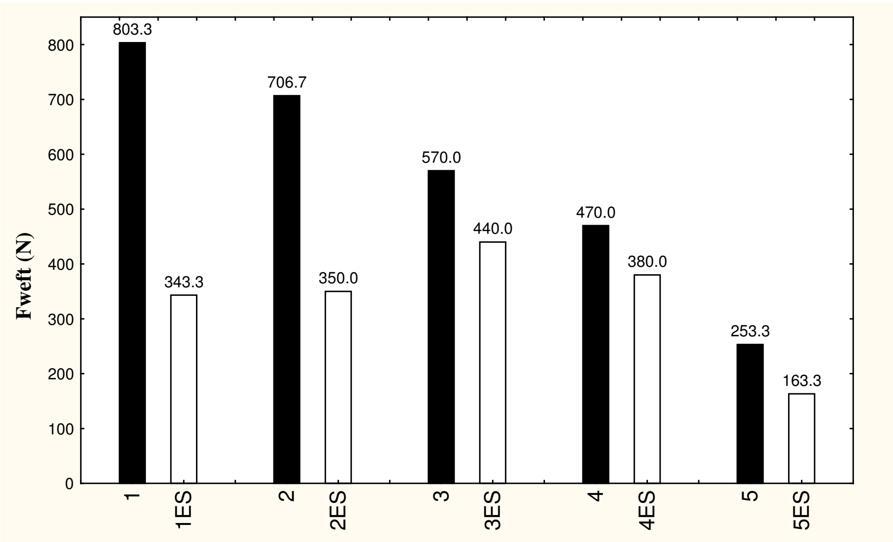

Figure 2. Tensile strength in weft direction of fabrics before and after finishing

With the decrease of the tensile strength in the warp and weft directions decreased the stiffness of the garments and increased the drape behavior as can be seen on figures 3, 4, and 5.

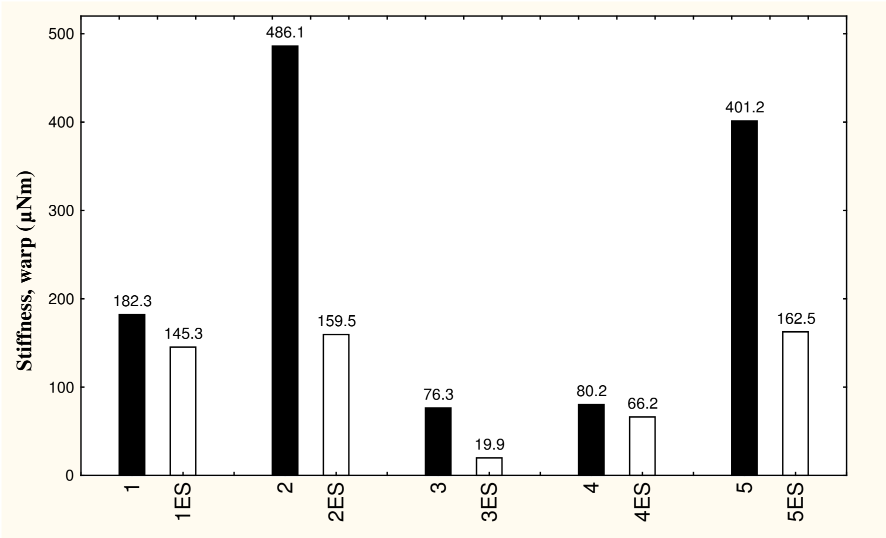

Figure 3. Stiffness in warp direction of fabrics before and after finishing

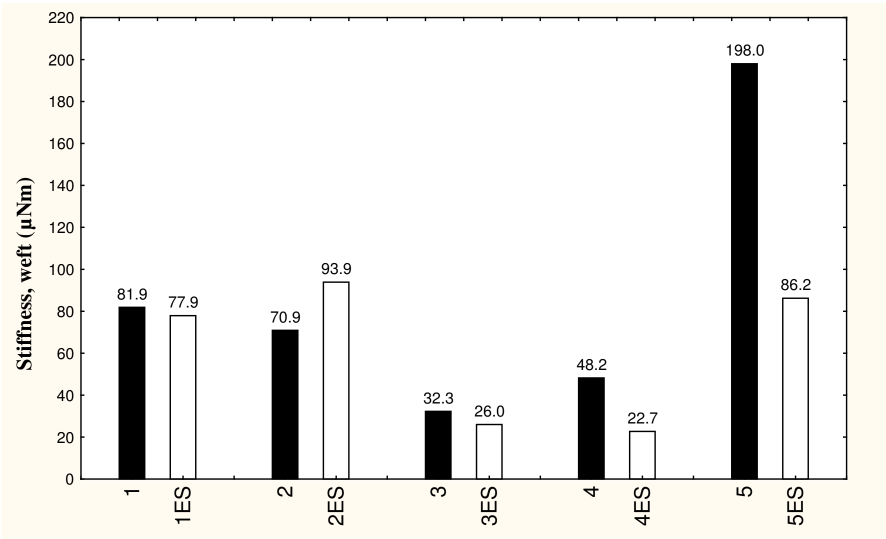

Figure 4. Stiffness in weft direction of fabrics before and after finishing

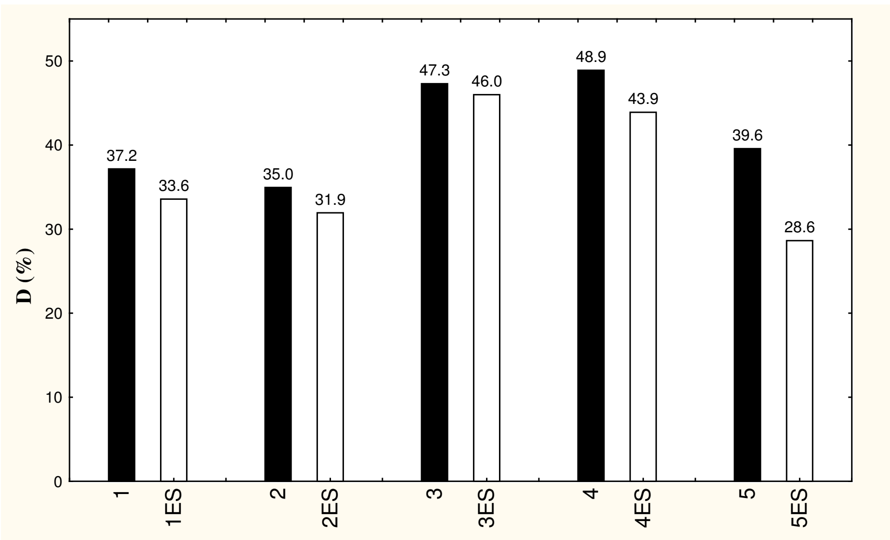

Figure 5. Coefficients of drape behavior of fabrics before and after finishing

The results of abrasion resistance of untreated and treated fabrics are given on figure 6. As can be seen from the results of the figure 6 the abrasion resistance increased on the samples 1, 2, and 4 and a very low decrease of abrasion resistance is noticed on samples 3 and 5.

The increase of the abrasion resistance is due to the appearance of the fibrils on the fiber surface which have higher resistance to abrasion.

Tabela 3. *Colour coordinates of lyocell fabrics after finishing processes*

Fabric code	*Description of finishing techniques*	*Colour coordinates*				
		*DL**	*Da**	*Db**	*DC**	*DH**
1/1ES	Enzyme, silicon	2.48	0.51	-3.70	-2.64	2.64
2/2ES	Enzyme, silicon	3.23	-1.12	-2.30	-2.55	-0.19
3/3ES	Enzyme, silicon	2.38	-2.35	-2.44	-3.19	-1.13
4/4ES	Enzyme, silicon	3.69	2.41	4.30	-4.29	-2.42
5/5ES	Enzyme, silicon	5.35	0.61	-1.33	-1.36	-0.55

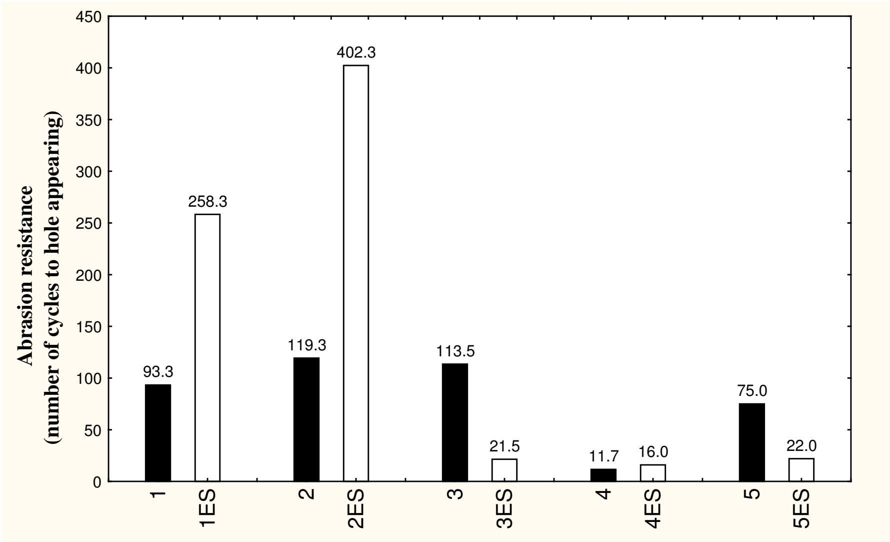

Figure 6. Abrasion resistance of fabrics before and after finishing

The results of the measuring of the water retention values on untreated and fibrillated fabrics are given on figure 7. An increase of water retention values was noticed on all treated samples due to the refibrillation and morphological changes occurring on the surface of the fabric.

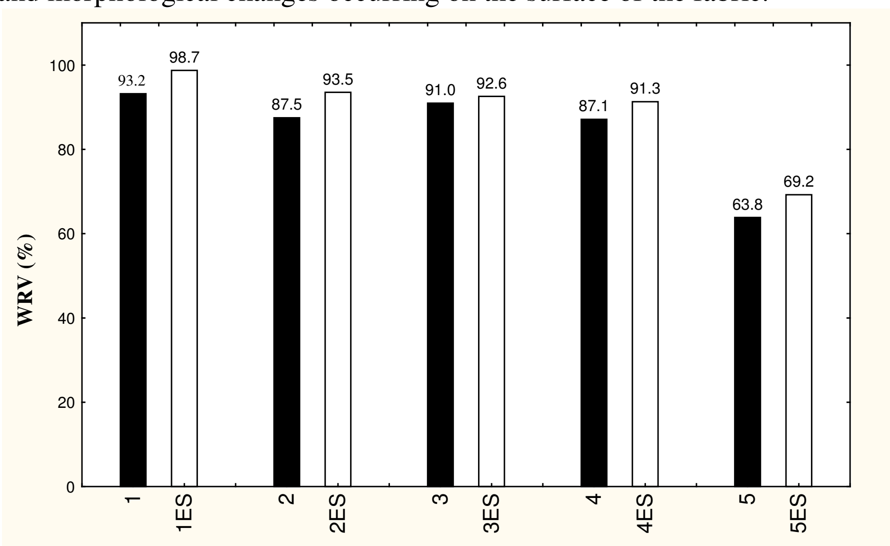

Figure 7. Water retention values of fabrics before and after finishing

Different techniques of finishing induced different changes of the color given in table 3. All tested samples are lighter and the highest difference was noticed on sample 5ES were *DL** had the highest values. All samples due to the refibrillation process have duller hue. But all together the changes in the hue of the dyes after finishing were small.

Summarizing the results the following conclusions can be made: mechanical fibrillation in alkaline media and enzymatic defibrillation treatments significantly modify the tenacity and breaking strength of lyocell fabrics. Defibrillated fabrics have reduced stiffness, increased drape behavior and increased water retention values and can be successfully washed in domestic rotary washing machine without crease formation.

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Designing of composite/core-spun yarns for the cost optimization in value-added products

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Abstract: *The goal of this study is to manufacture antibacterial composite yarns in the production of value-added fabrics for optimizing cost of the product. Various fibers, namely, bamboo, antibacterial polyester and conventional polyester were used as the materials to obtain composite/core-spun yarn structure. Lightweight woven fabric constructions using plain & twill weave with these yarns were manufactured to show if these yarns could provide antibacterial fabrics, were applicable to weaving process and possessed enough mechanical strength to be utilized in industrial textile processes. Both mechanical & antibacterial tests were performed. Cost analysis was done to understand cost optimization of the product.*

Key words*: composite/core-spun yarn, antibacterial polyester fiber, bamboo fiber, value-added product, cost optimization*

1. INTRODUCTION

Antibacterial efficacy is one of the demanded characteristics that need to be improved for the textile products. Recently, textile consumers have antibacterial property expectations from many textile products like home-textiles (curtains, carpets, sheets, towels etc.) and apparels (socks, underwear etc.). There are many methods that provide antibacterial efficacy to the textiles. Textile finishing treatments are one of the common methods in providing antibacterial efficacy. However, the antibacterial property of the textiles achieved with this method is not as long-lasting as it is achieved in the fiber manufacturing stage. Synthetic antibacterial fibers are manufactured in a composite form and compounded with antibacterial additives so the antibacterial property is lasting for a long period on the other hand the chemicals applied on the textiles with finishing treatments can be washed out by daily usage (Palamutçu S. et al., 2009). Besides the chemicals applied on textiles have direct contact with the skin and this can result some problems associated with human health such as toxicity, allergy etc. There are various materials in a large range that are used to provide antibacterial efficacy to the textiles such as chitosan, citric acid, metallic salts, silver, copper, titanium dioxide, quaternary ammonium compounds, PHMB, triklosan, N-halamines, etc (Gao Y. and Cranston R., 2008; Seong H. et al., 1999; Nakashima T. at al., 2001). Core yarns have been manufactured with two different components having different properties to benefit from these properties. Core yarns have a core and a shell covering that core. The core component provides high strength, while the shell component provides properties such as appearance, comfort and feel/handle. Usually the core components are selected from synthetic fibers having high tensile strength and the shell components consist of staple fibers (Demirbaş S., 2005; Sawhney A.P.S. and Kimmel L.B., 1992a; Sawhney A.P.S. and Kimmel L.B., 1992b).

In this study, bamboo, conventional polyester and antibacterial polyester yarns were utilized to develop core-yarns that are applicable to weaving process for manufacturing light weight woven fabrics such as shirts and sheets/bed linings. The main goal in selecting the core structure for the study was to maintain a composite structure by combining the strong characteristics of these yarns such as the strength of anti bacterial polyester, the comfort of bamboo (natural regenerated fiber) and additionally the antibacterial efficacy of these yarns. Cost calculations were performed for the fabrics produced with these yarns in order to make a cost optimization.

2. EXPERIMENTAL

2.1. Materials

In this work single-plied bamboo, antibacterial polyester and conventional polyester yarns were used as the raw material (Table 1). Bamboo yarns that were used in the study were made up of 100% staple regenerated bamboo fibers. Conventional polyester and antibacterial polyester yarns had 100% polyester texturized multifilament fibers in their structure. All of these yarns were provided by ZORLU Holding Corporation's Textile Companies.

2.2. Yarn Design and Manufacturing

Different core yarns having various combinations of the yarns provided by the yarn manufacturer have been designed and manufactured by utilizing a yarn folding/twisting machine (Ağteks Directwist Yarn Folding-Twisting Machine) in order to obtain the composite structure (Table 2).

All of the core yarns, manufactured, were used as the weft yarns in the fabric design. Bamboo-bamboo and antibacterial polyester - antibacterial polyester core yarns were produced for manufacturing both the fabric samples and the control fabric samples that were required to be used in the antibacterial efficacy testing. Polyester - polyester core yarns were produced to manufacture the control fabric samples for the antibacterial efficacy testing (Table 1).

The yarns that were used as warp yarns for all of the fabric samples were produced as two-plied conventional polyester yarns having 300 T/m twist by using Ağteks Directwist Yarn Folding-Twisting Machine.

Table 1: Codes for the raw materials

Raw Material (Yarns)	CODE
Bamboo-Ne40	10
Polyester Ne40	20
Antibacterial Polyester Ne33	30
Bamboo-Ne40/2 (Ne20)	11
Polyester Ne40/2 (Ne20)	22
Antibacterial Polyester Ne33/2	33

Table 2: Codes and counts for the weft yarns

Yarns Used as Weft	Code	Ne	Nm
Bamboo (Core) - Bamboo (Shell)	1011	12	20
Antibacterial Polyester (Core) - Antibacterial Polyester (Shell)	3033	10	17,5
Antibacterial Polyester (Core) - Bamboo (Shell)	3011	11	19
Polyester (Core) - Polyester (Shell)	2022	11	19

2.3. Fabric Design and Manufacturing

For the production of woven fabrics, all of the warp yarns were chosen as two-plied conventional polyester yarns, same for all the woven fabric samples manufactured in this study in order to eliminate this as a factor for the comparison of the fabric samples.

Four different core yarns developed in this work, having different combinations of bamboo, conventional polyester and antibacterial polyester yarns were used as weft yarns in the weaving process (Table 2).

In addition to three different fabric samples, three more fabric samples were required to be produced as control samples for the antibacterial efficacy tests in order to find out if the amount of bamboo and antibacterial polyester had any effect as a constituent of the fabric on the antibacterial efficacy of the fabric samples (Table 3).

All of the samples were woven by a sample-type rigid rapier weaving machine equipped by an electronic dobby.

Table 3: Technical information about the fabrics

Weft (Core-Shell)	Warp (2-plied)	Fabric Construction	Warp Density [thread/cm]	Weft Density [thread/cm]	Warp Count [Ne]	Weft Count [Ne]
Bamboo-Bamboo	Polyester	Twill 2/2 Weave	24	18	20	12
Bamboo-Antibacterial Polyester	Polyester	Twill 3/1 Weave	24	18	20	11
Antibacterial Polyester-Anti bacterial Polyester	Polyester	Plain Weave	24	18	20	10
Polyester-Polyester ***(control sample)***	Polyester	Plain Weave	24	18	20	11
Bamboo-Bamboo ***(control sample)***	Bamboo	Plain Weave	24	18	20	12
Antibacterial Polyester-Anti bacterial Polyester ***(control sample)***	Antibacterial Polyester	Plain Weave	24	18	33/2	10

2.4. Characterization

Core-shell structure of the yarns and the structure of two-plied yarns were characterized and assessed by an optical microscope. Some examples taken from the optical microscope in order to demonstrate the core-shell structure of the yarns can be seen in Fig. 1.

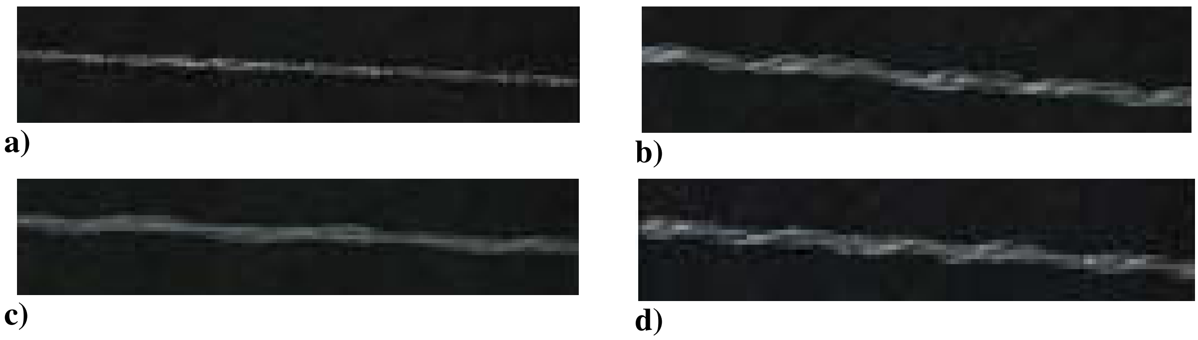

Figure 1: Photographs taken from the optical microscope: ((a) 1011, (b) 3011, (c) 3033, (d)2022.)

2.5. Testing Process

Tensile tests for yarn samples and antibacterial efficacy tests for fabric samples were performed. For yarn tensile tests EN-ISO 2062 yarn tensile strength and breaking elongation standard was used. Tensile tests were performed by using James Heal strength testing device. 5 specimens of 25 cm long yarns from different yarn samples were taken and assessed.

For antibacterial efficacy tests AATCC 147 antibacterial efficacy standard for textile materials was used. Fabric specimens having 2.5 x 5 cm dimensions from all of the fabric samples produced were taken. These tests were completed in a private laboratory, Bioorient. For the tests, *Bacillus subtilis (ATCC 23857)* gram positive and *Klebsiella pneumonia (ATCC 10031)* gram negative bacteria were used.

3. RESULTS AND DISCUSSION

3.1. Tensile Tests

When the tensile strength values for the single-plied yarns are considered, it can be seen that the conventional polyester yarn has the highest value and it is followed by antibacterial polyester yarn and bamboo yarn, respectively (Table 4). Since it's synthetic, conventional polyester yarn has the highest value. Although it's synthetic and the same polymer displaying the same properties, antibacterial polyester has very lower value than conventional polyester. This can be caused by the additives that were added to the structure of the antibacterial polyester in the masterbatch process since they might have caused some discontinuities in its structure. Since bamboo yarn is consisted of regenerated bamboo fibers which show lower tensile values than synthetic fibers and the natural fibers that are not regenerated, tensile values are the lowest for bamboo yarn.

The tensile strength results of two-plied yarns resemble the results of single-plied yarn because of the same reasons (Table 4). Two-plied conventional polyester yarn has the highest tensile strength value and it is followed by two-plied antibacterial polyester yarn and two-plied regenerated bamboo yarn, respectively.

When a comparison of the tensile strength values of core yarns are made, it is obvious that the highest value was obtained by the yarn having antibacterial polyester both as core and shell (Table 4). This yarn is followed the yarn having antibacterial polyester in the core and bamboo in the shell and the yarn having bamboo both in the core and shell, respectively. These results are not unexpected, since the yarn having synthetic yarn both in its core and shell has the highest tensile value and the yarn having regenerated yarn both in its core and shell has the lowest tensile value.

When two-plied and single-plied yarns having the same material in their structure are compared, the two-plied yarns display better tensile strength results than the single-plied yarns (Table 4).

Table 4: Tensile strength values for the yarns

Yarn Code	Twist and Twist Direction	Yarn Count [Ne]	Mean Tensile Strength [cN/tex]	Std. Deviation	Mean Elongation [%]	Std. Deviation
10	NONE	40.0	10.93	0.99	13.82	0.60
20	intermingled	40.0	42.13	1.57	21.99	2.14
30	intermingled	33.0	26.89	0.63	16.34	0.60
11	S 500T/m	20.0	12.29	1.54	11.54	1.60
22	S 500T/m	20.0	43.27	0.41	26.00	0.99
33	S 500T/m	16.5	29.37	0.56	20.75	1.27
1011	S 500T/m	12.0	8.99	0.88	12.74	2.48
3033	S 500T/m	10.0	23.54	3.40	22.27	4.93
3011	S 500T/m	11.0	15.83	1.01	17.80	1.20

3.2. Antibacterial Efficacy Tests

Antibacterial efficacy tests were performed on all of the fabrics manufactured with the core yarns 1011, 3011 and 3033 and control fabric samples (Fig. 2 and 3). Control fabric samples having bamboo, conventional polyester and antibacterial polyester for both their warp and weft yarns were produced to determine the effect of the amount of these yarns on antibacterial efficacy. The results obtained are qualitative according to AATCC 147.

When the test results were examined, it was found that the fabric samples and the control fabric samples showed some antibacterial efficacy. Although it was observed that bacteria could proliferate both on the fabric and control fabric samples, some improvement was achieved in terms of antibacterial efficacy for the fabric samples (Fig. 2 and 3).

Bamboo, so-called naturally having antibacterial efficacy, did not display very much this characteristic (Fig. 2a and b and Fig.3b). This was thought to happen since the yarn made of bamboo fibers consisted of regenerated bamboo fibers instead of natural bamboo fibers. Therefore, bamboo might have lost some what its antibacterial efficacy due to the chemical processes it had passed through in the regenerated fiber production. However, the tests should be performed on the fabrics consisting of yarns having natural bamboo fibers in its structure in order to be sure of bamboo fibers' antibacterial efficacy.

a) b) c)

Figure 2. Antibacterial test results for fabric samples according to the AATCC 147 Standard Test Method: a) 1011 b) 3011 c) 3033

Although it was observed that the fabrics consisting of antibacterial polyester displayed some antibacterial efficacy, it was lower than expected (Fig. 2b, 2c and Fig. 3a). This might be because of the masterbatch process that was used to incorporate antibacterial characteristic to the polyester fibers. Maybe, masterbatch process might not be a very efficient technique to incorporate antibacterial property to the fibers, since the bacteria are destroyed with the contact with the antibacterial additives and since not much of the additives used in this technique placed on the surface of the fibers in order to destroy all of the bacteria with the contact. To obtain much valid results, tests according to the AATCC 100 standard, which gives quantitative results instead of qualitative results, can be done.

a) b) c)

Figure 3. Antibacterial test results for control fabric samples according to the AATCC 147 Standard Test Method: a) 100% Antibacterial polyester b) 100% Bamboo c) 100% Polyester

3.3. Cost Analysis and Optimization

Cost analysis was also performed for three of the fabric samples in order to see the difference of their costs and if the cost was optimized for the value added product with core-yarn consisting of bamboo fiber as the shell and antibacterial polyester as the core for the weft yarn and with conventional polyester yarn as the warp yarn. In order to compare the costs of these three fabrics, they were all assumed to be produced with the same fabric construction, plain weave and all of the calculations were performed according to this assumption. Raw material costs can be seen in Table 5. The other cost values such as hourly wages for the personnel, cost of electric power etc. were taken from ITMF Report 2008.

Table 5: Costs of raw materials

Raw Material (Yarns)	Initial Cost per kg
Bamboo-Ne40	4.5€ - 5.5$
Polyester Ne40	3.3€ - 4$
Antibacterial Polyester Ne33	6.5€ - 8$

Fabric Consisting of the Core-Yarn Bamboo (Shell)-Antibacterial Polyester (Core)

* Cost for the production of the two-plied bamboo yarn as shell: 8.13 $ / kg

- Cost for the production of the core-yarn as weft yarn: 10.98 $ / kg
- Cost for the production of the two-plied conventional polyester yarn as warp yarn: 5.13 $ /kg
- Cost for the weaving process: 8.90 $ / kg and 1.682 $ / m^2

Fabric Consisting of the Core-Yarn Antibacterial Polyester (Shell)-Antibacterial Polyester (Core)

- Cost for the production of the two-plied antibacterial polyester yarn as shell: 10.17 $ / kg
- Cost for the production of the core-yarn as weft yarn: 12.14 $ / kg
- Cost for the production of the two-plied conventional polyester yarn as warp yarn: 5.13 $ / kg
- Cost for the weaving process: 9.65 $ / kg and 1.912 $ / m^2

Fabric Consisting of the Core-Yarn Bamboo (Shell)-Bamboo (Core)

- Cost for the production of the two-plied bamboo yarn as shell: 8.13 $ / kg
- Cost for the production of the core-yarn as weft yarn: 10.49 $ / kg
- Cost for the production of the two-plied conventional polyester yarn as warp yarn: 5.13 $ / kg
- Cost for the weaving process: 8.584 $ / kg and 1.579 $ / m^2

4. CONCLUSIONS

Core yarns make textile products gain multi-functionalities in various ways according to the materials used. In this study, the antibacterial efficacy characteristics for the fabrics and also cost optimization were tried to be achieved by designing core-shell yarns having antibacterial polyester and bamboo as the core component and bamboo and antibacterial polyester as the shell component. The main aim in this study was to investigate the optimized results for the fabrics regarding the comfort, handle/feel, strength, antibacterial efficacy and to understand whether cost optimization could be obtained by using two different materials for the core yarn making it have composite structure and gain applicability to industrial textile processes. When the results of the yarn tensile strength tests were examined, it was found that the core yarns have inferior tensile strength values than their counter-part two-plied yarns. Also it was determined that the yarns having two-different components in their structure inherently showed tensile strength values between its components' tensile values; lower than the synthetic one and higher than the bamboo yarn. When the results of antibacterial tests were examined, it was obtained that the fabric samples and the control fabric samples showed some antibacterial efficacy. When the cost calculations are considered, it is obvious that the cost of the value-added yarn is in the acceptable range when compared to the core-yarns having 100% bamboo and 100% antibacterial polyester in its structure. Therefore, the value-added product, the core-yarn designed, having bamboo as the shell part and antibacterial polyester as the core part, is a promising product having optimum values in terms of mechanical performance, antibacterial efficacy and cost optimization when it is compared with the other yarns produced.

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ISOTROPIC PHYSICAL AND MECHANICAL PROPERTIES OF MULTILAYERED COMPOSITES

Stana KOVAČEVIĆ, Darko UJEVIĆ, Ivana GUDLIN SCHWARZ, Blaženka BRLOBAŠIĆ ŠAJATOVIĆ

Abstract: *Basic features of the isotropic mechanical properties of multilayered surface materials containing woven and knitted fabric and polyurethane are described. Isotropic properties were investigated based on physical and mechanical properties due to the specific application of complex fabrics from different structures and raw material compositions. According to the results obtained it can be claimed that the highest tensile strengths mainly act in the warp and weft directions of the fabric in relation to other directions. Breaking elongation mostly followed the course of tensile strengths in testing directions. The tensile strengths are the lowest at* 15^0 *and* 195^0 *respectively and at* 165^0 *and* 345^0 *respectively with very low values representing critical places in case of loading; elongation and module of elasticity are also the lowest in these directions. Weave pattern also influences the physical and mechanical properties of the fabric in different directions; in case of twill weave tensile strength is higher in the diagonal directions of the weave in relation to the direction making an angle of* 90^o *with diagonals. It can be claimed that multilayered textile composites containing woven fabric as one layer are anisotropic, especially using the standard method of testing tensile strength and breaking elongation. Anisotropy is alleviated by testing circularly cut specimens with a 200 mm long diameter, but module of elasticity decreases.*

Key words*: multi-layered composites, woven fabric, knitted fabric, polyurethane, isotropic mechanical properties*

1. INTRODUCTION

Textile composites possess anisotropic properties when their physical and mechanical properties differ in testing directions. Woven fabrics are distinctly anisotropic, but anisotropy decreases in composite materials combined with polyurethane and knitted fabric. Previous investigations mention that several multilayered textile composites also have orthotropic physical and mechanical properties, such as nonwovens [1-3]. The investigations of this paper are based on the investigations of the isotropy of multilayered textile composites with woven fabrics in different weave patterns.

Multilayered textile composites consist of two or more surface materials, mostly from different materials. All components in the final product influence the properties of multilayered composite materials. The proportions of one component can bi different which enables to obtain a composite material with target properties for the predetermined application. Based on physical and mechanical properties composite materials are mostly anisotropic, with different types of anisotropy, especially with fabric proportion. Since composite materials from textile fabrics are used for various applications, in which stresses in different directions occur, physical and mechanical properties in all directions are essential. The multilayered loading of composite materials causes different deformations resulting in a shorter life cycle and poor appearance. The directions having the lowest tensile strengths and the highest elongation at break are put at risk; these are the directions between the warp and weft directions. In one-layered materials the results of the multi-layered investigation differ in relation to multi-layered composite materials; as a consequence, this kind of investigation is rarely carried out. In order for composite materials to fulfill its purpose, it is desirable that the multi-axial properties of the composite material are uniform [4-5].

2. PHYSICAL-MECHANICAL PROPERTIES OF MULTI-LAYERED COMPOSITES CONTAINING WOVEN FABRIC

When external forces (stress) act, internal cohesion forces withstand. By lessening internal forces joining molecules, the body in the state of stress begins to deform. Stress is expressed as a ration of internal forces acting on the area unit of the sample.

$$\sigma = \frac{F}{S} \quad \left(N / mm^2\right) \tag{1}$$

The strength of a material refers to the material's ability to withstand an applied stress without failure. The strength can be tensile, bending, tearing and compressive.

Sample deformation is a change in the body dimension per unit of length during stress, and it is mostly tested by the tensile strength tester.

$$\varepsilon = \frac{\Delta l}{l_0} \times 100 \, (\%) \tag{2}$$

Stress and deformation of elastic samples are proportional, and their relationship in the coordinate system is linear. If the relationship between stress and deformation is linear, and in the coordinate system a straight line is drawn at the beginning of stress, the sample in this part is elastic, the straight line is called Hooke's straight line, and it is defined by Hooke's law. Degree of elasticity or Young's modulus of elasticity is expressed according to the following equation:

$$E = \frac{\sigma}{\varepsilon} = \frac{\frac{F}{S_0^{\,2}}}{\frac{\Delta l}{l_0}} = \frac{F \times l_0}{S_0^{\,2} \times \Delta l} \approx \mathrm{tg}\alpha \quad \left(N / mm^2\right) \tag{3}$$

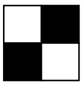
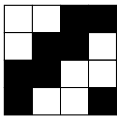
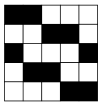
where:

E - modulus of elasticity (N/mm^2),
σ - stress (N/mm^2),
F . breaking force (N),
ε - elongation at break (%),
Δl - elongation at break (mm),
l_0 - initial length of sample (mm),
S_0 - transversal surface of the sample (mm^2).

3. EXPERIMENTAL PART

Physical-mechanical properties of multilayered surface materials with components of woven fabric, polyurethane and knitted fabric were investigated. Fabric samples are 100% polyester, it is on the front side of the surface material with different weave types. The fabrics are thermally reinforced on the front side with polyurethane sponge and then with knitted fabric; in this manner they produce a multilayered product for making car seat covers. Samples were different in woven fabrics, the thickness of the polyurethane sponge and the knitted fabric type. One sample was the fabric in plain weave, the other one was the fabric in twill weave (2/2) and the third one was the fabric in irregular twill weave with the opposite direction of diagonals than the other sample (Table 1). Investigations were performed between 0 and 360 degrees within a circle with a distance of 15 degrees. Breaking force and elongation at break were tested on the Apparecchi Branca S.A tensile tester according to the ISO 5081 standard. Investigations were performed on non-standard prepared samples of fabrics in form of a 200 mm diameter circle, and in place of fastening the clamps the circle was expanded by 50 mm on each side so that the distance between the clamps was always 200 mm. The investigations were performed in climatic conditions of 65 ± 2% relative humidity and temperature 22^0 C. According to the results and Equation 3 the modulus of elasticity was calculated for each sample in the test directions.

Table 1: Basic parameters of multilayered composites.

Investigated parameters and standards		**Multilayered composites for seat upholstery**		
		Sample 1	**Sample 2**	**Sample 3**
Fabric density (threads/10 cm)	**Warp**	**300**	**130**	**180**
	Weft	**200**	**110**	**180**
Yarn count (tex)	**Warp**	**49**	**139**	**46**
	Weft	**47.5**	**137**	**46**
Yarn breaking force ($\overline{X}$/S/CV) (cN/cN/%)	**Warp**	**802.79/120.11/16.08**	**1981.67/154.78/7.81**	**807.00/206.40/25.77**
	Weft	**763.28/124.01/16.25**	**1875.35/415.22/22.14**	**765.22/118.87/15.53**
Breaking elongation ($\overline{X}$,/S/CV) (%)	**Warp**	**19.57/3.03/15.48**	**29.26/3.32/11.33**	**17.87/4.71/26.36**
	Weft	**22.52/4.17/18.53**	**28.36/6.55/23.10**	**22.52/4.17/18.53**
Raw material composition	**Warp**	**100% polyester**		
	Weft			
	Sponge	**Expanded polyurethane**		
	Knitted fabric	**Warp knitted locknit fabric (charmeuse)**	Two guide bar structure – pillar and 2 and 1 lapping structure	**Plain jersey**
Weave type				

$\overline{X}$ - arithmetic mean (cN), S - standard deviation (cN), CV - variation coefficient (%)

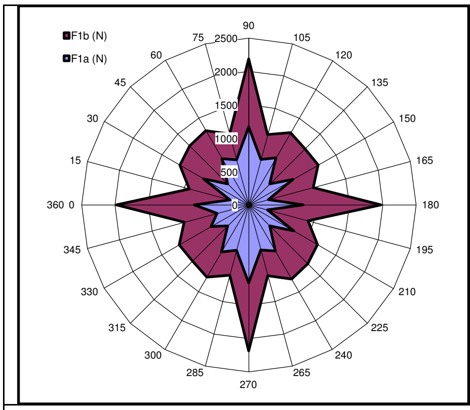


Figure 1: Breaking force of the fabric sample 1 in case of standard and non-standard testing; F1a - breaking force of sample 1 in case of the standard sample (N), F1b - breaking force of sample 1 in case of the non-standard sample (N).

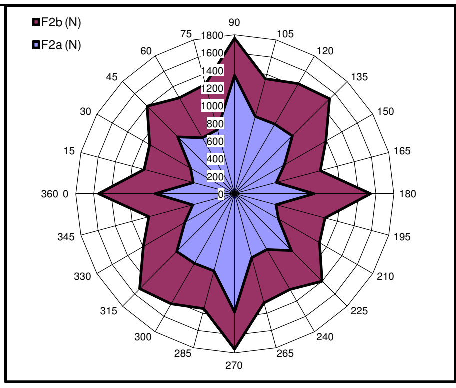


Figure 2: Breaking force of fabric sample 2 in case of standard and non-standard testing; F2a - breaking force of sample 2 in case of the standard sample (N), F2b - breaking force of sample 1 in case of the non-standard sample (N).

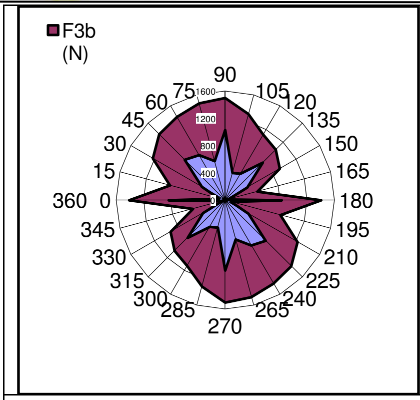


Figure 3: Breaking force of sample 3 in case of standard and non-standard testing ; F3a - breaking force of sample 3 in case of the standard sample (N), F3b - breaking force of sample 1 in case of the non-standard sample (N).

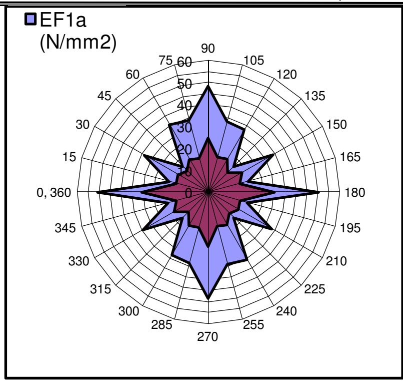


Figure 4: Modulus of elasticity of sample 1; EF1a - modulus of elasticity of sample 1 in case of standard samples (N/mm^2), EF1b - modulus of elasticity of sample 1 in case of non-standard samples (N/mm^2).

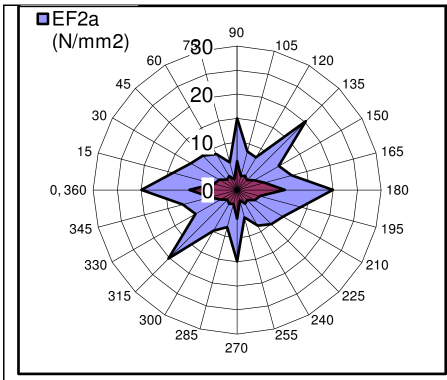


Figure 5: Modulus of elasticity of sample 2; EF2a - modulus of elasticity of sample 2 in case of standard samples (N/mm^2), EF2b - modulus of elasticity of sample 2 in case of non-standard samples (N/mm^2).

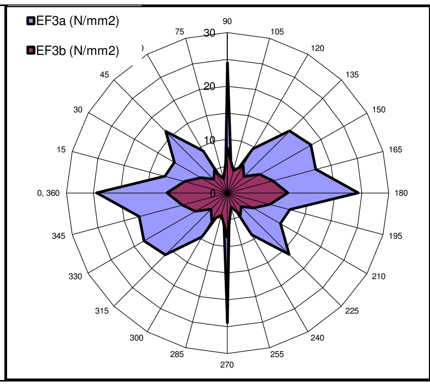


Figure 6: Modulus of elasticity of sample 3; EF3a - modulus of elasticity of sample 3 in case of standard samples (N/mm^2), EF3b - modulus of elasticity of sample 3 in case of non-standard samples (N/mm^2).

4. RESULTS AND DISCUSSION

Test results of breaking forces and breaking elongation of the yarn and multilayered textile composites and modulus of elasticity with statistical values are given in ***Figures 1*** to ***6***.

The breaking force of the composite material was measured in different directions (degrees). The first sample of the woven fabric in plain weave, the second sample of the woven fabric in twill weave with diagonals in the right direction, and the third sample of the fabric in twill weave with diagonals in the left direction.

The breaking force of the second sample is the highest in all directions in relation to other samples despite the fact that the warp and weft density is the lowest. This is caused by a thicker warp and weft yarn with a higher breaking force and a thicker sample. This sample of the fabric is woven in twill weave with diagonals in the right direction, and the values of breaking forces in this direction are higher.

Modulus of elasticity is an essential parameter in composites used for making car seat covers. As a consequence of long sitting and stress the car seat covers deform to a certain extent in these places.

5. CONCLUSION

Multilayer textile composites, in which fabric represents one layer of the composite, are anisotropic materials. Breaking force, breaking elongation and modulus of elasticity are decisive because they define material isotropy. The fabric impairs composite orthotropy especially in warp and weft direction where the mentioned parameters are the highest. Differences between the highest and lowest values are apparent, and they cannot be compensated. Due to relatively high strength, durability, elasticity, greater possibility of design and comfort, possibility of surface treatment and easy care the fabric will be further used in composites for making car seat covers, irrespective of isotropic properties. Despite great deviations in breaking forces and modulus of elasticity among the test directions the plain weave fabric exhibited a relatively high strength and symmetry of the values in the coordinate system. Samples of fabrics with weaves creating diagonal contours (twill weave) should be avoided because they affect higher asymmetry and anisotropy of the results obtained.

ACKNOWLEDGMENTS

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THEORY OF YARN DYNAMICS DURING UNWINDING FROM PACKAGES

Stanislav PRAČEK

Abstract: *We derive the system of coupled nonlinear differential equations that govern the motion of yarn in general. The equations are written in a (non-uniformly) rotating observation frame and are thus appropriate for description of over-end unwinding of yarn from stationary packages. We comment on physical significance of virtual forces that appear in a non-inertial frame and we devote particular attention to a lesser known force, that only appears in non-uniformly rotating frames. We show that this force should be taken into account when the unwinding point is near the edges of the package, when the quasi-stationary approximation is not valid because the angular velocity is changing with time. The additional force has an influence on the yarn dynamics in this transient regime where the movement of yarn becomes complex and can lead to yarn slipping and even breaking.*

Key Words: *yarn unwinding, packages, balloon theory, yarn tension, angular velocity.*

1. INTRODUCTION

Yarn unwinding is an essential step in many textile processes (Barr&Catling, 1976; Padfield,1958) . The quality of the fabric that is produced directly depends on the regularity of the unwinding: the tension in the yarn should be low and constant. The characteristics of the unwinding process are thus important for production of high quality garments and should therefore be optimized.

2. KINEMATICS

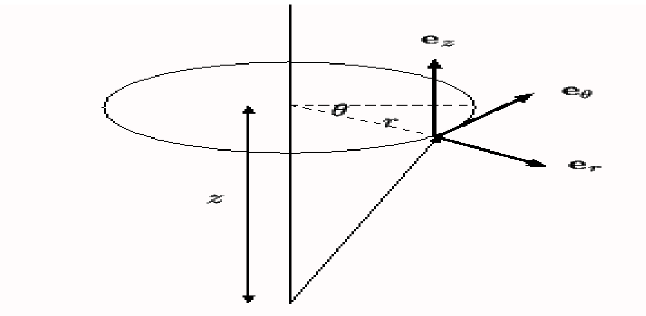

Figure.1: Cylindrical coordinate system rotates around the z axis with an angular velocity

The yarn is parametrised with arc length s (s is therefore the length of yarn from the origin of the coordinate system to the given point on the yarn). The coordinates of a point are given by r, the radial distance from the axis, θ, the polar angle and z, the vertical distance from the origin (Kong, 1997 ; Kong&Rahn&Goswami,1999).

It should be kept in mind that each point has its own triplet of base vectors e_z, e_θ, e_r, respectively pointing in vertical, tangential and radial direction. The radius vector pointing to a point on the yarn can be decomposed along radial and vertical directions (the polar angle dependence is hidden in the e_r vector):

$$r(s,t) = r(s,t)e_r(\theta(s,t),t) + z(s,t)e_z \tag{1}$$

We have emphasized that coordinates of a point depend explicitely on both the time of observation t and on the arc length s, where the point is located at given time t.The velocity of a point on a yarn that is being withdrawn (with withdrawing speed V) is given by the total time derivative:

$$v = \frac{dr}{dt} = \frac{\partial r}{\partial t} + \frac{\partial r}{\partial s}\frac{\partial s}{\partial t} \qquad (2)$$

It is important to note that the velocity is not given by the local (partial) time derivative, denoted by $\partial r/\partial t$. This derivative does not take into account that in the infinitesimal time Δt the point moves to a different position along the yarn (i.e. to a different arc length s). The contribution to velocity due to this movement is described by the additional term $\partial r/\partial s\ \partial s/\partial t$. The withdrawing speed is equal to $V=-\partial s/\partial t$ and we obtain the following expression:

$$v = \dot{r} - V\frac{\partial r}{\partial s} \qquad (3)$$

where the dot denotes the partial derivative with respect to time. It's worth noting that $t=\partial r/\partial s$ is the unit tangential vector to the yarn. Indeed the direction of the withdrawing velocity at a given point should be in the direction of the yarn.
To calculate the time derivative of the radius vector we make use of a relation between derivatives in an inertial and a rotating frame:

$$\left(\frac{\partial}{\partial t}\right)_K = \left(\frac{\partial}{\partial t}\right)_{K'} + \omega x. \qquad (4)$$

When applied to a base vector, that is rotating around the Z axis together with the yarn, this equations gives

$$\frac{\partial e_i(t)}{\partial t} = \omega \times e_i(t) \qquad (5)$$

The partial time derivative of the radius vector is then found to be:

$$\dot{r} = \dot{r} e_r + r\dot{e}_r + \dot{z} e_z + z\dot{e}_z = \dot{r} e_r + r\dot{\theta} e_\theta + \dot{z} e_z + \omega \times (re_r + ze_z) = v_{rel} + \omega \times r. \qquad (6)$$

The final expression for the velocity of a point is of the form

$$v = v_{rel} + \omega \times r - V\frac{\partial r}{\partial s} \qquad (7)$$

The three contributions to the velocity of the point have very simple physical interpretations. The first term is the relative velocity in the non-intertial frame; it describes how the form of the yarn is changing from the point of view of an observer that is rotating together with the yarn, but it is not equal to the velocity of a given point in the non-intertial frame. (This term is dropped in the quasi-stationary approximation that we describe below.) The second term is the circular velocity of the point due to the rotation of the frame; this is the velocity of a point that is fixed in the non-inertial frame. Finally, the last term is the withdrawing velocity that we introduced above.

By analogy, the acceleration of a point is given by the total time derivative of the velocity. By a lengthy but straight-forward calculation we obtain the following expression:

$$a = a_{rel} + 2\omega \times v_{rel} - 2V\omega \times \frac{\partial r}{\partial s} + \omega \times (\omega \times r) + \dot{\omega} \times r - 2V\frac{\partial v_{rel}}{\partial s} + V^2 \frac{\partial^2 r}{\partial s^2} \quad (8)$$

This complex expression can be given more compact form if we introduce a differential operator D, which follows the motion of the point in the rotating frame (Fraser&Ghosh&Batra,1992):

$$D = \frac{\partial}{\partial t} - V\frac{\partial}{\partial s} \quad (9)$$

The fact that this operator "follows the motion of the point in the rotating frame" means, that the partial time derivative operator only operates on the coordinates of the point (r, θ, z), but it gives zero when applied on the base vectors e_z, e_θ, e_r.

The simplified expression for the acceleration is:

$$a = D^2 r + 2\omega \times (Dr) + \omega \times (\omega \times r) + \dot{\omega} \times r \quad (10)$$

This expression is reminiscent of an analogous expression for acceleration of a point object in a rotating frame, with partial time derivatives replaced by the differential operator D.

3. DINAMICS

Newton's law in the form of **F**=m**a**, where **F** is the force on the body, **a** the acceleration and m the mass of the body, can be used to describe the motion of point bodies and the centre-of-mass motion of rigid bodies. Here we are dealing with yarn, which is a deformable body, and we want to describe not only the motion of the yarn as a whole, but also it's shape itself (Praček, 2002). For this reason we partition the yarn in a large number of short (infinitesimal) segments of length δs and we apply Newton's law for each individual segment (Fig.2).

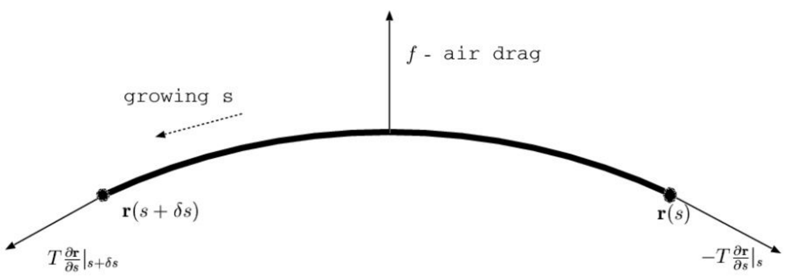

Figure 2: A segment of yarn and forces that act on it.

The three largest forces that act on each segment are:

- the air drag for that part of the yarn that forms the balloon (or the force of friction for the part of yarn between unwinding and lift-off point on the package, which is sliding on lower layers of yarn)
- the force imparted to the segment by the yarn "attached" to the right end point (at arclength s), -T ∂**r**/∂s(s). Scalar T is the yarn tension, and the force is obviously directed along the yarn.
- the force imparted to the segmend by the yarn "attached" to the left end point (at arclength s+∂s), T ∂**r**/∂s(s+∂s).

The last two forces are due to internal elastic stress which appear because the yarn is being strained. In tridimensional bodies the elastic state is described by a tensor (stress tensor), while in a one-

dimensional body such as yarn a scalar quantity T (tension) is sufficient. It is measured in units of force [N].
We can thus write the second Newton's law for the yarn segment as

$$ma = \left(T\frac{\partial r}{\partial s}\right)(s+\delta s) - \left(T\frac{\partial r}{\partial s}\right)(s) + F \tag{11}$$

The mass of a segment is m=ρδs, where ρ is the linear density of mass (i.e. mass per unit length). We write the external force **F** as **F=f**δs, where **f** is the linear density of external force (i.e. external force per unit length). We divide the previous equation by δs and we go the limit of infinitesimal length of the segment, δs→0:

$$\rho a = \lim_{\delta s \to 0} \frac{\left(T\frac{\partial r}{\partial s}\right)(s+\delta s) - \left(T\frac{\partial r}{\partial s}\right)(s)}{\delta s} + f \tag{12}$$

The limit in this expression is by definition the derivative of function T∂**r**/∂s with respect to arc-length s. The final result, the equation of motion for an infinitesimal yarn segment, can be written as:

$$\rho a = \frac{\partial}{\partial s}\left(T\frac{\partial r}{\partial s}\right) + f \tag{13}$$

or, if we take into account the expression for the acceleration,

$$\rho(D^2 r + 2\omega \times Dr + \omega \times (\omega \times r) + \dot{\omega} \times r) = \frac{\partial}{\partial s}\left(T\frac{\partial r}{\partial s}\right) + f \tag{14}$$

4. VIRTUAL FORCES IN A NON-UNIFORMALY ROTATING FRAME

The D^2r term in the equation of motion can be interpreted as the acceleration of a point in the rotating coordinate system. The other three terms on the left hand can be moved to the right side of the equation and reinterpreted as virtual forces that appear due to the non-inertial character of this observation frame. These are not »real« physical forces, but rather forces that an observer in a non-inertial frame would feel because of inertial effects. To emphasize the difference the virtual forces are also called system forces, inertial forces or pseudo-forces. It should be kept in mind that these forces do not appear in equations of motion if they are written in an inertial frame, even if the motion of the body itself is accelerated. They only appear when the equations are expressed in the form appropriate for a non-inertial obsertvation system.

The three virtual forces that we're dealing with are:

1. $-\rho 2\omega \times Dr$ the Coriolis force
2. $-\rho\omega \times (\omega \times r)$ the Centrifugal force
3. $-\rho\dot{\omega} \times r$ an additional force due to changes of the rotational velocity.

In most of the introductiory textbooks on mechanics the only case that is considered is that in which the angular velocity is constant, so that only Coriolis and the centrifugal forces appear. For this reason the third force is less known and unfortunately it is often neglected even when it plays some role. We were unable to find any mention of this virtual force in the available litterature on yarn unwinding and the balloon theory.

It is interesting to describe how an observer standing on a merry-go-round would feel each of these forces. Usually we first notice the centrifugal force; this force »tries« to »eject« us from the merry-go-round. Coriolis force can be seen at work when we throw an object in the radial direction. As seen from our point of view, the object work fly in a straight line as in an inertial frame, but it will deviate in a direction that is perpendicular to its velocity. The third force could be felt if the merry-go-round would suddenly come to a halt. As our experience tells us, we would most likely fall in this event. This force therefore isn't always negligible: it has very sensible effects when the angular velocity suddenlty changes.

5. CONCLUSIONS

We have shown crucial steps in the derivation of the equation of motion of yarn: the introduction of the non-uniformly rotating obsrvation frame, the calculation of velocity and acceleration and the application of Newton's second law to an infinitesimal segment of yarn. The origin of the virtual (system) forces was described. We've emphasized the role of the lesser known virtual force that can have important effects near the edges of a package.

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INVESTIGATION OF SPINNING COMPONENT PARAMETER EFFECTS ON HAIRINESS OF COTTON ROTOR SPUN YARNS BY USE OF A FULL FACTORIAL DESIGN

Merve KUCUKALI OZTURK, Banu UYGUN NERGİS

Abstract: *Hairiness is one of the most important characteristics which affects weaving, knitting, dyeing and the finishing process in textiles. The properties of fibres and yarn production stages are known to be influential for yarn hairiness. Yarn hairiness is defined as fibre ends not embedded in the yarn body, but protruding from it at different lengths. However, there were limited numbers of studies on effect of spinning components on hairiness. Effect of some spinning component parameters such as opening roller coating, navel configuration and torque stop type on the hairiness of Ne 30/1 rotor spun cotton yarns is studied by designing a full factorial experiment. Minitab 16.0 was used to evaluate the results. The results of the statistical analysis showed that opening roller coating, navel configuration and torque stop type had significant effects on yarn hairiness. Navel configuration had the largest effect on the yarn hairiness. Presence of whirl inserts in the spiral navels deteriorates the hairiness of the yarns. The effect of opening roller coating is slightly larger than that of torque stop type. Yarn hairiness is improved with use of diamond-nickel coating on opening roller. Besides, minimum yarn hairiness values were obtained by using the increased torque stop.*

Key words*: opening roller, navel, torque stop, rotor spun yarn, full factorial design, experimental design*

1. INTRODUCTION

OE rotor-spun yarns are described basically as two zone structures comprising a core of fibers that are aligned with the helix of the inserted twist and form the bulk of the yarn, then an outer zone of wrapper fibers occurring irregularly along the core length (Koç E. et al., 2005). A detailed work on the surface structure of rotor yarns shows that the variation of surface appearance along the yarn length can be classified into six groups: ordered, loosely wrapped, hairy, multiple wraps, opposingly wrapped, tightly wrapped and belts. With respect to these classifications, it has been shown that the yarn consisted largely of the first three classes (Lawrence C.A., Finikopulos E., 1992).

During the spinning process, fibers are continuously fed into the rotor, while the yarn is simultaneously and continuously taken up. Due to the rotor speed, the yarn is always taken up under tension caused by the centrifugal forces acting on the yarn elbow within the rotor. Thus, the yarn elbow rotating with the rotor practically forms a crank, which twists the yarn section following the take-off nozzle outside the rotor. In rotor spinning, this process represents the twisting process. In this way then, twist, in rotor spinning is produced primarily outside the rotor, between the take-off nozzle and the subsequent yarn deflection or yarn nip point. It continues from there, against the yarn take-up direction, into the yarn elbow within the rotor up to the yarn peel-off point, and beyond that another few millimeters into the mini-sliver in the rotor groove. This process is at the root of the principle of twist equalization in the tensioned yarn. This twist diffusion is particularly affected by yarn friction at the take-off nozzle. The yarn undergoes a directional change of approx. 30° in the yarn takeoff tube which follows the take-off nozzle. If this deflection point is relatively sharp-edged, part of the yarn twist is held back. Points like this are referred to as torque-stops (Trommer G. et al., 1995).

Selection and optimum use of the spinning components are important parameters in rotor spinning. The most important spinning components are opening roller, rotor, navel (take-off nozzle) and torque stop and the effects of these components on the properties of rotor yarns have been investigated by many researchers. Nawar et al. (2003) concluded that imperfections of the rotor yarn increased when coarsely grooved navel and larger rotor diameters are used. Das and Ishtiaque (2004) concluded that increased rotor and opening roller speed and higher trash content in the draw frame sliver increased the end breakage rate during spinning. Kaplan and Göktepe (2006) suggested that for coarse rotor yarn

(49 Tex) produced from 100% cotton waste, if minimizing yarn evenness and imperfections is the goal of the production process, the smooth steel navel should be selected; if hairiness, tenacity and elongation are the most important criteria, the spiral ceramic navel is the appropriate one. Tyagi et al. (2003) found that the use of higher twist factor and notched nozzle decreases the yarn bulk and increases the snarling tendency of acrylic-cotton rotor spun yarns, the spiral nozzle produces less hairs at a constant machine twist and results in lower values of single strand, knotted and looped yarns strength, presumably due to high twist effect. Kong L.X. et al. (1996) observed that increase in the rotor speed lead to deterioration in 34 and 60 Tex cotton yarn uniformity. Increasing the opening roller speed upto a certain value decreased yarn imperfections whereas further increase beyond that value had an opposite effect. In another study, Duru and Babaarslan (2003) claimed that when spinning Ne 20/1 polyester/waste blend rotor yarns, increasing the opening roller speed negatively affects yarn tenacity and positively affects evenness and hairiness. However, according to the results of Tyagi (2004) for viscose rotor yarns, a higher opening roller speed causes the yarns to be reasonably more hairy. In another study, Tyagi (2003) concluded that the spin finish and opening roller interact with each other to determine yarn properties. The yarn tensile properties generally show a descending trend with increasing opening roller speed. The yarns produced with higher opening roller speed show lower unevenness and fewer imperfections, particularly at higher level of add-on finish. According to Manich and De Casteller (1986) both rotor and take-off nozzle type exert a significant influence on residual twist, which tends to increase when the nozzle produces a rising false twist effect and to diminish when the friction of the yarn against the rotor increases. Erbil Y. et al., (2008) studied the influence of navel type on the hairiness properties of rotor-spun blend yarns and concluded that the number of notches on the navel, the physical form of notches, the structure of the navel surface and the surface geometry of the navel had important effects on hairiness.

Hairiness is one of the most important characteristics which affect weaving, knitting, dyeing and the finishing process in textiles. The properties of fibers and yarn production stages are known to be influential for yarn hairiness. Yarn hairiness is defined as fiber ends not embedded in the yarn body, but protruding from it at different lengths (Erbil Y. et al., 2008). However, there were limited numbers of studies on effect of spinning components on hairiness.

Main concern of the researchers has been the effects of processing speeds of rotor and opening roller, rotor diameter and, surface characteristics of take-off nozzle on rotor yarn properties. Distinctively, this study includes effects of the properties of torque stop together with opening roller surface and clothing properties and take-off nozzle (navel) type on Ne 30/1 cotton yarns', that are widely commercially used, hairiness properties.

2. MATERIALS AND METHODS

2.1 Material

Ne 30/1 cotton yarn was spun from fibers whose properties are given in Table 1.

Table 1: Fiber Properties

Fiber				Trash content in sliver		
Cotton Type	Tenacity (cN/ tex)	Fineness (Micronaire)	Effective Length (mm)	Neps	Dust	Trash particles
23,5% Syria 73,5% USA	30,10	4,02	27,80	275	1046	154

2.2 Method

In order to study the effects of certain processing parameters on yarn hairiness, Ne 30 cotton yarns were produced by employing various combinations of opening roller, navel and torque stop types. The effects of each of these parameters and their interactions on the hairiness of the yarns produced were investigated.
As shown in Table 2, 2 opening roller, 3 navel and 3 torque stop types were selected. The spinning conditions and machine settings used in the study are also given in Table 3.

Table 2: Properties of the Spinning Components

		Levels		
Parameters	Designation	1	2	3
Opening roller type	A	Nickel coated, 22 ° tooth inclination, 2,4 mm tooth pitch	Diamond-Nickel coated, 22 ° tooth inclination, 2,4 mm tooth pitch	-
Navel type	B	Ceramic, spiral surface	Ceramic, spiral surface, long whirl insert	Ceramic, spiral surface, short whirl insert
Torque stop type	C	No torque-stop	Moderate torque-stop	Increased torque-stop

Table 3: Spinning Conditions and Machine Settings

Machine type	Schlafhorst Autocoro Corolab 94-95
Spinning box type	SE9
Rotor type	V-shaped groove, Boronized-diamond
Rotor diameter	33 mm
Rotor speed (rpm)	100000
Opening roller speed (rpm)	7046
Twist coefficient (α_e)	3,9
Take-off speed (m/min)	120
Sliver count (Ne)	0,120

With the aim of generating results for practical applications, it was essential to select the yarn count and the twist factor that is conventionally adopted by spinning mills. Average hairiness values were calculated as stated in ASTM D5647-01 using photoelectric based testing system attached with the ZWEIGLE G565 hairiness tester with a pretension of 5cN. The test length of 100 m from each specimen was tested for the fibers having a length of 3mm at the speed of 50 m/min. An average of 5 readings was taken for the purpose. The instrument also gives the total number of protruding fibers having a length above 3mm (S3). Tests were carried out under standard atmospheric conditions (RH 65 ± 2% and 20 ± 2 ºC).

2.3 Full Factorial Design

Full factorial experiment was designed to investigate and identify the relative significance of opening roller, navel and torque stop type on yarn hairiness. To systematically vary experimental factors, a discrete set of levels should be assigned each factor as done in Table 2. Full factorial designs measure response variables using every treatment (combination of the factor levels). A full factorial design for n factors with $N_1,\dots, N_n$ levels requires $N_1 \times \dots \times N_n$ experimental runs—one for each treatment. While advantageous for separating individual effects, full factorial designs can make large demands on data collection (http://www.mathworks.com).

In this study, the number of combination that must be created for full factorial design is 2x3x3=18 based on number of levels (Table 4).

Table 4: Randomized full factorial experiment design table

StdOrder	RunOrder	PtType	Blocks	A	B	C
3	1	1	1	1	1	3
1	2	1	1	1	1	1
7	3	1	1	1	3	1
11	4	1	1	2	1	2
5	5	1	1	1	2	2
13	6	1	1	2	2	1
12	7	1	1	2	1	3
18	8	1	1	2	3	3
8	9	1	1	1	3	2
17	10	1	1	2	3	2
6	11	1	1	1	2	3
16	12	1	1	2	3	1
2	13	1	1	1	1	2
15	14	1	1	2	2	3
4	15	1	1	1	2	1
14	16	1	1	2	2	2
10	17	1	1	2	1	1
9	18	1	1	1	3	3

ANOVA-factorial was performed using Minitab 16.0 program to achieve analysis of variance for three factor design with one replicate. The significance of independent variables and their interactions on the yarn hairiness were tested at a 0.05 probability level. A probability value (p) that was smaller than 0.05 led to the conclusion that the independent variable had a significant effect on the dependent variable.

3. RESULTS AND DISCUSSION

The average hairiness values of rotor yarns were calculated and reported in the Table 5.

Table 5: Experimental layout using an full factorial experimental design

Exp No	A	B	C	Average Hairiness (S3)
1	1	1	3	249
2	1	1	1	185
3	1	3	1	1073
4	2	1	2	244
5	1	2	2	288
6	2	2	1	324
7	2	1	3	249
8	2	3	3	461
9	1	3	2	791
10	2	3	2	737
11	1	2	3	212

12	2	3	1	687
13	1	1	2	215
14	2	2	3	224
15	1	2	1	458
16	2	2	2	263
17	2	1	1	168
18	1	3	3	678

The effects of opening roller, navel and torque stop type on yarn hariness can be graphically seen in the Figure 1.

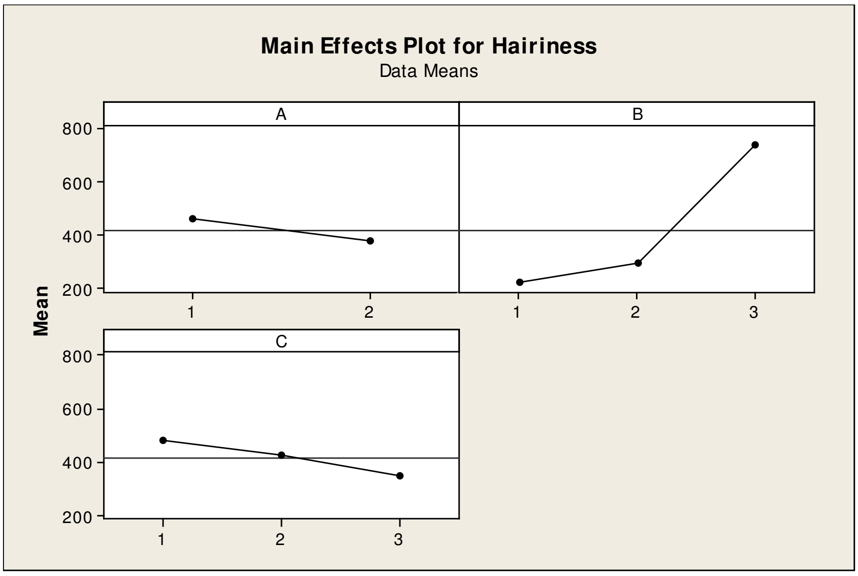

Figure 1: Main effects plot for yarn hairiness

As in the Figure 1 seen, navel type has the highest effect.
ANOVA analysis with α=0.05 was performed to the values gained from the full factorial design to get quantitative measure of effect of analyzed parameters. Three factor interactions (AxBxC) were ignored and the results of reduced ANOVA table were listed in Table 6.

Table 6: ANOVA table for the mean response

Parameters	Sum of squares	DF	Mean square	F value	p	Contribution (%)
A	34848	1	34848	10.54	0.031	5.95%
B	943963	2	471981	142.74	0.000	80.62%
C	56631	2	28315	8.56	0.036	4.83%
A*B	40719	2	20359	6.16	0.060	3.48%
A*C	20634	2	10317	3.12	0.153	1.76%
B*C	78514	4	19628	5.94	0.056	3.35%
Error	13227	4	3307			
Total	1188536	17				

R^2 = 98.89% R^2(adj) = 95.27%
Since the values of R^2 is 98.89% and R^2(adj) is 95.27%, expressiveness of the model is high.

The normal probability plot which also supports the goodness-of-fit of the model is presented in Figure 2. It can be concluded from normal probability plot that data set is normally distributed since the points lie close to a straight line.

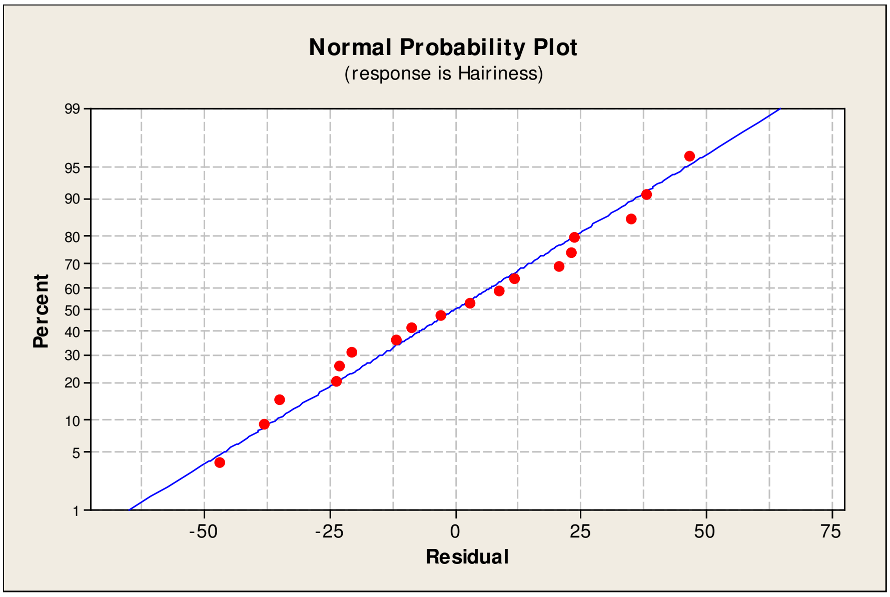

Figure 2: Normal probability plot for the response of hairiness

With respect to Table 6, probability values lower than 0.05 shows that the established model is meaningful. All three parameters have significant effect on yarn hairiness. The contributions are 80.62%, 5.95% and 4.83% for the navel type, opening roller and torque stop respectively.
The statistical analysis of variance for yarn hairiness showed that changes in the navel properties had the highest effect on the hairiness properties of the yarns and for all opening roller and torque stop types, hairiness tended to increase for the yarns produced by the navels in the order of B1, B2, B3 (B1: ceramic, spiral surface without whirl, B2: ceramic, spiral surface with long whirl, B3: ceramic, spiral surface with short whirl). The presence of whirl inserts in the spiral navels deteriorated the hairiness of the yarns. The navel exerts strong frictional forces on the yarn at the time of false twist release. The inserts on the navel increases the friction between the fibers and the navel and the untwisting of the yarn might not have been completed successfully and might have caused the fiber ends protrude from the yarn body.

Effect of opening roller coating has also a significant effect on yarn hairiness ($p<0.05$). Hairiness was slightly improved with use of diamond-nickel coated opening roller instead of nickel coated opening roller. Diamond-nickel coated opening rollers are more capable of opening the bundle into individual fibers and they give less damage to the fibers than the nickel coated ORs. Diamond-nickel coated OR might have resulted in less fiber breakages than the nickel coated one. Fiber breakage means shorter fibers in the yarn which result in higher hairiness. Diamond nickel coated opening rollers are more resistant to abrasion and their service life is extended. This is also an advantage in terms of economic production.

Minimum yarn hairiness values were obtained by using the increased torque stop. It can be explained with that torque stop determines the degree of twist present in the rotor (at the peripheral twist extent zone) and with increased torque stop the wrapper fibers might have wrapped the yarn more easily as the twisting length of the fibers is higher the twisting zone in the rotor.

The ANOVA table showed that p values are 0.060, 0.153, and 0.056 for the interactions of AxB, AxC and BxC respectively. Interaction plots for hairiness were given in Figure 3.

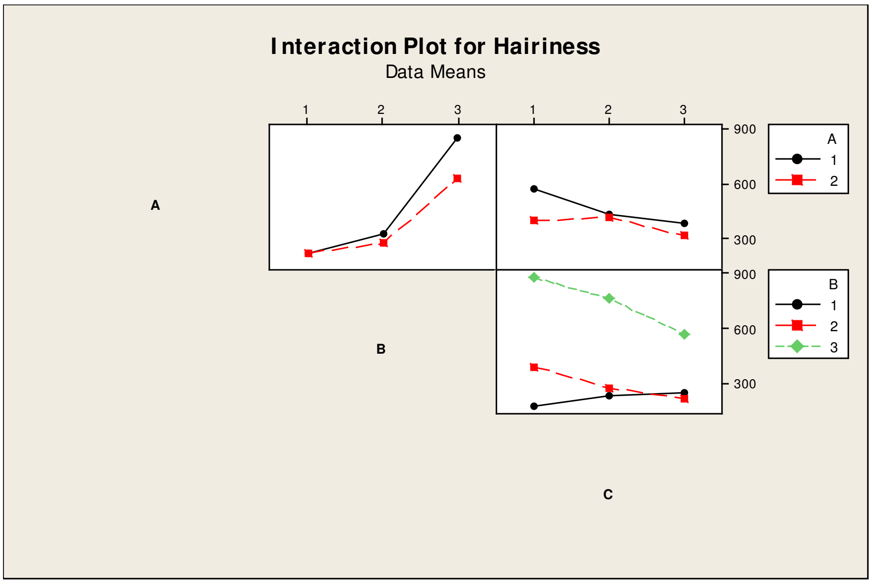

Figure 3: Interaction plots for hairiness.

In Figure 3, if the line connecting levels of both factors are not parallel; this indicates that there is meaningful interaction taking place between these factors. Interaction means the effect of the first factor does not remain the same regardless of the level of the second factor and vice versa. From this standpoint, there are non-negligible interactions between factors A and B (AxB), A and C (AxC), B and C (BxC).

4. CONCLUSION

In this research, effects of some spinning component parameters such as opening roller coating, navel configuration and torque stop type on the hairiness of Ne 30/1 rotor spun cotton yarns is studied by designing a full factorial experiment. ANOVA-factorial was performed using Minitab 16.0 program to achieve analysis of variance. The results of the statistical analysis showed that opening roller coating, navel configuration and torque stop type had significant effects on yarn hairiness. Navel type has the largest effect on yarn hairiness. Presence of whirl inserts in the spiral navels deteriorates the hairiness of the yarns. The effect of opening roller coating is slightly larger than that of torque stop type. Yarn hairiness is improved with use of diamond-nickel coating on opening roller. Besides, minimum yarn hairiness values were obtained by using the increased torque stop.

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CRITICAL STAGES IN THE SPINNING PROCESS OF THERMOPLASTIC FIBERS WITH MICRO / NANOPARTICLES

Mirjam LESKOVŠEK, Urška STANKOVIĆ ELESINI

Abstract: *The melt spinning process of thermoplastic fibers with embedded micro / nanoparticles presents a major challenge for researchers. Both micro and nanoparticles have the tendency to cluster and this phenomenon result in difficulties at spinning or even make the spinning impossible. Thus the spun fibres are often uneven. Fibres with incorporated micro / nanoparticles have already been made in our previous attempts. But the investigations of these fibres have shown that they have poor properties due to the formation of the particle' clusters. So the goal of further research was to determine at which stages the clusters occur and how to avoid them.*
Micro / nanoparticles, used in our research, were made in the form of suspension, so they had to be dried. It has been found that most of the clusters already formed during the drying phase. Powderly dried micro / nanoparticles, must be prior fibre spinning process, processed into adequate, for spinning appropriate form. Otherwise, the powder settles on the walls of the dosing device, instead of moving in the extruder. When handling with the powder, it was necessary to pay attention to the environmental conditions, since the micro / nanoparticles, used in the research were sensitive to atmospheric moisture, leading into further aggregation.
Processing of powder particles into appropriate spinning form leads to production of spinning concentrate (i.e. masterbatch). The preparation of masterbatch includes incorporation of powder particles into basic polymer and granulation of cooled, dried mixture. The advantage of preparing the masterbatch is also in the fact that clusters of particles, formed in drying process, can be broken into smaller aggregates by forces of the kneading process of masterbatch.
Prepared masterbatch with micro / nanoparticles is now suitable for final preparation of fibres, although the fibre spinning is limited to the amount of added particles. According to several researches the amount does not exceed a few per cent of fibre mass.

***Key words**: spinning process, microcapsules, nanocapsules, agglomeration, clusters, masterbatch*

1. INTRODUCTION AND THEORY

The biggest problem by melt spinning of thermoplastic fibres with micro / nanoparticles is the size of the particles and the resulting particle clusters. Therefore, the process requires additional preparation of raw materials, as follows in the present study. The input fibre components (thermoplastic polymer granules, suspension of micro or nano particles) are prior the spinning process subjected to two main procedures:
1. drying of aqueous suspensions with micro/nanoparticles (because the aqueous suspension is inappropriate for the spinning process, it has to be dried into the powder),
2. making an appropriate spinning concentrates from fibre forming polymer and dried microcapsules (because of its size, the powder form of microcapsules is not suitable for direct feeding of the spinning device; therefore the granular form of input spinning components are required).

The adverse effect that occurs between these two procedures is the creation of suitable conditions for particles aggregation, which further leads to their uneven distribution in the fibres and their deformation.

The idea of incorporation of microcapsules in the fibres by melt spinning process brings two fields that have not been fully explored yet:
- drying of aqueous suspensions of particles and
- producing the polymer concentrates with microcapsules (e.g. masterbatch).

2. EXPERIMENTAL WORK

In our research, microparticles were microcapsules with the average size 1,91 microns. According to our previous research we found out that both particles (micro and nano) behave were similarly in the preparation phases of spinning. They both have tendency to cluster. The clusters disturb spinning process, especially at the production of very fine fibres.
Microcapsules in our research were incorporated into polypropylene fibres (narrow molecular weight distribution, MFR = 30 g/10min, T_m= 145C)

The process of fibre production in our research was composed of the following phases:
- production of microparticles in the form of suspension (aqueous solution);
- drying of aqueous suspension with the intention to get powder, which will be suitable for melt spinning;
- an appropriate storage of dry particles;
- production of masterbatch with the microcapsules;
- fibre spinning with added masterbatch.

The key parameters of each phase are presented in Table 1. To verify the results of each phase testing methods are also added to the following table.

Table 1: The successive phases of thermoplastic fibres production with additives and their key parameters.

Phase		Key parameter	Testing method
Particle production		- type of chemicals - time of production - other parameters (pH, T)	- particle size distribution - SEM microscopy (size and deformation) - deformation of particles
Particle conversion into powder		- type of drying (dryers) - concentration of suspension - time and velocity of drying	- dried particle size distribution - SEM microscopy (size and deformation of particles and formation of clusters)
Storage of dried particles		- humidity and temperature at drying process - storage conditions	- SEM microscopy (formation of clusters)
Mixing of particles with polymer granules	**Direct feeding of spinning device with dried particles**	- method of dosing	-
	Manufacturing of masterbatch	- type of mixing (by hand or mechanical) - mixing temperature - mixing velocity	- SEM microscopy (deformation of particles and formation of clusters)
Fibre spinning		- addition of lubricant (if needed) - other parameters of the spinning device	- particle size distribution in fibres - confocal microscopy - SEM microscopy (fibre morphology, longitudinal split and cross section view of the fibres, deformation of particles)

According to the previous research, the following two critical phases are essential:
1. drying of aqueous suspension into a powder and
2. production of masterbatch.

2.1 Drying of aqueous suspension into a powder

To prevent the particle cluster formation in the initial stages of the fibre production, the appropriate type of drying should be chosen. Two different kinds of the drying processes have been studied in this research:
1. spray drying with the mixed flow and
2. spray drying with co-current flow.

Comparative parameters for both types of drying are shown in Table 2.

Table 2: Comparative parameters for spray drying with mixed and co-current flow.

Key parameter	**Type of drying**	
	Mixed flow stream	**Co-current flow stream**
Principle of drying	Drying air enters at the top and the atomizer is located at the bottom	Particle suspension and hot air pass through the chamber in the same direction
Drying temperature	Inlet T = 240 °C Outlet T = 80 °C	180 °C
Drying velocity	40 ml/min	3 ml/min
Concentration of the suspension of the particles	8%	2% – 8%

2.2 Production of masterbatch

The production of polymer concentrate with particles is the further phase in which may come to clustering of particles. The process can be done in two ways:
1. by mixing of components manually,
2. by mechanical mixing of components.

In the case of a manual mixing it was necessary to use the lubricant. The amount of dried microcapsules was limited.

In the case of mechanical mixing, the kneading-mixing device was used in which all the materials were heated above the melting point of the thermoplastic polymer. The melt is mixed with two rotors. The cooled melt was furthermore granulated. The conditions of described preparation are given in the Table 3.

Table 3: The condition parameters of the masterbatch preparation at kneading-mixing device.

Kneading parameter	**Value**
Frequency of the rotors [min^{-1}]	50
Kneading temperature [°C]	200
Kneading time [min]	7

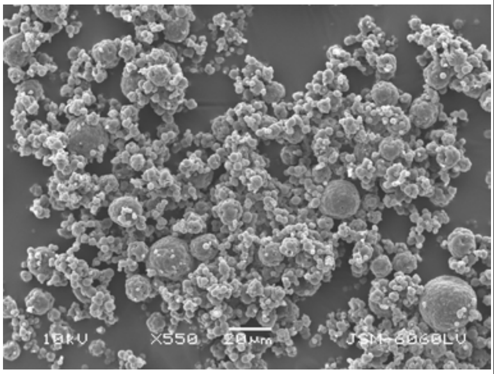
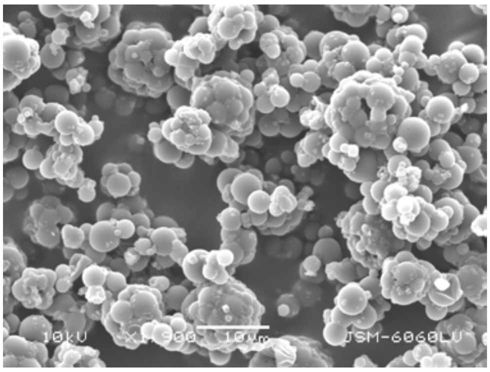
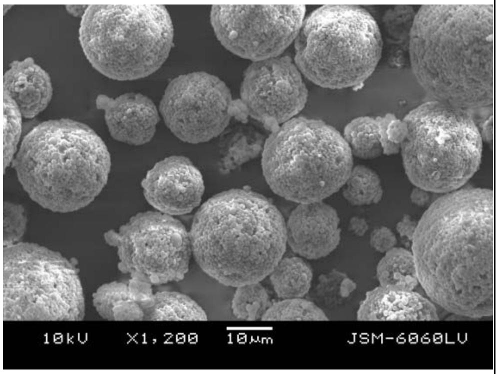
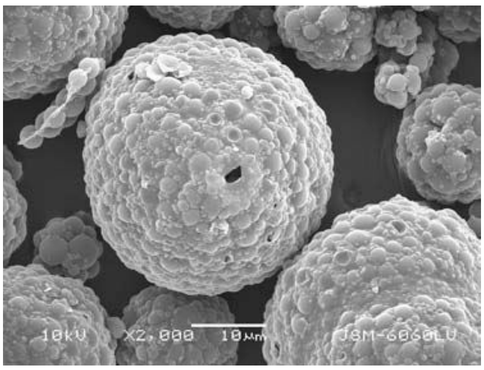
3. RESULTS

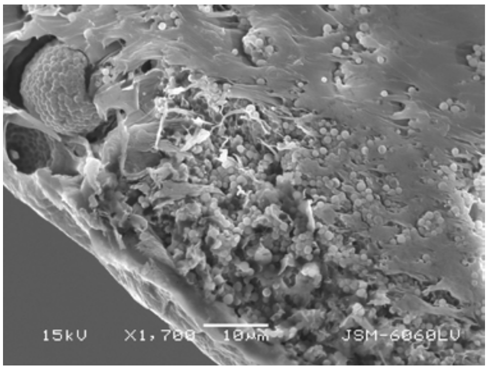
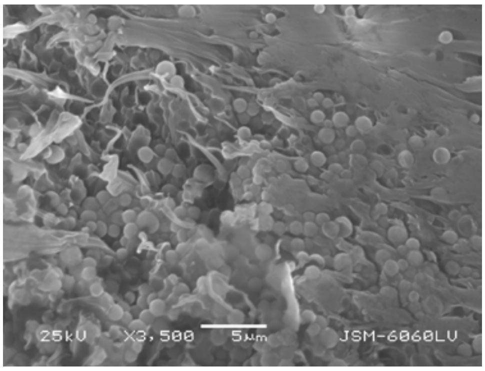
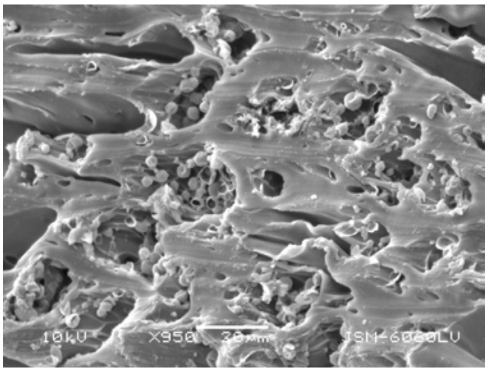
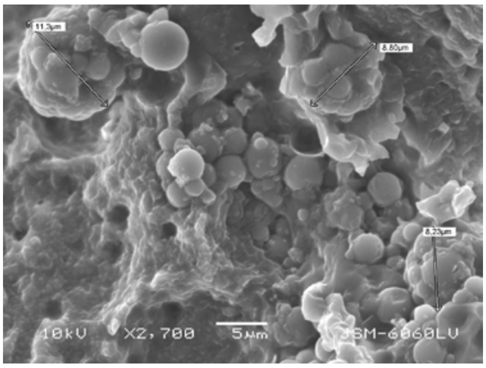
During the research, two main parameters were followed:
- size distribution of microcapsules, through which the size and number of clusters were pursued and

- deformation of microcapsules.

The results of the particle size distribution and deformation are shown in the Table 4. Particle size distribution was determined by particle size analyser while deformation of microcapsules was evaluated by Scanning Electron Microscope (Figure 1-8).

***Table 4**: Evaluation of size distribution of microcapsule and deformations after two different methods of drying and mixing.*

	Particle size distribution	**Deformation of the particles**
Co-current flow of drying	Mean size of the particles (microns): 6,82. Mean size of the clusters (microns): < 20.  *Figure 1: Microcapsules dried with co-current flow (SEM, magnification: 550 x).*	No deformation found.  *Figure 2: Microcapsules with no deformation, dried with co-current drying flow (SEM, magnification: 430 x).*
Mixed flow of drying	Mean size of the particles (microns): 16,27. Mean size of the clusters (microns): < 60.  *Figure 3: Microcapsules dried with mixed flow of drying (SEM, magnification: 1.200 x).*	No deformation found.  *Figure 4: Microcapsules with no deformation, dried with mixed drying flow (SEM, magnification: 2.000 x)*

Manually preparation of masterbatch	Larger clusters.  *Figure 5: Microcapsules in larger clusters, manually preparation of masterbatch (SEM, magnification: 1.700 x).*	No deformation found.  *Figure 6: Microcapsules with no deformation, manually preparation of masterbatch (SEM, magnification: 3.500 x).*
Mechanical preparation of masterbatch	Smaller clusters.  *Figure 7: Microcapsules in smaller clusters, mechanical preparation of masterbatch (SEM, magnification: 1.000 x).*	Small deformation.  *Figure 8: Microcapsules with small deformation, mechanical preparation of masterbatch (SEM, magnification: 2.700 x).*

4. DISCUSSION AND CONCLUSION

The common problem at melt spinning with different types of additives is aggregation, especially when micro/nano particles are involved. Numbers of parameters influence the mentioned phenomena. In this research it has been found that the clusters arise mainly in three phases of pre-spinning process: when microcapsules are converted from aqueous suspension into the dry powder, while storage the particles and in the preparation of masterbatch.

In selecting the method of drying it is important to choose co-current type of spray drying in which liquid particles and drying air travel in the same direction. In this way, the water evaporates faster, which prevents the formation of large aggregates of particles. When drying with mixed-flow, microcapsules remain longer in the hot air and as a consequence large clusters occur more often. The deformation of particles is not visible at any type of drying process.

When making masterbatch, microcapsules are mixed with the granules of basic polymer. Manual feeding of spinning device with dry microcapsules and granulates of polymer the same time is not appropriate. The microcapsules stick to the walls or feeding device and hinder evenly feeding of extruder screw. Therefore the particles are not distributed homogeneously in a polymer melt and in the fibre. However, when masterbatch is produced by mixing microcapsules with the basic polymer, kneading equipment has to be involved. Mixing it by hand is not sufficient to achieve the homogeneity of mixing. The deformation of the particles, resulting from mechanical blending, is minimal.

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EXPERIMENTAL STUDIES OF THE DEFORMATIONAL PROPERTIES OF SINGLE TUCK STITCH FABRICS

Nadiia Bukhonka

Abstract: *The paper is devoted to the experimentally investigations of the stretch and recovery properties of the nine types single tuck stitch fabrics comparing with plain knit fabric. The knitted fabrics are produced by the flat knitting machine 10 gauge from the 31 x 2 tex half-wool yarn. The structures repeat at height of knit fabrics consists of combination of two courses: plain and plain tuck stitches with different stitch repeat at the width R_b = m x n (m – the number of knit loops, n – the number of tuck loops). The results of investigation showed that the total deformation of knitted fabrics and its component decrease along width but, practically not change along length*

Key words: *tuck stitch, stitch repeat, deformational properties, total deformation, rapidly reversible deformation, slowly reversible deformation, irreversible deformation*

1. INTRODUCTION

Clothing comfort during usage of the apparel and fitting cloth to the human body is very important characteristic of the knitted fabrics. Amongst other it depend on the deformational properties of the fabrics. Breaking load characterized durability and wearing quality of the cloth in the process of exploitation even if cloths, in the process of and use, are exerted to considerably less deformation and tensile stress then breaking load. Different yarn and knitted fabric structures respond differently on deformational properties.

Basic stitches (interloping), the loop index, the stitch repeat in the width of tuck stitches and other factors are influence on the all properties of the tuck stitch knitted fabrics. Dimensional properties of tuck stitches are investigated in the papers [1-11] and concluded that combination order of knit-tuck stitches played an important role in all properties of the knit fabrics. In the paper [5] are indicated that tuck stitch fabrics have the lowest resistance to abrasion. The density fabrics decrease with increase the loop length in the stitch repeat on the tuck stitch, and the density ratio factor isn't change [6]. The analyses of investigations results about influence of the different stitch repeat in the width of tuck stitches on the dimensional properties of knit structures has demonstrated the importance of the stitch repeat in the width [8]. Comparing with plain knit fabric, the tuck loops reduce fabric length and length-wise elasticity, the higher yarn tension on the tuck and held loops causes them to rob yarn from adjacent knitted loops making them smaller and providing greater stability and shape retention [9-11]. The width of single tuck stitches is bigger and length is smaller than in plain fabrics produced on the same equal numbers of needles with equal numbers of courses and length of the loop yarn. That could be explained by tendency of tuck loops to unbend what causes that adjacent loops wale draw aside creating the idle between the wale. At the same time the surface of single tuck stitch fabrics decrease and surface density increase compared to the plain knit fabrics [9, 10].

The dimensional characteristics, tensile properties and strength behavior of the fabric and yarn of different type of knitted fabrics were subject of many investigations [12-20]. Influence of different type of knit fabrics, especially 1x1 rib, half-cardigan rib, half-milano rib, interlock, single-pique and cross miss interlock, made from cotton yarn of the different densities on the mechanical properties are investigated in the paper [12]. The investigation showed that with increase density of knit fabrics the tensile properties such as linearity of load-extension, tensile energy and tensile resiliency tended to increase. The tensile resiliency value was much greater in the course direction than the wale direction for 1x1 rib, half-cardigan and interlock, but for another of the knit structures this differences were negligible. In generally, the elongation greater in the course direction than in the wale direction. Analyses of deformations of the interlock knit fabric in the wale and course directions are presented in the paper [14]. The study indicated that when knitted fabric sheet is subject to a tension along wale direction an extra compressive stress field inside loop in course direction is induced. Simulation of the elongation deformation of weft-knitted fabrics and weft knitted reinforced composites made of glass fibers in one, two and multiple directions are presented in the paper [15]. The works shows the efficiency of the Finite Element Method for the complex analyses of the knitted fabrics. Hysteresis phenomena of tensile load (stress) under extension and recovery process were estimated in terms of time dependence of tensile load by using several kinds of knitted fabrics [19]. Tensile load extension and recovery processes two kinds of plain fabrics from cotton and polyurethane yarns are investigated in the paper [20].

The main objective of this research is to analyze the influence of the presence of tuck stitch loops of different stitch repeat at the width on the deformational properties of single knit fabrics.

2. EXPERIMENTAL PART

2.1. Preparation of samples

The samples of single knit fabrics were knitted on a 10 gauge V-bed flat bed-knitting machine with 200 needles from 31 x 2 tex half-wool yarns. The following parameters in the process of knitting were used: the stitch cam, yarn tension and take-down were constant.

After being knitted the fabrics were for 24 hr laid on the flat surface under a standard atmosphere to facilitate recovery from the stress imposed by knitting. After this dry relaxation the fabric samples were washed in a household fully automatic washing machine with woolen program which at 30°C containing 3 g/l of an efficient wetting agent according [21, 22]. After wash relaxation, the fabrics were laid, with minimum stress, on flat surface under a conditional atmosphere for at least 24 hr.

2.2. Measurements of fabrics dimensions

Graphical representation the plain (variant 1) and nine type of tuck stitch (variants 2-10) knit fabrics are presented in the Table 1, where the stitch repeat in the width $R_b = m \; x \; n$ (m – the number of knit loops, m = 1, 2 or 3, n – the number of tuck loops, n = 1, 2 or 3).

After wash relaxation the following properties of the knitted fabric were measured:

- <u>main characteristics of knit structures</u>:
  - the densities of knitted fabric in horizontal D_h (the number of wales per 100 mm) and vertical D_v (the number of courses per 100 mm) at 10 different places of each samples;
  - the length of yarn of the one loop l in the mm – determined as an average of twenty unrowed courses (plain – l_1, tuck stitch – l_2);
  - the mass of 1 m^2 m_s in the g/m^2 – determined as an average from the mass of 5 samples, each having an area 200 cm^2;
  - the thickness M in the mm – determined as an average from the thickness at 10 different places on every samples;
- <u>deformational properties</u> of 5 samples of 150mm x 25mm nominal dimensions in wale and course directions according [10, 22, 23]. Specimens were clamped over an area of 25mm x 25mm at each end leaving a gage length of 100 mm. The samples are stretched to a fixed load 6 N during 60 min on the testing machine. After stretched the fabrics were laid on flat surface for at least 120 min.

After measurements the deformational characteristics in wale and course directions were calculated by the following formulas [10, 23]:

- total deformation:

$$E = E_1 + E_2 + E_3 \quad \text{or} \quad E = \frac{L_1 - L_0}{L_0} \cdot 100, \tag{1}$$

- rapidly reversible deformation:

$$E_1 = \frac{L_1 - L_2}{L_0} \cdot 100,$$

(2)

- slowly reversible deformation:

$$E_2 = \frac{L_2 - L_3}{L_0} \cdot 10 \quad (3)$$

- irreversible deformation:

$$E_3 = \frac{L_3 - L_0}{L_0} \cdot 100, \quad (4)$$

where L_0 – original distance between bench marks prior to tension force (100 mm), mm;
L_1 – distance between bench marks, measured while specimen is under tension force following 60 min, mm;
L_2 – distance between bench marks, measured after release of the tension force following 8 s of recovery, mm;
L_3 – distance between bench marks, measured after release of the tension following 120 min, mm;

3. RESULTS AND DISCUSSION

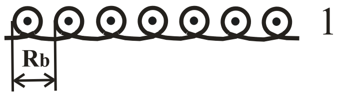
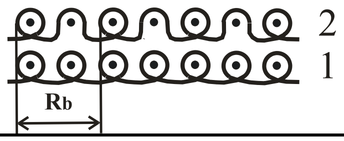
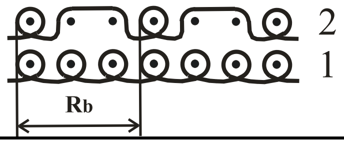
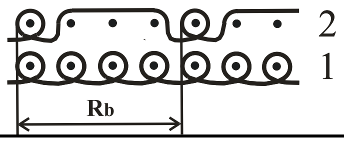
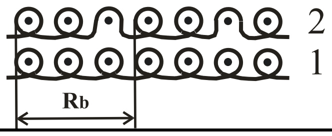
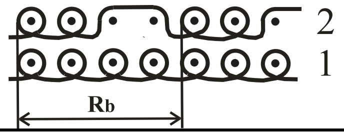
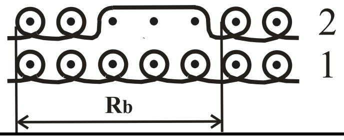
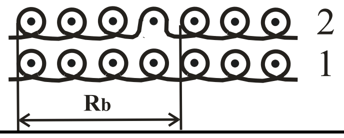
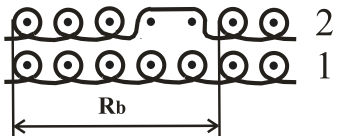
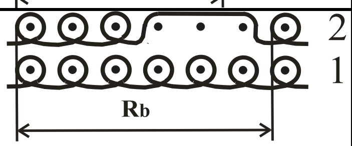
The structure of tuck stitch fabrics (variants 2-10) consist of the loops of normal height and tuck loops. The results of investigations of the influence of the different stitch repeat in the width R_b on the dimensional properties of tuck stitches are presented in the paper [8]. The wales W, courses C and fabric density S are depends of the stitch repeat in width R_b of tuck stitches. With increase the number on knit loops m from 1 to 3 at constants numbers of tuck loops n = const (1, 2 or 3) the wales W of tuck stitch are increasing linearly, and the courses C and the fabric density S are decrease. With increase the number on tuck loops n from 1 to 3 for constant the number of knit loops m = const (1, 2 or 3) the courses C of tuck stitch is linear increase, and the wales W and the fabric density S are decrease.

Deformation of knitted fabrics during extension is passing as a process of destroy of inner equilibrium systems of loops which taking place trough:

- changes in configuration of loops on the way that some part of loop yarn straightening, the other part more bending at the same time increasing the length of specimen in the direction of extension, and shrinkage in the direction perpendicular to extension;
- change in yarn orientation (mostly in the direction of disposition the yarn in the loop) and simultaneously increase the sum of the length projection of the part of yarn in the loops in relation to the direction of extension;
- displacement the contacts point between yarn causing the change of some part of the loop length on the account of the adjoining loops in the presence of yarn friction;
- stretching or shrinking separate part of yarn in the loop taking part simultaneously.

The intensity of deformation and relaxations of knitted fabric are characterized by total deformation, which consist of the rapidly reversible, slowly reversible and irreversible deformations.

Table 1. Graphical representation of knit fabrics and main characteristics of structure

Varia-nts of fabrics	The structure repeat in the height	Graphical representation of knit fabrics	*m*	*n*	D_h	D_v	l_1, *mm*	l_2, *mm*	m_s, g/m^2	*M*, *mm*
1.	Plain		1	0	87	88	6,45	-	373	0,81
2.	Tuck 1x1 Plain		1	1	70	72	6,34	9,97	382	0,86
3.	Tuck 1x2 Plain		1	2	64	75	6,47	10,75	391	0,88
4.	Tuck 1x3 Plain		1	3	61	78	6,84	15,46	394	0,92
5.	Tuck 2x1 Plain		2	1	71	62	6,15	12,21	383	0,89
6.	Tuck 2x2 Plain		2	2	68	67	6,23	13,61	390	0,90
7.	Tuck 2x3 Plain		2	3	64	70	6,49	14,76	392	0,94
8.	Tuck 3x1 Plain		3	1	76	57	6,24	8,41	382	0,90
9.	Tuck 3x2 Plain		3	2	72	62	6,31	9,88	384	0,93
10.	Tuck 3x3 Plain		3	3	64	64	6,36	11,64	386	0,95

Rapidly reversible deformation in the knitted fabric is in connection with elasticity of the yarn and interloping and stand for linear part of the force extension curve up to the yield point which recover after the force is removed. Slowly reversible deformation is in connection width leveling of the stress in the part of the loops and change in the loops form during of which residual part of elastic deformation continue to recovery. Irreversible deformation is in connection with displacement the contacts point inside loops and deformation of yarn (collapse, elongation and the like) and begins after a little more continued observation of deformation when rapidly and slow reversible deformation is not visible. That part is considered as residual extension or irreversible deformation. According to this when knitted fabrics is subject to forces below its yield point then most of the extension is recoverable (reversible extension) but if forces is sufficient to extend fabric beyond yield point that fraction of the extension will be permanent (irreversible extension).

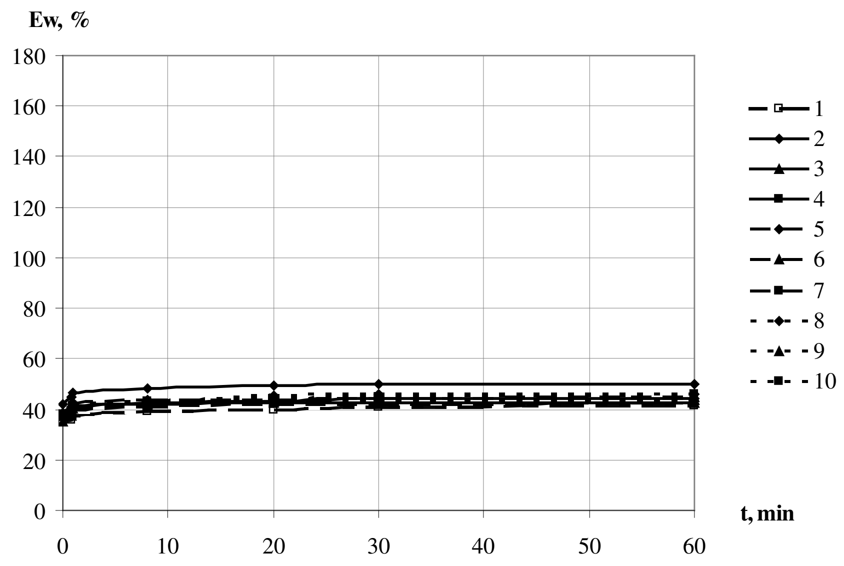
Investigation of tensile testing is carrying out by testing machine under constant loading of 6 N within the cycle «loading – unloading – relax».

At the stage «loading» the deformation by extension of knitted fabrics is taking place with perturbation of extern an inner connection between elements of knitted fabrics structures. Thank to the structure of the knitted fabrics their inner and outer connections are determined by forces of friction and cohesion witch arise between loops yarn. Intensity of friction force depends on elastic unbending characteristics of the yarn. At this stage is taking place total deformation.

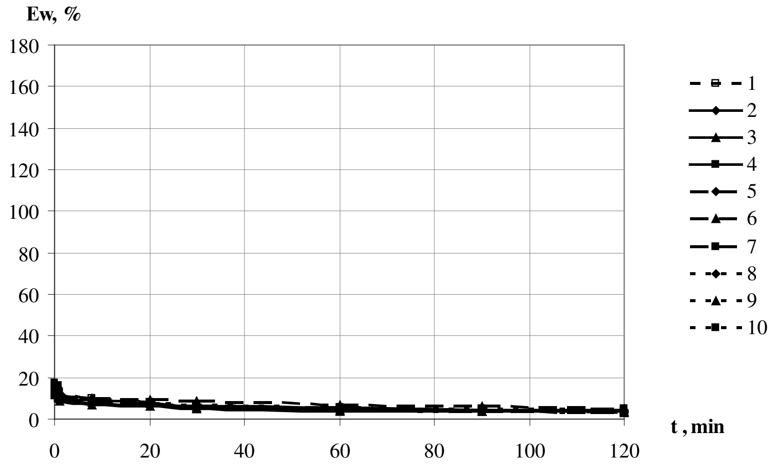
On stage of «unloading» after removal of the force, the knitted fabrics begin reverse process of relaxation. Thanks to elastic forces the treated samples recover its original dimension rapidly at first and than more slowly until those forces will be equal to friction forces which arise in the knitted structure. Inside «relax» stage it is possible to define rapidly reversible, slowly reversible and irreversible deformation.

The predominance of irreversible component of the total strain, changes the size and shape of the product in use, and thus the greater component of the rapidly reversible deformation in the total deformation, the better the product retains its size and shape.

Based on experimental research, the date about change of fabric the cycles «loading – unloading – relax» in the length and width directions are presented in the Fig. 1 and 2. On this figure are showed stretch of the fabrics during tension force acting 60 min (stage «loading») and after unloading and release tension following 120 min (stage «relax») in the both - wale and course direction.

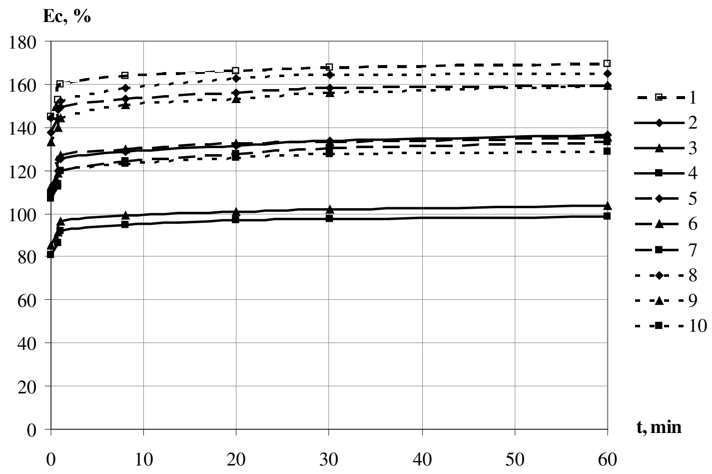


a

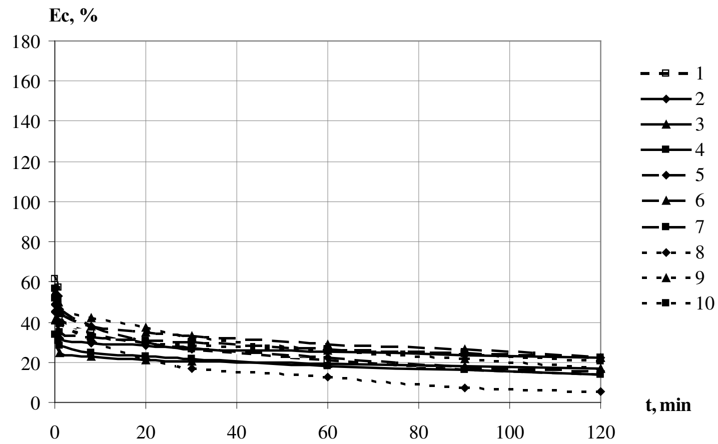


b

Figure. 1. Graphics of fabric stretch in wale direction during tension force following 60 min (a) and after release tension following 120 min (b)



a



b

Figure. 2. Graphics of fabric stretch in course direction during tension force following 60 min (a) and after release tension following 120 min (b)

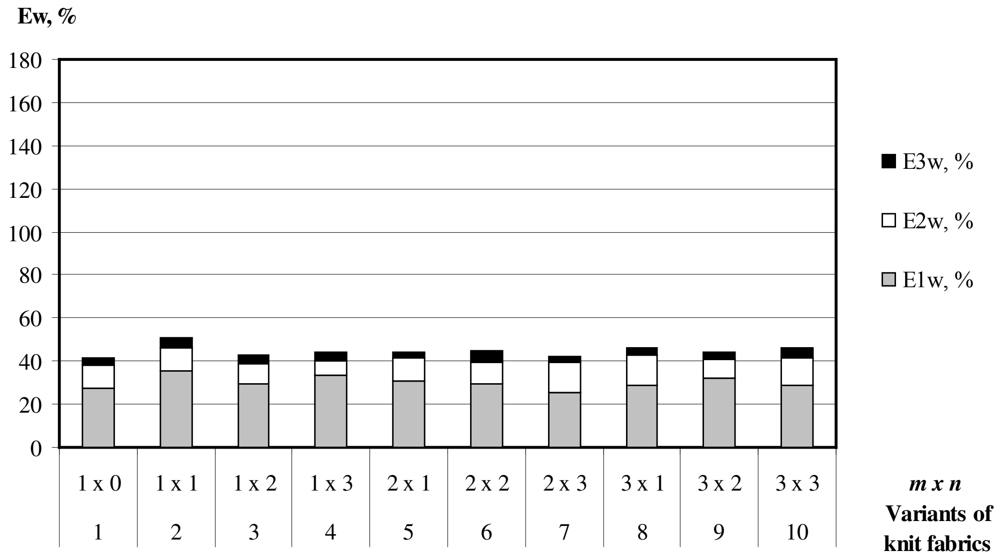
As could be seen from the Fig. 1 and Fig. 2, the main change in the length (wale direction) and width (course direction) occurred in the first 10 minutes of loading. During the «relax» stage the main change in deformation along the wale direction occurs in the first 10 minutes, and along the course direction – during 120 minutes of rest. In the process of loading and rest (Fig. 1) the repeat of tuck stitch loops has little effect on the deformation of knitted fabrics along the wale direction. In the process of loading along course direction, introduction tuck loops in to the structure of the knitted fabrics, reduces the deformation of knitted fabrics (Fig. 2, a).

The values of the different kind of deformation of tuck stitch knitted fabrics (variants 2-10) in comparison with the plain knitted fabric (variant 1) are presented on the Fig. 3. As can be seen from Fig. 3 the value of the total deformation and its components in course direction are bigger than in wale direction. The value of the total deformation in wale direction (Fig. 3, a) is between 42,4-50,0 %, what is slightly more than the plain knitted fabric (41,2 %). The value of the rapidly reversible deformation of the investigated knit fabric structures including plain knit fabric is between 25,4-35,6 %, slowly reversible – 7,2-13,8 %, irreversible – 3,0-5,2 %.

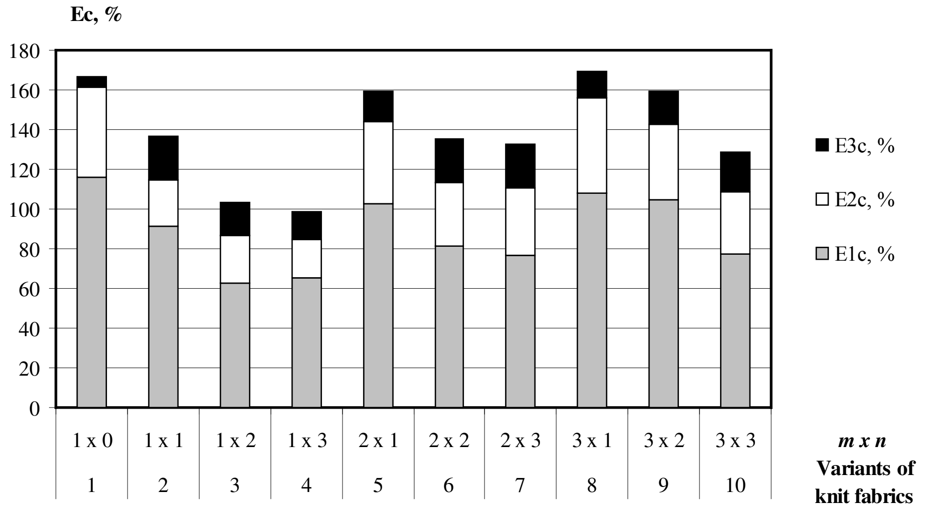
Total deformation in tuck stitch fabrics along course direction depends of different stitch repeat at the width of tuck stitches. The presence of tuck loops in the structure knitted fabric generate decrease of total deformation in comparison to plain knitted fabric The value of total deformations for tuck stitch fabrics is between 98,8-165,0 % and plain knit fabric – 169,6 %. It could be explained by presence of tuck loops in the structure of knitted fabrics which produce decrease of rapidly reversible and slowly reversible deformations and increase irreversible deformation in comparison to plain knitted fabric. The value of components of total deformation is for:

- rapidly reversible deformation of tuck stitch fabrics 62,4-104,8 % and plain knit fabric – 116,2 %;
- slowly reversible deformation of tuck stitch fabrics – 9,6-37,8 % and plain knit fabrics – 45,4 %;
- irreversible deformation of tuck stitch fabrics – 13,6- 22,4 % and plain stitch fabrics – 5,4 %.

With increase the number of tuck loops from n = 1 to 3 under constant number of loops m total deformation of knitted fabrics along the course direction decreases. With increase the number of loops from m = 1 to 3 under constant number of tuck stitch n the total deformation increases on the count increases rapidly and slowly reversible deformations (Fig. 3, b).

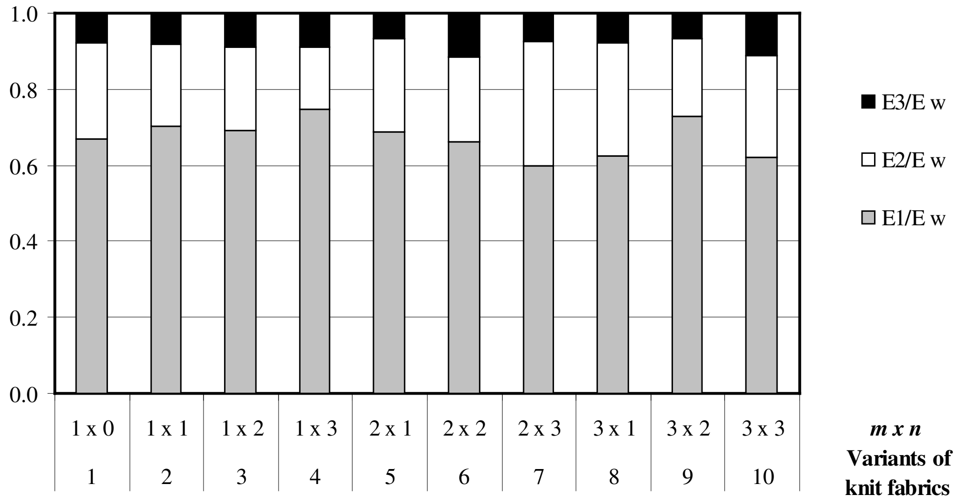


a

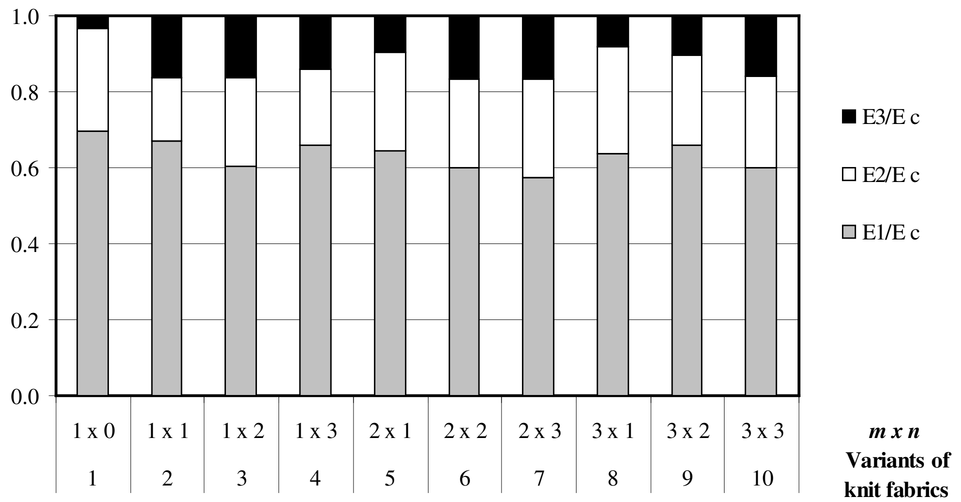


b

Figure. 3. Diagrams of deformations along wale (a) and course (b) directions of fabrics



a



b

Figure. 4. Content of the components of the total deformation on wale (a) and course (b) directions in total deformation

4. CONCLUSIONS

The analyses results of investigations about influence of the different stitch repeat in the width R_b of tuck stitches on the deformational properties of knit structures in compared with plain knit fabric, has showed following:

- the total deformation of knitted fabrics and its component along length practically not depend on the repeat in the width R_b of tuck knit fabrics;
- the presence of tuck stitch loops in the structure of knitted fabrics cause decrease of total deformation and its component, along course direction;
- with increase the number of tuck loops from n = 1 to 3 under constant number of loops m the total deformation of knitted fabrics along the course direction decreases. With increase the number of loops from m = 1 to 3 under constant number of tuck stitch n the total deformation increases on the count increases rapidly and slowly recovery deformations. This effect is attributed to a combination of different number of elements of tuck stitch (plain and tuck loops) structure.

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EXPERIMENTAL STUDIES OF THE MAIN CHARACTERISTICS OF BASIC COMPLEX WEFT-KNITTED STRUCTURES

Olena KYZYMCHUK

Abstract: *The results of research of the main characteristics of the basic complex weft-knitted structure, which repeat consists of plane course and incomplete rib course, are presented at the report. The main objective of this research is to analyze the influence of the number of the turned off needles in repeat on the main characteristics of knit structure. The fabrics have been made at the flat bed-knitting machine 10 gauge from the 50 x 2 tex blended flax-consisting yarn. All measurements of the structures parameters have been made on the fabrics at the fully relaxation stage after washing.*

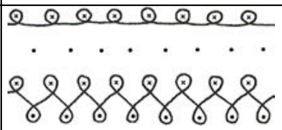
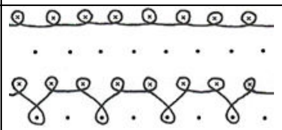
1. INTRODUCTION

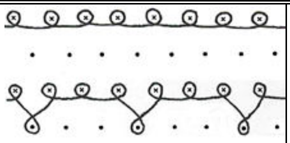
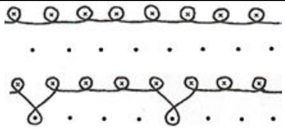
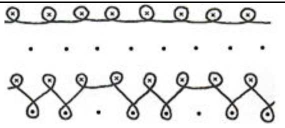
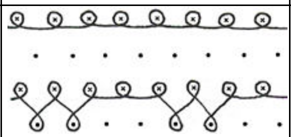
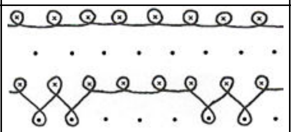
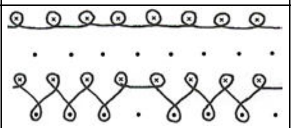
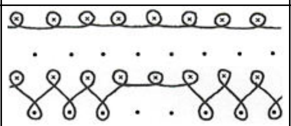
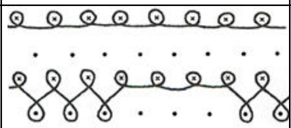
There is a tendency to the consumption of ecologically health products in the whole world. Such trend have been influencing on the textile industry of Ukraine, in particular on the production of knitwear. Therefore there is multiplying of the use of flax-consisting yarn in the knitting production. This tendency allows substantially shortening the import of cotton to our country. The subject of this research is knitted fabric of the basic complex weft-knitted structure, which has been made from 50 x 2 tex blended flax-consisting yarn (30 % flax and 70 % cotton fibre). The main objective of this research is to analyze the influence of the number of the turned off needles in repeat on the main characteristics of knit structure.

2. EXPERIMENTAL PART

The basic complex weft-knitted fabric, which repeat consists from two rows: jersey course and incomplete rib course of different repeat have been chosen to research, Fabrics have been made in follow way:
- the jersey course has been made by needles of back needlebar only;
- the incomplete rib course has been made by all needles of back needlebar and the some needles of front needlebar, which worked according to a repeat.

Table 1. Main characteristics of knit structure

Variant of knitted structure	Graphic of interlooping	number of the turned off needles in repeat		number of courses per 100 mm		number of wales per 100 mm		Loops length, mm		Thickness, mm	Basic weight, g/m²
		parts	percent-tages	face	back	face	back	plane course	not full rib course		
1		0/2	0	55	108	48	48	7,27	7,00	2,11	548,6
2		1/4	25,0	49	97	28	55	6,94	7,21	1,88	464,7

3		2/6	33,3	46	90	20	58	6,94	7,14	1,67	406,4
4		3/8	37,5	46	92	15	59	6,99	7,12	1,68	415,5
5		1/6	16,7	50	98	34	51	6,91	7,48	2,07	498,8
6		2/8	25,0	49	96	28	54	6,88	7,36	1,93	456,5
7		3/10	30,0	48	95	22	54	7,09	7,34	1,83	447,5
8		1/8	12,5	49	97	38	50	7,09	7,55	2,01	503,7
9		2/10	20,0	49	97	31	52	7,11	7,55	1,93	470,8
10		3/12	25,0	51	102	27	53	7,10	7,00	1,99	490,4

The number of on/off needles of front needlebar is 1, 2 or 3. Nine variants of the basic complex weft-knitted structures have been produced, the graphic records of which are presented in a table. The front side of the knitted fabric is a side with the skipped loops. The knitted fabric of the simple combined interloping, in which repeat the jersey course and rib 1+1 course are alternated, have been produced for comparison.

All variants of knitting fabrics have been produced at flat bed knitting machine 10 gauges with the unchanging technological parameters of knitting process (depth of sinker, yarn tension and draw-off force). The measurements of the structure parameters have been made according to standards on the fabrics at the fully relaxation stage after washing in a washing-machine. The research results are presented in a table.

3. RESULTS AND DISCUSSION

The researches have showed that the structure parameters of the basic complex weft-knitted structure are depended on the variant of the combined interlooping. Graphical and analytical dependences of stitches density from the percent (x) of the turned off needles in repeat of incomplete rib are presented on fig.1-2.

The graphics show that the stitches density of the knitted fabric is different on the front and the back side. Number of the courses at the back side (N_{cr}) is practically two times less than at face side (N_{cl}). That can be explained by the structure of these fabrics. One course of knitted structure at front side is produced by two systems; here two courses are produced at the back side of fabrics.
It should be noted that the stitches density of the knitted fabric on a wales direction goes down insignificantly (to 5 %) with multiplying the number of the turned off needles at repeat of incomplete rib.

Density of the knitted fabric on a courses direction which is expressed the number of wales per 100 мм, has opposite dependence on the variant of knitted fabrics at the face and the back side of fabric. So when the numbers of the turned off needles in repeat of incomplete rib are multiplying, the number of wales at face side of knitted fabric diminishes, that is naturally. At the same time, the number of wales at back side of knitted fabric is multiplying. It can be explained by junctures type between nearly loops. On a fabric with the less percent of the turned off needles at incomplete rib more loops junctures connect the loops, which are formed on a different needlebars. Therefore distance between the loops, which have been formed on two nearly needles of one needlebar is growing. At the same time the number of loops which have been formed in succession on the needles of one needlebar is multiplied on a knitted fabric with more percent of the turned off needles at incomplete rib, that approaches them in fabric (areas of jersey).

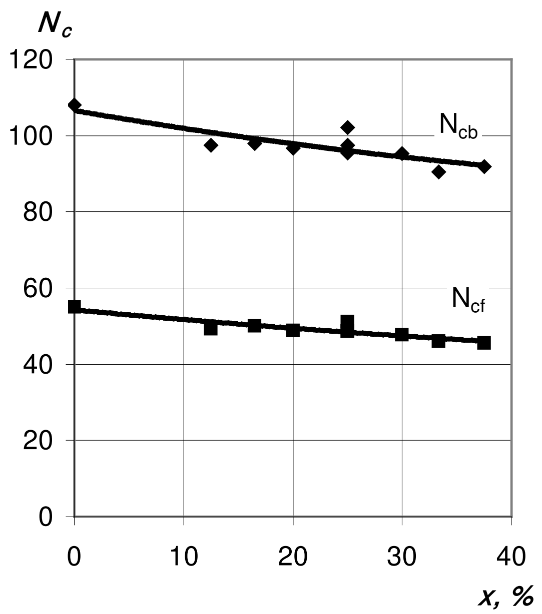


Figure 1.

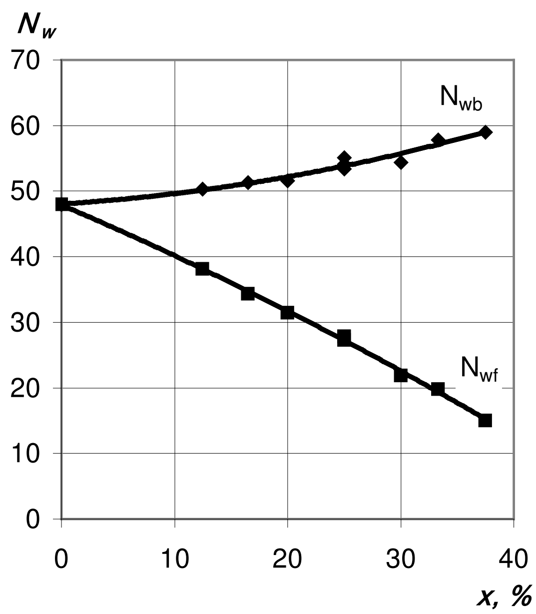
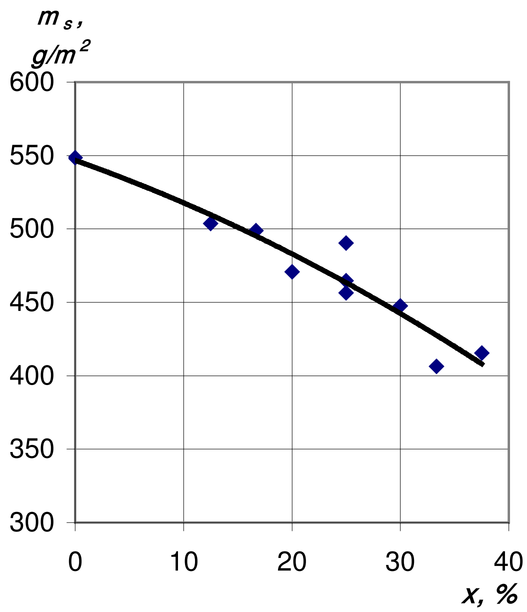


Figure 2.



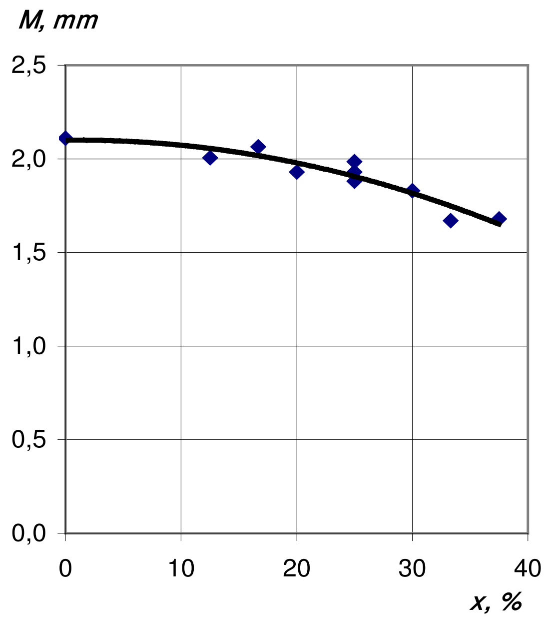


Fig.3 **Fig.4**

It should be noted that the stitches density is practically identically for the fabrics variants with the identical percent of the turned off needles (variants 2, 6 and 10) and don't depend on the repeat of incomplete rib.

The investigation of loops length show that in knitted fabrics, which have got alternation of rib 1+1 course and jersey course, the loops length of jersey exceeds the loops length of rib by 5%. The loops length of jersey is less the loops length of incomplete rib for all other variants knitted fabric of the basic complex weft-knitted structure. This difference diminishes with multiplying the number of the turned off needles at the repeat, I.e. with multiplying the areas of jersey in interlooping. In addition, the middle loops length of both courses: jersey and incomplete rib decreases with multiplying the number of the turned off needles in repeat.

The basic weight (m_s) and the thickness (M) of knitted fabrics diminishes with multiplying the number of the turned off needles in repeat of incomplete rib (fig. 3 and 4). The variants knitted fabric of the basic complex weft-knitted structure, in which the percent of the turned off needles does not exceed 20 %, have got practically an identical thickness. The thickness of fabric goes down considerably with the further increase of number of the turned off needles in repeat, I.e. with multiplying the areas of jersey,

The analytical dependences, which allow supposing the knitted fabrics properties on the planning stage, have been received on the basis of the mathematical processing of experimental data:

- the basic weight (R^2=0.91)

$$m_s = 546,73 - 2,60\,x - 0,03\,x^2\ ,$$

where x is the percentages of the turned off needles at not full rib course;

- the thickness (R^2=0,89)

$$M = 2,1 + 0,0007\,x\ - 0,0003\,x^2\ .$$

4. CONCLUSION

This research shows that number of the turned off needles in incomplete rib have substantial influence on main characteristics of the basic complex weft-knitted structure, which repeat consists of jersey course and incomplete rib course. The mathematical dependences of structure's parameters of knitted fabric from the percent of the turned off needles have been received as a result of the experiment. That allows supposing the knitted fabric properties on the stage of design.

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INVESTIGATION OF SEAM PUCKER ON SEAMS FOR TALIORED GARMENTS

Miguel Angelo Carvalho, Goran Demboski, Maja Nofitoska

Abstract: *Quality of seams is one of the most important aspects contributing to overall garment quality. Occurrence of seam pucker leads to aesthetically unacceptable appearance of garments and may cause inconvenience in wear.*
In garment manufacturing industry, manufacturers are faced with increased pressure to remain competitive which mainly depends on productivity and quality. Although, technological advances contribute to quality improvement, there is still need of predicting possibility of seam puckering occurrence and undertaking preventive actions to achieve satisfactory seams.
The paper investigates the relation between seam pucker on fabrics for tailored garments and woven fabric formability, cover and tightness. For the range of investigated fabric, the correlation was found between formability and tightness and percentage of seam pucker.

Key words*: seam pucker, formability, fabric tightness, TAV*

1. INTRODUCTION

In the apparel industry, there has been a constant increase of the degree of automation in sewing operations, directed towards improved control and higher quality. However, there are still production problems as a result of structural fabric properties having influence on garment tailorability and appearance. The appearance of seams on finished garment is one of the most important features of high quality products. The term formability has been established to describe the ability of two dimensional fabrics to get converted into three dimensional garments. The formability can be used for predicting of seam pucker occurrence, especially in sewing operations with overfeed [1, 2].

Seam pucker is defined [3] as "a ridge, wrinkle or corrugation of the material or a number of small wrinkles running across and into one another, which appear in sewing together two pieces of cloth". It has been regarded as one of the most serious faults in garment manufacturing, thus reducing the aesthetic value of garments [4]. It appears along the seam lines of garments when the material properties and sewing parameters are not properly chosen [5, 6]. For several decades, much research on seam pucker was conducted to solve the problem in garment manufacturing. Researchers, including Dorkin and Chamberlain [7], identified four primary causes of puckered seams.

To be able to reduce percentage of defect garments we must monitor the sewing process. Chmielowiec and Lloyd [8] have equipped a Pfaff lockstitch machine with sensors measuring presser-foot force and displacement, thread tension and needle penetration force. They were able to detect the effect of "presser-foot bouncing", and analyzed some correlation between presser-foot compression force and seam pucker.

Park and Ha [9] developed a process for optimizing sewing conditions to minimize seam pucker using the Taguchi method. The parameters selected for optimization have been: sewing speed, stitch length, sewing thread tension and presser foot pressure. Dobilaite and Petrauskas [10] supposed that the shear and flexibility of the fabrics are the main factors influencing occurrence of puckering, as they determine fabric deformation during sewing process. Besides shear and flexural properties and thickness, they have found that surface density, extensibility and formability are also associated with this defect. Dobilaite and Juciene [11] investigating the effect of rotational frequency of a sewing machine main shaft and pressing force on seam pucker. It was established that in all causes that the pucker height increases with growing rotational frequency of the main shaft, and decreases with increasing pressing force. Mariolis and Dermatas [12], have proposed a method of estimating the seam pucker with automatic control of the seam quality focusing only on the evaluation of seam pucker. Mak and Li [13] have presented an objective method by using image analysis and pattern recognition technologies.

Beside the increase of degree of automation and monitoring, there is still need of getting information before the production regarding fabric inclination to puckering and taking actions to minimize its incidence. The aim of this paper is to investigate the occurrence of seam pucker of a range of woven fabrics of various structural parameters and finishing, and to investigate the relations between seam puckering and factors describing fabric structural properties.

2. EXPERIMENTAL

A range of wool and wool blend woven fabrics for outerwear garments having various structural parameters were investigated for seam puckering. The details of fabrics structure are shown in Table 1. Fabric thickness varies from 0.29 to 0.45 and fabric weight from 167-250 g/m^2. Regarding weave, all the samples have small repeat weaves: plain, 2/1 twill and 2/2 twill weave.

Table 1: Investigated fabric structure details

Samples	Composition	Fabric thickness, mm	Fabric weight, g/m^2	Warp density, cm^{-1}	Weft density, cm^{-1}	Finishing	Weave
A	98% wool 2% Lycra	0.36	213	32	24.8	standard	2x1 twill
B	98% wool 2% Lycra	0.41	227	32	26.2	standard	2x1 twill
C	100% wool	0.29	167	31.2	27.6	standard	2x1 twill
D	100% wool	0.34	187	31.2	28	standard	2x1 twill
E	100% wool	0.39	213	30.8	25.6	¼ milled	2x2 twill
F	100% wool	0.41	227	30.8	28.2	¼ milled	2x2 twill
G	44% wool 54% PES 2% Lycra	0.39	200	29	20	standard	plain
H	44% wool 54% PES 2% Lycra	0.39	200	29	20	waterproof and oilproof	plain
I	44% wool 54% PES 2% Lycra	0.45	250	35.4	24.4	standard	2x2 twill
J	44% wool 54% PES 2% Lycra	0.45	250	35.4	24.4	waterproof and oilproof	2x2 twill

The seams type 1.01.01, applying stitch type 301 were produced using PFAFF industrial lockstitch sewing machine. The samples were produced in warp and weft direction. All the samples were sewn using needle size of 100 Nm, Tt=25tex sewing thread, at constant machine speed.

The degree if seem pucker for the sewn samples was calculated using the equation of seam pucker percentage. The percentage of pucker in the seam is calculated from the difference between the thicknesses of the seam and the double thickness of the tested fabrics (1):

$$SP = \frac{(T_2 - T_1)}{T_1} \cdot 100 \quad [\%] \tag{1}$$

Where:
SP - seam pucker (%)
T_1 - double thickness of fabric (two layers of fabric), (mm)
T_2 - seam thickness, (mm)

In order to investigate fabrics mechanical properties under low loads, the samples were tested on a KESF system for fabric objective evaluation under small loads. The formability of the samples was calculated using Kawabata i Niva equations:

$$F = \frac{EM}{F_m \cdot LT} \cdot B \cdot \frac{G}{2HG5} \tag{2}$$

Where:
EM - extension at 500 gf/cm
B - fabric flexural rigidity, $g \cdot cm^2 / cm$
G - fabric shear rigidity $g / cm \cdot \deg$
F_m – maximum force of fabric extension (500 gf/cm)
LT - linearity of the stress strain curve
$2HG5$ - histeresis of bending rigidity at 5^0g/cm
The fabric total fractional cover was calculated using Pierce equations:

$$C_f = C_1 + C_2 - C_1 \cdot C_2 \tag{3}$$

Where:
C_f, C_1, C_2 are fabric total fractional cover, warp cover and weft cover respectively.
Fabric tightness was calculated in average, warp, and weft direction:

$$T_f = \frac{t_1 + t_2}{t_{1\max} + t_{2\max}} \tag{4}$$

$$T_1 = \frac{t_1}{t_{1\max}} \tag{5}$$

$$T_2 = \frac{t_2}{t_{2\max}} \tag{6}$$

Where:
T_f, T_1, T_2 are respectively fabric average, warp and weft tightness.
t_1, t_2 are respectively warp and weft density
$t_{1\max}, t_{2\max}$ are respectively maximal warp and weft density.

Maximal warp and weft density are calculated using Seyam and El-Shiekh and Russell equations (14).

3. RESULTS AND DISCUSSION

The results of seam pucker percentage are shown in table 2.

Table 2: Seam pucker of seams in warp and weft direction

Samples	T_{21}*	T_{22}	T_1	SP_1	SP_2
A	0.95	0.92	0.36	31.94	27.77
B	1	0.95	0.41	21.95	15.85
C	0.9	0.85	0.29	55.17	46.55
D	0.95	0.9	0.34	39.71	32.35
E	1.05	1	0.39	34.62	28.2
F	1.07	1.02	0.41	30.49	24.39
G	0.95	0.9	0.39	21.49	15.38
H	0.95	0.9	0.39	21.49	15.38
I	1.15	1.1	0.45	27.77	22.22
J	1.15	1.1	0.45	27.77	22.22

SP - seam pucker, (%)
T_2 - seam thickness, (mm)
T_1 - double thickness of fabric (two layers of fabric), (mm)
*Note: The indices 1 and 2 is respectively for samples by warp and weft direction

The results in table 3 indicate differences in seam pucker percentage regarding samples in warp and weft direction. The samples sewn in warp direction have greater percentage of pucker for all tested samples. The difference in seam pucker percentage regarding both directions is due to different mechanical properties of the fabric in principal directions. Namely, all the samples have asymmetrical set i.e. greater thread density in warp direction, which affects the severity of seam pucker. The seam pucker values ranges from 55.17% for the sample C in warp direction to 15.38% for samples G and H in weft direction. Sample C shows greater percentage of pucker in both principal directions followed by sample D which show second highest seam pucker in both directions.
The Total appearance values (TAV) calculated from KESF-B system along with formability values are shown in table 4.

Table 4: TAV values and formability of investigated samples

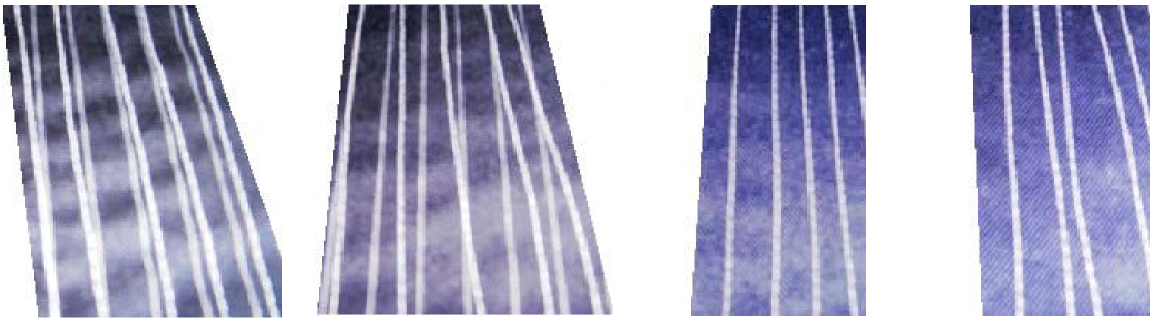
Samples	TAV	*F_1, mm^2	**F_2, mm^2	***F, mm^2
A	2.88	0.0589	0.425	0.1881
B	2.78	0.0576	0.385	0.1783
C	1.73	0.021	0.1214	0.0596
D	1.87	0.031	0.0841	0.0537
E	2.35	0.0473	0.1735	0.0992
F	2.43	0.0503	0.1691	0.1005
G	2.61	0.0208	0.3993	0.1343
H	2.73	0.0432	0.3416	0.1508
I	3.91	0.0281	0.6323	0.2044
J	4.04	0.0264	0.5804	0.1877

**F1-formability in warp direction, **F2-formability in weft direction, ***F-average formability*

It can be seen that there is relation between percentage of seam pucker and formability. The samples C having higher pucker obtains lowest formability in average, warp and in weft direction out of all tested samples. As expected, sample D which has second highest percentage of seam pucker have the second lowest average formability values. Additionally, the samples C and D have lowest TAV values. The sample having highest TAV values are samples I and J having high TAV values of 3.91 and 4.04.

Those samples have also the highest average formability values and highest formability values in weft direction.

The figure 1 shows pictures of seams for the samples C, D, I and J taken under narrow angle. Photographs confirm the difference in puckering between samples C and D (lowest formability and lowest TAV) and sample I and J (highest formability and highest TAV). There is also high correlation found between fabric thickness and percentage of puckering in warp (0.76) and weft (0.78) direction.



Sample C Sample D Sample I Sample J

Figure 1: Seam samples of fabrics in warp direction

To investigate correlation between fabric parameters describing fabric degree of firmness, and percentage of seam pucker, fabric cover and tightness were calculated for all samples. The coefficient of linear correlation between percentage of seam pucker and fabric cover and fabric tightness are given in table 5.

Table 5: Coefficients of linear correlation between fabric cover and tightness and percentage of seam puckering.

Percentage of seam pucker	Cover factor			Tightness by Seyam and El-Shiekh			Tightness by Russell		
	C_1	C_2	C_f	T_1	T_2	T_f	T_1	T_2	T_f
SP_1	-0.26	0.20	-0.08	-0.64	-0.11	-0.57	-0.68	-0.06	-0.65
SP_2	-0.22	0.22	-0.04	-0.65	-0.14	-0.59	-0.69	-0.07	-0.66

Note: C_1-cover factor by warp, C_2-cover factor by weft, C_t-fabric cover factor, T_1-tightness by warp T_2-tightness by weft, T_t-fabric average tightness

It can be seen that there is no correlation between fabric cover factor and percentage seam pucker. Also, there is no correlation found between degree of pucker and tightness by weft. However, there is good correlation found between tightness by warp and fabric tightness using Seyam and El-Shiekh and Russel equations, with higher correlation values when applying Russel equation. Comparing seam pucker in warp and weft direction, there is somewhat higher correlation obtained for puckering in weft direction compared to warp direction. Results indicate that fabric tightness can give better indication of puckering that the cover factor. The fabric tightness represent the ratio of fabric actual and maximum thread density, while fabric cover represent the ratio of the area of the fabric occupied by threads and whole area of the fabric. The equations for fabric tightness used in this calculation, take in account fabric weave which could be the reason for higher correlation found when using fabric tightness.

4. CONCLUSION

The occurrence of seam pucker has been investigated for seams of class 1.01.01, of 301 stitch type, using a range of woven fabrics for tailored garments.

The results obtained show that seams in warp directions have higher percentage of puckering due to asymmetrical fabric set and consequently difference in mechanical properties in warp and weft direction.
For a range of investigated seams it was found that samples having highest percent of seam puckering have lowest formability and lowest total appearance value. The high correlation was found between fabric thickness and degree of puckering.
The correlation between fabric cover factor and fabric tightness and percentage of seam pucker was also investigated. There was no correlation found between fabric cover and degree of puckering. The good correlation was found between fabric average and warp direction tightness and the percentage of seam puckering.

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USABILITY CHARACTERISTICS ANALYSIS OF MEN'S SOCKS MADE OF COTTON/POLYAMIDE MIXTURE

Dragan DJORDJIC, Mirjana RELJIC, Vasilije PETROVIC

Abstract: *Men's socks are made of cotton, polyamide and elastane mixture are an integral part of men's clothing. The socks quality plays an important role in the usability properties. The socks usability properties are reflected by the following characteristics: fineness of yarn, abrasion, heel and fingers perforation, socks knitting density, water-vapor permeability. In this paper is shown the comparison of test results obtained from cotton yarn with winding, polyamide yarn with winding and the yarn decomposed from socks. Test results show a weakening of the quality elements while wearing i.e. the socks abrasion which affects on the wearing duration of the cotton socks.*

Key words*: Abrasion, Socks, Cotton, Polyamide, Yarn Strength*

1. INTRODUCTION

The socks are a must knitted clothing product designed for almost every occasion. Over several thousand years of its existence, it no longer serves only to protect your feet from the cold and from shoes but also it is an essential fashion accessory that can significantly improve the visual outfit. The socks also serve to apsorb and remove the moisture and sweat from the feet and prevent a number of consequences that may result with wet feet.

From its beginning till now, the socks changed their appearance. Ones of the first socks that occurred, were found in Egypt dating from 300-500 AD and having a really odd shape (Figure 1). It is assumed that the socks shape with separate toes was designed to wear with sandals. In Figure 2, it can be seen how the socks used by the Copts look like that date from the 5th century BC. These socks are knitted in the technique of "interference" and it is interesting that the big toe is separated from the rest of the feet.

Figure 1. The socks found in Egypt

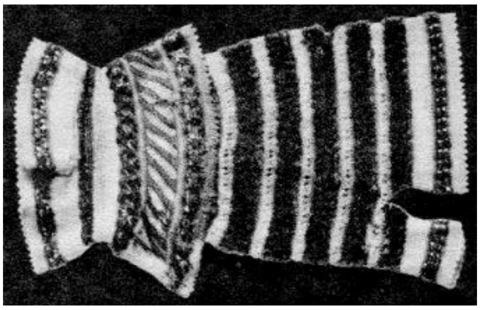


Figure 2. The socks from the fifth-century BC used by Copts

In recent times, when it's already outdated the classic socks production, increasingly popular socks with separate toes appear. The socks with five toes have recently gained recognition as a new and comfortable genre in the footwear.

Figure 3. The socks with five toes

The socks can be made from yarns of different materials such as: 100% cotton, 100% wool, 100% polyamide, 100% polyester, acrylic/elastane mixture... The socks made of this raw material composition have their pros and cons; the deficiencies can be eliminated by combining of a certain raw material composition and the quqlity can be improved. The deficiencies are evident if the socks are made of a single raw material composition. The service life of socks can be significantly extended by combining polyamide and cotton. By adding up to 20% polyamide into the socks raw material composition, the positive qualities of the cotton, as a great natural material that absorbs moisture and prevents sweating, are not lost. By adding a certain percentage of elastane the service life of socks also extends because it significantly improves the elasticity of the socks, the foot adapts better and follows the foot line while walking.

Some socks besides their visual, aesthetic and protective characteristics also play a role in the medical purposes. It prevents thrombosis of the internal veins. In developing these socks, the rew materials such as polyamide, cotton, viscose and elastane or their mixtures are used.

The socks friction is not yet permanently solved, but by the use of certain fibers it can be significantly delayed. Initially, the friction causes the threadbare yarns and then comes thinning at the place where is the most intense friction and ultimately it leads to the first hole appearance. The places where the friction mostly occurs are at the heel, toes and sock foot. If the socks are made of the natural and synthetic yarns, the natural yarns will be removed firstly and then the synthetic ones.

2. CHARACTERISTICS COTTON, POLYAMIDE AND FINISHED SOCKS

Characteristics of polyamide fibers

The synthetic polyamide fibers (PA) are obtained from polymers whose macromolecules contain amide groups (-NHCO-), with:
- Short and long sequences of methylene groups (-CH-) in the aliphatic polyamide fibers, of which the most important are PA 6 and PA 6.6 fibers;
- methylene and cyclic groups in the so-called acyclic polyamides and aramides, Qiana fiber type;
- aromatic groups in aromatic polyamides and aramides, Nomex and Kevlar-type, in which there are at least 85% of the amide groups linked to the aromatic residues;
- aromatic heterocyclic groups in the aromatic heterocyclic polyamides which get the label by heterocyclic type, for example. aramide is composed of aromatic and imides groups (Carmel fiber);
- heterocyclic groups in the polyheterocyclic polymers.

Most of polyamide fibers are formed from the polymer melt. However, the aromatic polyamides or aramids are formed from the solution because they can not be melt. The polyamide fibers are produced in the form of filaments and staple fibers like, normal, special or modified fibers. They can be with the round or profiled cross-section. To the modified fibers, the fibers of the various luminosity, antistatic, differential paintable, white or colored and reduced volatility fibers belong. The polyamide fibers are the strong (3-9 cN / dtex) and highly elastic fibers (elongation of 15-70%). Under normal conditions, the fibers absorb moisture from 3.5 to 4.5%. Without the light stabilizers, they have relatively small stability towards the light; towards dilute acids and alkalis the fibers are stable but towards concentrated acids and oxidizing agents are unstable. The electrostatic charge of fibers is great when the air humidity is low.

Characteristics of cotton fibers

The cotton fiber is a single-celled with the exquisite fineness and softness, and comes from the plant seeds. These fibers are the short staple fibers and their length is used for the quality characterization and classification. According to the staple length, the cotton is classified into four groups: short-fibers, middle-fibers, long-fibers and extra long-fibers. The cotton fineness due to its characteristic shape in the form of flat twisted tape is different, ranging in thickness from 10-40 µm. If the fibers are longer and finer then is possible to make of them the high-strength products. The cotton luminosity depends on the cotton fibers twistedness and wax contents.

Finer cotton has the moderate luminosity while rougher cotton has no luminosity. An important indicator of quality, besides the luminosity grades, is a cotton mercerisation degree. Low elasticity leads to intensive cotton clothes crumpling and because of that, by the interference with PES or PA fibers, these properties improve and with them the clothes drying velocity increases. The cotton fabric can be washed and boiled. Thanks to its very good properties, such as tensile properties (one of the stronger fibers), the friction resistance and sliding wires in dry and wet state (surface roughness due to the large number of twists), resistance to boiling alkaline solutions, high adsorption capacity, air permeability and good hygienics, the cotton is still virtually irreplaceable in making all kinds of the laundry - personal, hospital, bedding, towels and various types of clothing. The cotton has great application not only for clothes for daily use, sport, recreation, work clothes, as lining and as interlining material but also as technical textiles, blankets (terry), sewing thread…

In Table 1 The most important service properties of the apparel products based on polyamide fibers are given.

Table 1. Usability socks characteristics made of Co / PA fibers mixture

Socks made of Co / PA fibers mixture	
Aesthetics	Variable
Shelf life	Extremely long
Resistance to abrasion	Excellent
Tensile strength	Excellent
Elongation	Large
Comfort	Low
Sorption ability	Low
Thermal protection	Moderate
Look keeping	Excellent
Elasticity	Excellent
Dimensional stability	Excellent
Elastic recovery	Exceptional
Maintenance and Care	Machine wash

3. AUTOMATS FOR MAKING MEN'S SOKS

These automatic machines can be classified according to the socks type which are made to:
- single cylinder automatic machines for making women's, men's and children's socks,
- two-systems hosiery automatic machines for women's and men's socks and
- single cylinder hosiery automatic machines for women's socks.

The socks that were investigated in this study are made on a single-cylinder machine with 17 needles per 1 inch (the machine quality). In Figure 4. the socks knitting machine appearance of manufacturer Lonati marks 462 3 3/4 " is shown.

Figure 4. Hosiery automatic machine Lonati 462 3 3/4 " for making men's, women's and children's socks

The mechanism used for the loop forming

The elements of the loop forming are the latch needles and loop sinkers. The latch needles are placed in the needle cylinder, and loop sinkers into the sinker mechanism. Besides the latch needles and loop sinkers, this mechanism is composed of: needle presser, needle cylinder, crown for loop sinkers, platinum ring, needle and platinum locks, the elements used to create the heel and toes, thread guide bar as well as the device for the knitting density changing.

The needles starting is done using locks over the needles foots. During loop making the needles move vertically in channels of the needle cylinder. In doing so, the loop sinkers move horizontally in the radial channels of platinum ring and crown towards the cylinde center and opposite. The loop sinkers are run using the platinum locks with the help of the loop sinkers foot. While the loops making, the locks have performed an important role as they do needles starting. The locks are deployed around the cylinder and they just by themselves make the steel components system of a certain form that affects the needles foots and the needles guide bar. The mentined action allows operation of the individual needles. The hosiery automatic machines typically have a two-sided action locks that are placed in the basic system for knitting and used for making the heels and toes. The exceptions are the machines with the one-sided spinning cylinder on which the tubular socks are produced.

At the present time there is a large number of different heel forms of the socks. Some of them are: conventional, Y-shaped, wedge-shaped, etc..Methods of the heel making differ from one another according to the schedule of needles which are involved or not involved in the work. The specificities of the heel and toes making are reflected in the necessity of making a spherical shape. Therefore, the procedure for these processes is usually requires the exclusion of the needles with a high foot, the gradual withdrawal of low-foot needles, gradually adding low-foot needles and involving needles with high foot.

4. SOCKS ABRASION BY THE MARTINDALE METHODE ISO 12947

The abrasion principle of this method is carried out in the following way: the circular test tube (diameter 38 mm) is subjected to a defined load and rubs on the abrasion tool (standard fabric - wool fabric by which test tube is abraded,140 mm in diameter and 215 g /m² mass per unit area) by shift movements that follow the path by Lissajous (Figure 5). Figure by Lissajous presents a path which is formed by movement and changes from the circle to the gradually narrowed ellipse, until it becomes a straight line from which the ellipses gradually develop and more and more expanding into diagonally opposite direction, before this path repeats. The test tube holder that holds the abrasion tool is free to rotate about its axis which is perpendicular to the test tube plane. The abrasion resistance evaluation of textile surfaces is determined by evaluating the appearance changes.

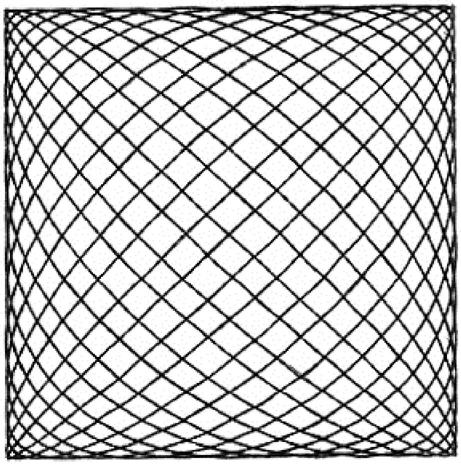


Figure 5. Figure by Lissajous

The conditioning and testing is carried out under standard laboratory conditions of (20 ± 2) ° C and relative air humidity of (65 ± 5)%.

There is a given cycles number of the abrasion device (in this case for the first check is tasked 10,000 cycles) and periodically the appearance of the abrasion surface is checked. When the prescribed appearance of the test tube surface is noticed, the test tube can be removed and its change appearance is evaluated and the number of cycles needed to change the look of tubes is noticed or in this case, to the emergence of the first hole or for a knittwear when a thread breaks and causes hole emergence.
The determination of mass loss is done according the standards table prescribes the number of moves for which the abrasion damage of the test tube occurs (Table 2). In our case, the test tube damage occurred at 100,000 cycles and according the table, the test tube mass is measured at 25,000 cycles, 50,000 cycles, 75,000 cycles and 100,000 cycles. Before starting the abrasion process and instaling the test tube, the sample mass is measured, then on the specified number of cycles the machine stops, the test tube should carefully be removed from the tube holder with tweezers and then using the brush, threadbare material removes from both sides of the test tube and the test tube is measured accurately to the nearest 1 mg. Based on the mass before the abrasion process and the the mass after, the mass loss is calculated.

Table 2. Test intervals for testing the weight loss

Test series	The number of movements needed for the test tube abrasion damage to occur	Determining the mass loss under the following numbers of abrasion movements
a	≤ 1000	100,250,500,750,1000,(1250)
b	>1000≤5000	500,750,1000,2500,5000,(7500),
c	>5000≤10000	1000,2500,5000,7500,10000,(15000)
d	>10000≤25000	5000,7500,10000,15000,25000,(40000)
e	>25000≤50000	10000,15000,25000,40000,50000,(75000)
f	>50000≤100000	10000,25000,50000,75000,100000,(125000)
g	>100000	25000,50000,75000,100000,(125000)

5. EXPERIMENTAL SECTION

The yarn and finished socks are analyzed. One yarn is made of 100% cotton and the other yarn of mixture - polyamide 90.7% and 9.3% elastane.The 40 measurments of breaking forces and just as much measurments of the finished sock were done. The breaking forces analysis made according to standard EN ISO 2062, 1995 (2009). The test tubes taken from the foot part without including the heel and toes. The test tube length is 250 mm and the coil separation velocity is 250 mm / min. The sock yarn is taken from the calf and foot parts.

Table 3. Cotton yarn package

Mesurment number	Breaking force (N)	Breaking elongation(%)
1.	4,185	4,495
2.	4,265	4,546
3.	4,485	4,731
4.	4,265	4,491
5.	3,915	4,079
6.	4,150	4,444
7.	4,050	4,395
8.	4,265	4,364
9.	4,365	4,569
10.	3,965	4,299
11.	3,935	4,284
12.	4,565	4,619
13.	4,565	4,864
14.	4,535	4,824
15.	3,950	4,237
16.	3,900	4,356
17.	3,865	4,273
18.	3,765	4,067
19.	3,650	3,944
20.	3,835	4,179
21.	3,735	4,405
22.	4,135	4,660
23.	3,815	4,215
24.	4,115	4,544
25.	4,265	4,667
26.	4,115	4,663
27.	4,315	4,848
28.	3,715	4,054
29.	3,450	3,641
30.	4,150	4,455
31.	4,250	4,674
32.	4,115	4,523
33.	4,085	4,471
34.	3,850	4,078
35.	3,985	4,237
36.	3,735	4,189
37.	4,250	4,612
38.	4,100	4,438
39.	3,950	4,438
40.	3,715	4,188
average value	4,085	4,402

Table 4. Polyamide yarn package

Mesurment number	Breaking force (N)	Breaking elongation(%)
1.	3,135	2,676
2.	3,285	3,020
3.	3,065	2,427
4.	3,050	2,469
5.	2,815	1,977
6.	3,115	2,531
7.	3,335	2,889
8.	3,115	2,529
9.	3,400	2,835
10.	2,850	2,061
11.	3,465	3,108
12.	2,635	1,587
13.	3,100	2,374
14.	3,250	2,673
15.	2,900	2,151
16.	3,265	2,664
17.	3,085	2,328
18.	3,115	2,376
19.	3,000	2,361
20.	3,200	2,496
21.	3,215	2,463
22.	3,085	2,208
23.	3,335	2,616
24.	3,015	2,208
25.	3,265	2,496
26.	3,285	2,794
27.	3,235	2,739
28.	2,765	1,773
29.	3,335	2,871
30.	3,135	2,544
31.	3,065	2,289
32.	3,165	2,472
33.	3,250	2,583
34.	3,165	2,433
35.	3,200	2,583
36.	3,285	2,688
37.	3,100	2,313
38.	3,285	2,688
39.	3,100	2,184
40.	3,300	2,607
average value	3,144	2,477

Table 5. Cotton yarn of sock

Mesurment number	Breaking force (N)	Breaking elongation(%)
1.	3,015	3,879
2.	2,735	3,374
3.	3,665	3,519
4.	3,535	3,948
5.	3,385	3,562
6.	2,735	3,565
7.	3,015	3,939
8.	3,850	4,190
9.	3,415	3,771
10.	2,015	1,877
11.	2,650	3,616
12.	2,200	2,855
13.	2,535	3,197
14.	2,585	3,563
15.	2,700	3,352
16.	2,515	3,050
17.	2,635	3,099
18.	3,515	3,882
19.	2,950	3,764
20.	2,450	3,092
21.	3,685	3,944
22.	3,700	3,909
23.	1,550	1,863
24.	2,835	4,070
25.	1,965	2,534
26.	3,035	4,093
27.	3,515	3,329
28.	3,715	4,080
29.	3,265	3,540
30.	3,650	3,942
31.	3,650	4,020
32.	3,085	4,427
33.	3,235	3,604
34.	3,750	3,974
35.	3,435	3,647
36.	3,665	4,012
37.	3,585	3,971
38.	2,415	3,105
39.	2,365	2,264
40.	3,765	3,545
average value	3,049	3,524

Table 6. Polyamide yarn of sock

Mesurment number	Breaking force (N)	Breaking elongation(%)
1.	3,110	2,700
2.	3,085	2,256
3.	3,185	2,337
4.	3,235	2,485
5.	3,085	2,241
6.	2,885	1,864
7.	3,235	2,739
8.	3,135	2,361
9.	3,265	2,851
10.	3,265	2,896
11.	3,350	3,100
12.	3,135	2,253
13.	3,235	2,715
14.	3,135	2,541
15.	0,750	0,067
16.	3,235	2,643
17.	3,165	2,289
18.	3,100	2,223
19.	3,350	3,092
20.	3,050	1,959
21.	3,385	2,763
22.	3,150	1,968
23.	3,135	2,121
24.	3,135	1,983
25.	3,065	1,959
26.	2,965	2,097
27.	3,350	2,781
28.	3,150	2,253
29.	3,135	1,887
30.	3,150	1,968
31.	3,035	1,776
32.	3,085	1,280
33.	3,035	1,776
34.	3,115	1,959
35.	3,000	1,392
36.	3,150	2,031
37.	2,800	1,376
38.	3,285	2,256
39.	3,035	1,272
40.	3,065	1,656
average value	3,080	2,153

Table 7. Examination results of the yarn and finished sock Co / PA

Analysis:	Cotton yarn package	Polyamide filament yarn package	Cotton yarn decompoyed from finished product	Polyamide filament yarn decompoyed from finished product	Finished sock	
Rew material composition					list i stopalo	peta i prsti
Co(%) ISO 1833-11	100		100		75,0	73,8
PA (%) ISO1833-7		90,7		90,7	22,7	26,2
El (%) ISO 1833-20		9,3		9,3	2,3	/
fineness (tex) SRPS ISO 2060	23,6x1	9,9	23,9x1	9,7		
Breaking force (N) SRPS EN ISO 13934-1	4,085	3,144	3,049	3,080		
Breaking elongation (%) SRPS EN ISO 13934-1	4,402	2,477	3,524	2,153		
Abrasion ISO 12947 -cycle number until the first hole appearance					100.000	/
-mass loss at the abrasion ending (%)					3,1	/
Knitting density F.S2.013:1986 - vertically r/10cm					106	115
- horizontally p/10cm					90	95
Shrinkage when washed on 40 °C EN ISO 3759 -length (%)					-3,8	-3,8
-width (%)					-0,8	-0,8
Color fastness- when washed on 40 °C (mark) SRPS EN ISO 105-E01					4/4/4	4/4/4
-sweat (mark) SRPS EN ISO 105-E04					4/4/4	4/4/4
- dry washing out (mark) SRPS EN ISO 105-X12					4	4
-wet washing out (mark) SRPS EN ISO 105-X12					3-4	3-4

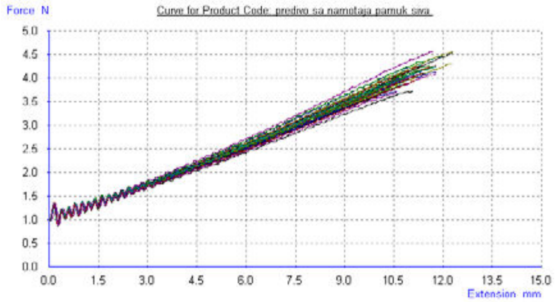
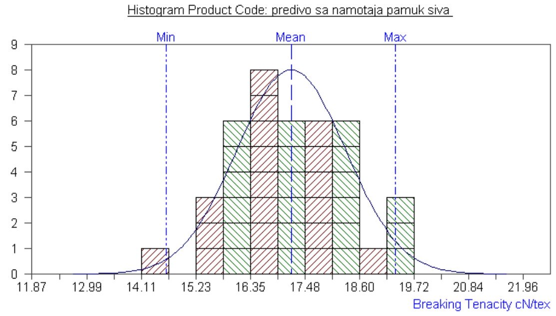


Diagram 1. The breaking force of cotton yarn package



Histogram 1. The breaking strength of cotton yarn package

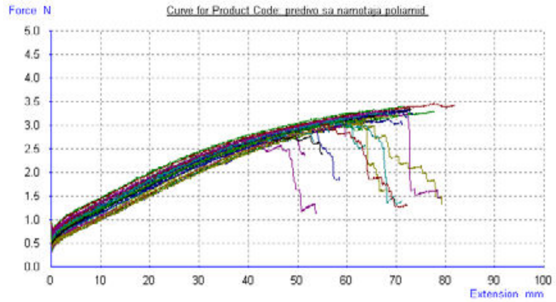
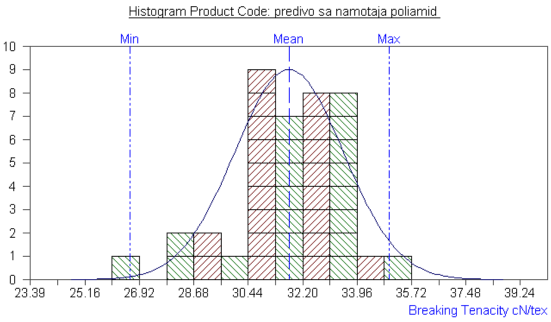


Diagram 2. The breaking force of polyamide yarn package



Histogram 2. The breaking force of polyamide yarn package

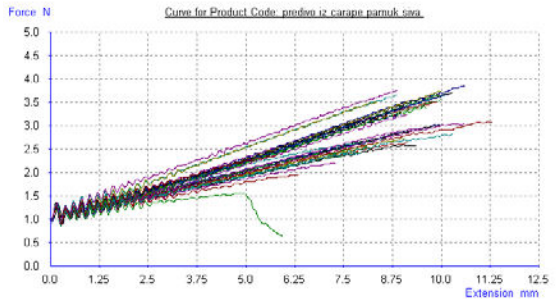
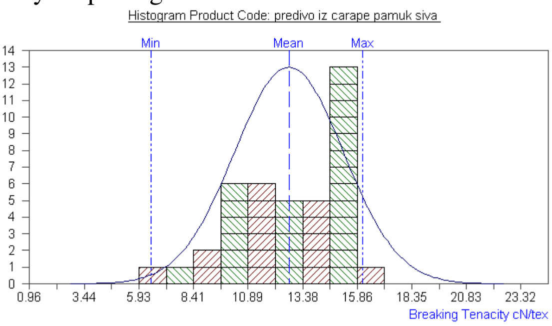


Diagram 3. The breaking force of cotton decomposed from the sock



Histogram 3. The breaking force of cotton yarn decomposed from the sock

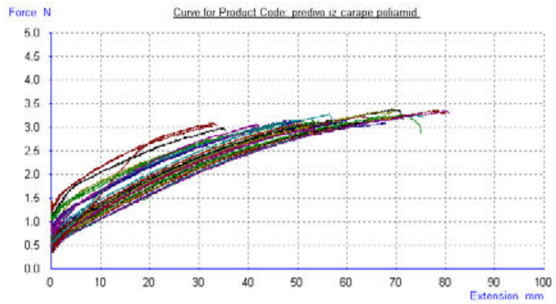
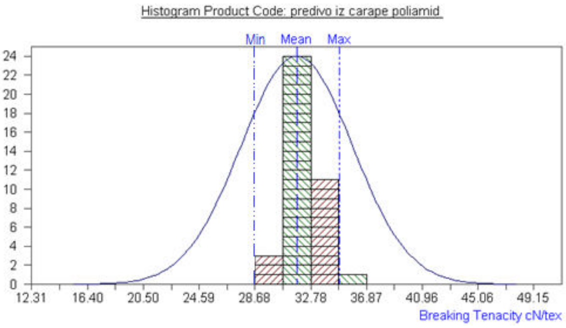


Diagram 4. The breaking force of polyamide yarn decomposed from the sock



Histogram 4. The breaking force of polyamide yarn decomposed from the sock

The Diagram 1 and Histogram 1 shows the breaking force of cotton yarn package and its movement. In the Diagram it can be clearly seen the uniformity of the 40 measurements without any major deviations in terms of breaking force and elongation. In the Histogram 1, a Gaussian distribution of the values expressed in cN / tex for cotton yarn package can be seen. In Diagram 2 and Histogram 2 the breaking force of the polyamide yarn package is shown which is more unequal with a lower values in terms of the breaking force and elongation in comparison with the cotton yarn package. In the

Diagram 3 and Histogram 3 the cotton yarn decomposed from the finished sock is shown and it can be noted that it is significantly unequel than in the yarn package examining which is a consequence of the knitting process and hosiery finishing, what has contributed to the strength and uniformity yearn losing up to 25%.

In Diagram 4 and Histogram 4 decomposed polyamide yarn from socks is shown and it has lost the uniformity in the knitting process and hosiery finishing but considerably less than cotton yarn and the difference in strength is lower by 13%, which is one of the positive characteristics of the artificial fibers, which are much more durable and resistant than cotton fiber. That is one of the reasons why the yearn of these fibers is used, combined with the cotton yearn in the cotton socks production. In Figures 6 to 11 the abrasion procedure is graphically presented according to the standard ISO 12947-2 and 3 before the abrasion starting and after 10.000, 40.000, 70.000, 95.000 and 100.000 abrasion cycles.

Figure 6. Appearance of polyamide - cotton sock before abrasion process

Figure 7. Sock look after 10,000 cycles

Figure 8. Sock look after 40,000 cycles

Figure 9. Sock look after 70,000 cycles

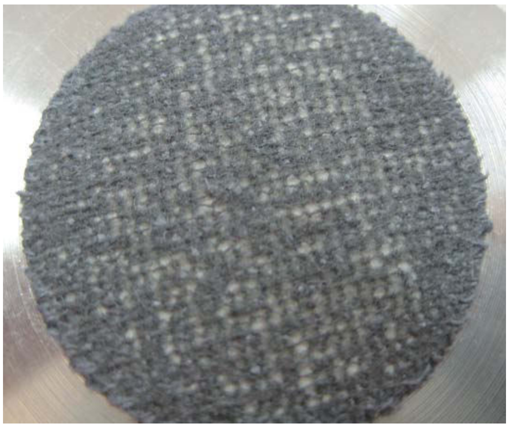


Figure 10. Sock look after 95,000 cycles

Figure 11. Sock look after 100,000 cycles

6. CONCLUSION

The investigated rew material-yarn and the finished sock made of cotton/polyamide mixture. Comparing the results obteined during the chemical and physical examinations, it is concluded that in terms of the yarn fineness there were no changes. The spinning difference of the unifilar yarn is insignificant. The significant change has occurred in the breaking force and elongation, ie. the breaking force of the yarn package is greater than the breaking force of yarn decomposed from sock for 25.36%. The breaking elongation is also higher within the yarn package for 19.58% than within the yarn decomposed from the sock. Based on the obtained results about the breaking force it can be concluded that in the production process due to technological process has come to a weakening of the breaking force. By measuring the test tube weight of the finished sock before and after the abrasion process, change is noted i.e. the weight loss of 3.1%. The obtained weight loss percentage indicates good usability value of the socks, ie. the shelf life will be longer than the shelf life of the sock that would be produced of 100% cotton fibers.

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DEVELOPING THE ACCURATE SITTING POSITION 3D BODY MODEL FOR GARMENT PROTOTYPING

Tatjana Kozar, Andreja Rudolf, Simona Jevšnik, Zoran Stjepanovič

Abstract: *The field of cloth simulation and garment prototyping has in the last twenty years attracted a lot of attention of numerous researchers. It enables a quick response to the clothing industry trends in order to ensure lower production costs while increasing the efficiency of garments' production. Development of garments is practically unthinkable without the help of advanced body scanning technology. It enables fast and reliable capture of physical body dimensions in the form of 3D scanned data. This technique allows the extraction of accurate anthropometric body dimensions to be used in 2D and 3D CAD system for design, construction, visualization and animation of garment appearance on virtual mannequins. In apparel industry the current use of innovative computer programs and virtual reality reflects virtual prototyping on virtual mannequins in a standing position. In this way modern clothing industry excludes physically disabled people for which garments need to be individually adapted to each person to ensure wearing comfort. In our contribution we are describing the development of an accurate 3D body model in sitting position. It represents the first step to garment virtual prototyping for physically disabled people and other people with special physical needs.*

Key words*: 3D body scanning, body scan reconstruction, virtual prototyping, clothes simulation, physically disabled people*

1. INTRODUCTION AND MOTIVATION

People with paraplegia state are characterized by immobility of lower body parts. It is the result of an injury or illness influences. The global apparel market does not offer large selection of garments to satisfy the people with this kind of special needs. Due to paralysis they are usually forced to use uncomfortable and unattractive clothing. On the other hand, it is well-known that paraplegic athletes often achieve great results at the Paralympics games. Therefore, there exists the need for sports and also fashionable clothes for their self-esteem enhancement, especially for the younger generation. Accurate sitting position parametric body model enables a virtual prototyping of sports and fashion garments for paraplegics. Adequate, comfortable and fashionable garments can help supporting their social assimilation in public life. At the same time the design and production of such garments can be stated as a special market niche for apparel producers.

2. THEORETICAL PART

The application of computer aided design (CAD) has become an obvious trend in many of industries. Their use allows an accurate and rapid development of virtual garment prototypes including their adaptation and change (Volino P. et al., 2005; Stjepanovič Z. et al., 2011; Rudolf A. et al., 2009). Garment simulation uses an artificial way to create its appearance as well as shape and form of the human body (Petrak S., 2007). The central pillar of garment simulation presents the efficient mechanical simulation model, which can accurately reproduce the specific mechanical properties of the cloth. The cloth is by nature highly deformable, therefore the mechanical representation should be accurate enough to deal with the nonlinearities and large deformations occurring at any place in the cloth, such as folds and wrinkles. Moreover, the garment cloth interacts strongly with the body that wears it (Stjepanovič Z.et al., 2012; Pilar T., 2012).

Three-dimensional scanning technology has enabled the generation of high-density point data sets that describe the surface of real objects, including objects such as the human body (Buxton B. et al., 2000). In our study we have reconstructed 3D body scan model in a sitting position with different computer graphic programs to perform garment simulation. We focused on physically disabled people to consider their needs through the development of suitable clothes by virtual prototyping. By fitting clothes on a sitting 3D body model, we can provide fashionable and comfortable clothes

3. EXPERIMENTAL PART

The study discusses the reconstruction of the 3D body scan model in a sitting position to perform garment virtual fitting for physically disabled people. In addition, we performed the following activities: 3D body scanning, pattern design and simulations of the garments' prototypes.

3.1 3D body scanning

Three-dimensional body scanner represents sophisticated data processing software, which has a major impact on a wide range of application domains. Clothing industry already benefits from the existence of systems that allow customers to have 3D model from themselves and use it in the context of a "virtual try-on" applications. Customers can exactly see how the clothes will fit on them and even have a choice of sizing and styling modifications (Buxton B., 2000). 3D body scanning of a sitting human body was performed on a 3D body scanner Vitus Smart at the Textile Technology Faculty, University of Zagreb. The scanner consists of 8 cameras to provide 500.000 to 600.000 points (point cloud). Scanned 3D body model in a sitting position is represented in Figure 1. Extraction of body measures was performed with the program package ScanWorx V 2.7.2. Special positions for measuring of body measures intended for trousers pattern design is shown in Figure 2.

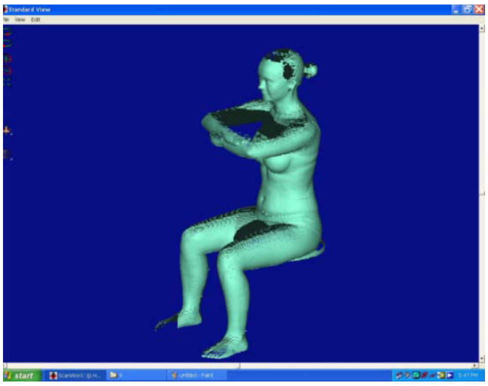


Figure 1: Scanned 3D body model in a sitting position

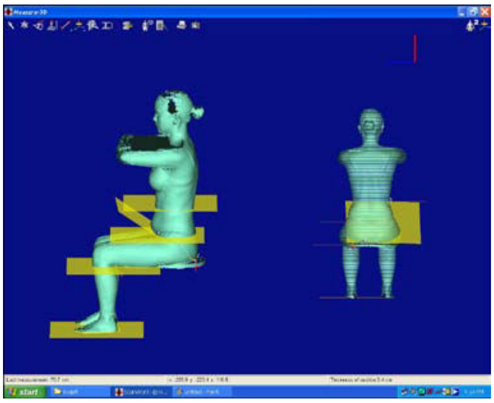


Figure 2: Extraction of body measurements with the program package ScanWorx V 2.7.2.

3.2 Reconstruction of a scanned 3D boy model in a sitting position

The capture of a human body data with 3D technology is characterized by number of problems which drive the effort towards the development of human body modelling technology. The generating process of scanned 3D body models involved the body reconstruction. Namely, 3D scanner cannot

produce sufficient scan data, which results in defected body models. The scanned 3D body model in Figure 1 shows defects in the area of the crotch and tights, arms and above the breast area. The 3D scan data is a set of points in 3D space that approximately laid on the surface of the scanned object, in this case a human body.

Point set parameters such as density, accuracy and completeness are determining its overall quality. For example, the completeness of the data set depends is crucial for the applicability of a virtual body model. The 3D scanner can only obtain data from the areas that are directly visible to the sensors. For simple objects it is acceptable, but a human body is complex and made of parts that mutually occlude each other. Therefore interruptions occur in occluded areas, typically at the groin and armpits (Stjepanovič Z. et al., 2012; Pilar T., 2012; Buxton B. et al., 2000).

The surface of a 3D body model influences the virtual garment fitting. For this reason the reconstruction of the scanned 3D body model was performed by using the following graphic programs: MeshLab, Blender, Atos and Netfabb (MESHLAB, 2012; BLENDER, 2012; ATOS, 2012; NETFABB, 2012).

3.3 Pattern design of underwear and trousers

In the world fashion market relatively low attention is given to clothing for disabled people. Our research relates to this problem with the application of a 3D body model in a sitting position to enable virtual garment fitting of different kind of suitable clothes, even those for special purposes.

Suitable clothes are also important for disabled children, which should not differ from clothes for healthy children. They should also meet requirements like ergonomic, thermo-regulation and aesthetic appearance (Sybilska W. et al., 2009). The underwear and trousers pattern designs were performed by using the Optitex PDS computer program package, Figures 3 and 4.

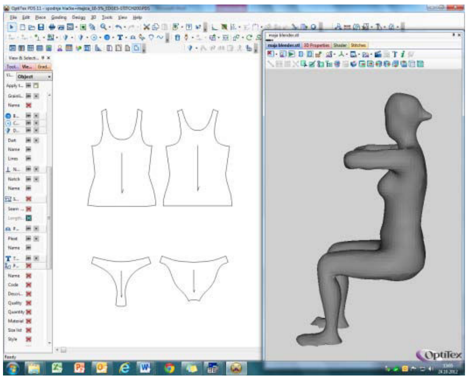


Figure 3: Pattern design of the underwear with the program OptiTex PDS

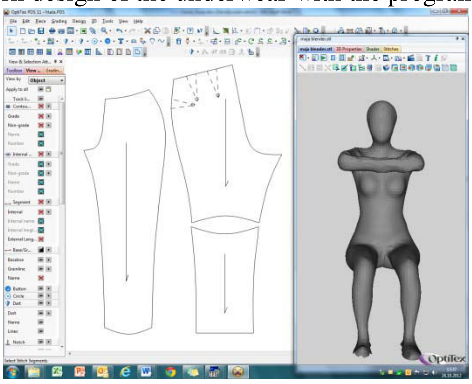


Figure 4: Pattern design of trousers with the program OptiTex PDS Creator

4. RESULTS AND DISCUSSION

4.1 Results related to the reconstruction of a scanned 3D body model in a sitting position

Reconstruction of the 3D body model in a sitting position was performed by different 3D computer programs: MeshLab, Atos, Blender and Netfab.
By using the program Atos we carried out the first phase of reconstruction of the 3D body model, Figure 5. Number of polygons was reduced from about 660.000 to 150.000 triangles using the tool Thin Mesh. With tools such as Repairing Mesh, Regularize Mesh, Eliminate mesh errors, Relax Mesh and Fill holes we repaired all the defects. Several operations were repeated to reduce mesh errors. The mesh was exported as a binary .stl file.

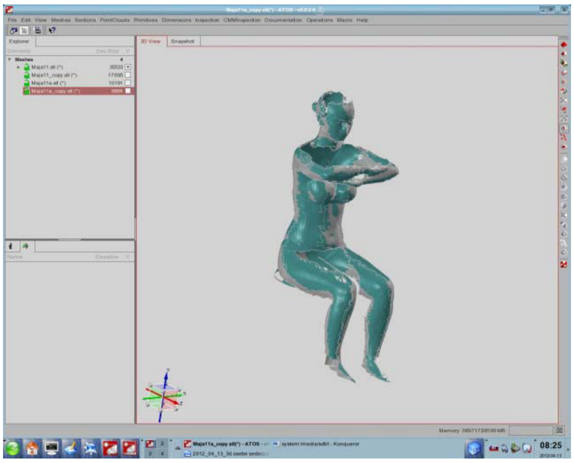


Figure 5: Program ATOS for reducing polygons in repairing the mesh

In the second phase we used the program MeshLab, Figure 6, because the mesh repaired in Atos, was still not watertight and totally uniform. We used the tool Poisson for Surface reconstruction. This tool is characterized by the realizing of one uniform average mesh from more partly overlapped meshes. The mesh was then exported as a .stl file again. After that we re-used the program Atos and the errors on a surface were totally eliminated, Figure 7.

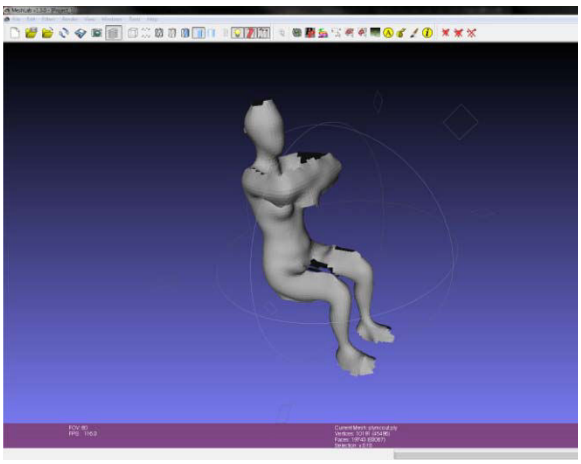


Figure 6: Program MeshLab for Surface reconstruction

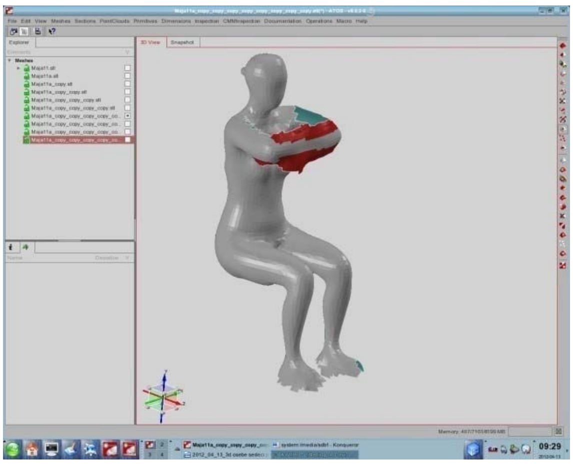


Figure 7: Program Atos for eliminating the remaining errors

In the last step we imported the reconstructed 3D body model into the program NetFab for scaling and rotating it, Figure 8. This was the last step before importation into the OptiTex program for garment simulation.

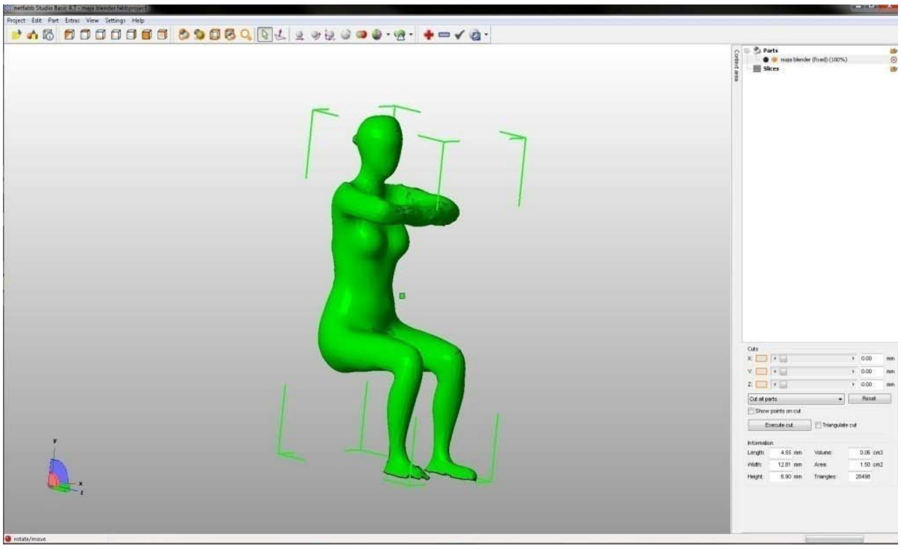
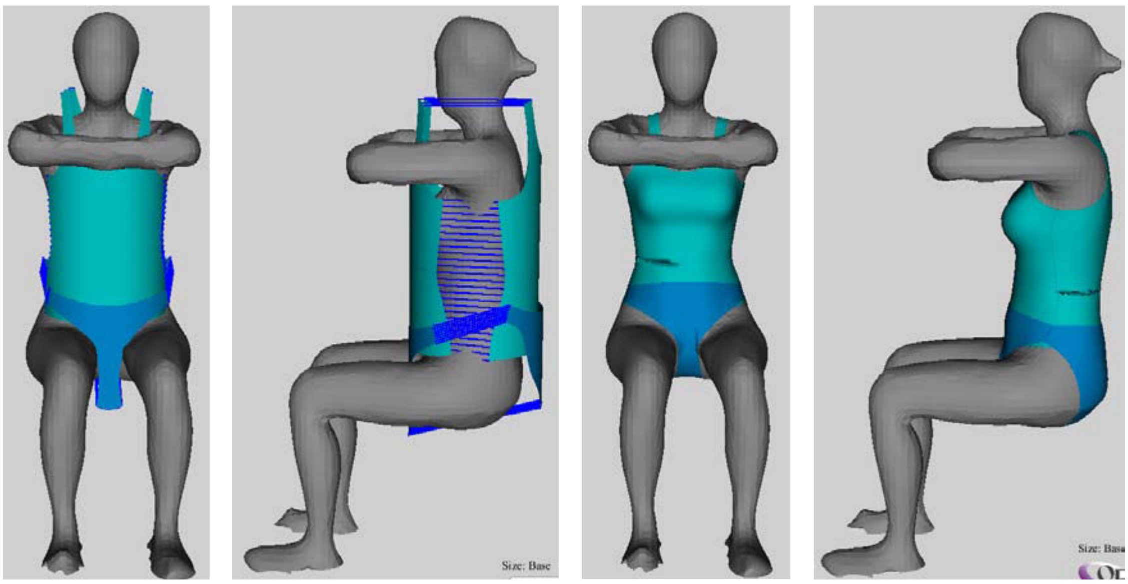


Figure 8: Program NetFab used for scaling and rotating the 3D body model

4.2 Results related to the virtual garment prototyping on reconstructed 3D body model in a sitting position

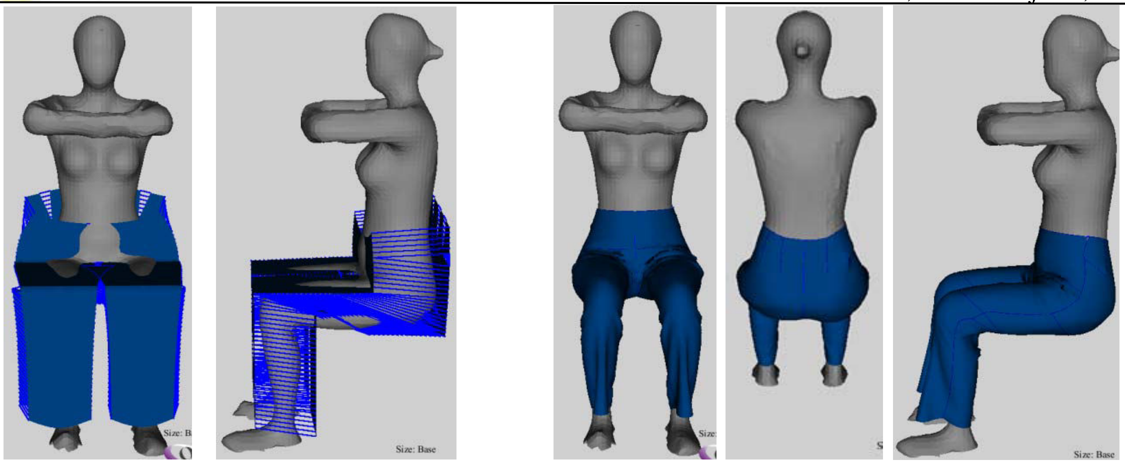
For simulation of the underwear and trousers prototypes the reconstructed 3D body model was imported into the program OptiTex PDS. In addition, it was necessary to define the patterns pieces by:
- type and position of the individual pattern piece (front part, back part, piece layer etc.)
- seam lines for stitching the patterns on the reconstructed 3D body model, Figures 9(a) and 10(a).

The properties of textiles were selected from the database of material properties which are an integral part of the software package OptiTex PDS. A large impact on the garments' simulation has stitching properties that were adapted to the individual garment taking into account real stitching demands. Virtual garments' prototypes on the 3D body model in a sitting position are represented in Figures 9(b) and 10(b).



(a) (b)

Figure 9: Simulation of the underwear on the reconstructed 3D body model in a sitting position



(a) (b)

Figure 10: Simulation of the trousers on the reconstructed 3D body model in a sitting position

5. CONCLUSIONS

Clothing design for disabled people is not the subject of a wide interest. To provide suitable and fashionable clothes with physical comfort for persons with movement dysfunction there is a need to ensure the proper garments patter design. The first step in this study was based on the reconstruction of the 3D scanned body model and its entry into the program for clothes construction and their virtual fitting. In the second step of the research it was determined if such a reconstructed 3D body model in a sitting position was suitable for simulation of the garments prototypes.

It can be concluded that the reconstructed 3D body model in a sitting position can be effectively use for 3D garment prototyping and simulation of constructed clothing. The simulation of the underwear and trousers was performed by choosing different types of textile materials. Characteristics of the textiles and simulation properties influenced the garments fitting to the 3D body model in the sitting position. Individual simulations exhibit similar folding. By adjusting the parameters of stitching the results for simulation have improved. Each pattern followed the reconstructed 3D body model shapes.

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DEPENDENCY OF A TEMPERATURE AND A SKIN MOISTURE FROM THE THERMAL FEATURES OF A SPORTS CLOTHING MATERIALS

Dragana Grujić

***Abstract**: This paper presents the dependence of thermal comfort of a sports chothing from the thermal features of materials that are incorporated in a clothing system. For making of the four constructionaly identical models of a female sweat suits, two poliester-microfiber fabrics have been used as a basic textiles in linen interlacement. For a lining the cotton knitwear in an interlock interlacement and a poliester knitwear in a tulle interlacement has been used. It was established that on the basis of the tested materials thermal characteristics (an air permeability, coefficient of a thermal conductivity and a resistance to the water vapor flow) and from the aspect of the thermal comfort, adequate combinations of the materials for making of the female sweat suits for sports can be selected. Based on a statistical analysis of the test results for the characteristics of materials and physiological parameters of individuals that were obtained threw rehearsals of wearing the sweatsuit, a matematical correlation is established between the skin temperature (Tskin) and the amount of secreted sweat (Eskin), the degree of the skin moisture (H skin) and the resistance to the water vapor flow as parameters of the termal features comnations of materials.*

Key words: *sports clothing, cuts construction, thermal features, sorption features, clothing comfort*

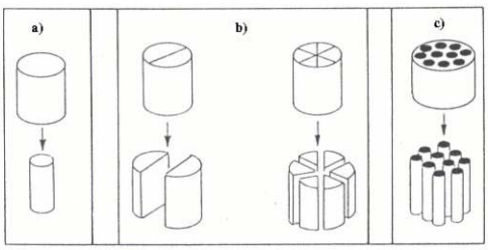
1. INTRODUCTION

Comfort while wearing clothes represents the result of a balanced heat exchange process between a body, clothes and ambient and it is dependent from the special thermal features of clothing that are representing her ability to transfer heat and moisture from the surface of a human body on the ambient. Large amount of factors has influence on a sense of comfort, (for example: a type of material that was used for the production of the garment, composition of the material, a surface mass, mechanical, thermal and sorption features and etc.), the garment's cut construction, a type of processing, a seating, a number of garment's layers and etc...

2. PROPERTIES AND APPLICATION OF THE POLYESTER MICROFIBERS

Microfibers, as a new generation of fibers are opening an interesting perspective for creative modeling of a textile surfaces and garment confectioning. Out of them are made extraordinary fine texttile surfaces for female and male clothing, that are characterized by a soft touch, a moderate shine, an elegant and beautiful „fall“ with a smooth, silky but soft contact surface.
For the production of a filament yarn with a fine and a finest capillaries of a filamentous titer from 1 to 0.1 dtex, two procedures are most commonly used. (Malej-Kveder S.,1990):

- A modified conventional procedure by using super couching or super straining
- Getting of the micro filamentous yarns by using a two or multicomponent fibers from a conjugated matrix-fibril’s fibers with endless fibrils of a one polymer component and sub sequential separation of the fibrils – filaments from the matrix



Picture 1: Different ways of getting filament’s yarns with the fine and the finest filaments: a) super coaching or super straining, b) from the two component fibers of a s/s type or the multicomponent fibers, c)from the two component matrix-fibril’s fibers of a MF type

Micro-filamentous yarns with the fine and the finest titers of individual filaments are used in a smooth form for the making of a “silk type fabrics”. Better imitation of the silk is accomplished by using of a thick-thin filaments or a mixture of filaments of the different titers and different forms of cross section and after-treatment of polyester’s products with an alkaline solutions. (Malej-Kveder S.,1990).

Micro-filamentous yarns in its textured form is characterized by a high luminosity, a pleasant touch, an extraordinary thermal features, a high elasticity and an ability of transferring and bonding of water and moisture. Because of high density of the fine capillaries and with that connected waterproofing and wind retention features, fabrics made of micro-filamentous yarns have “breathing” characteristics that is, air transfer, moisture, sweat absorption and therefor they have found its appliance in the area of the sports clothing for an active athletes and the clothing for recreation (ski sets, sweat suits etc.) with or without special surface facing and apertures.

The microfiber fabrics are distinguished with extraordinary isolation features and increased ability to transfer and bond the moisture or sweat, which is achieved on the basis of the capillary mechanism and functions of absorptions and migrations (Geršak J.,1993).

Textile’s surfaces from the microfibers are allowing, because of their fine structure, more efficient capillary transport of the moisture and they are enhancing regulation of a microclimate on the skin surface, compared to the textile’s surfaces with the usual construction parameters from the fibers of fineness > 1, 0 dtex. Microfiber’s textile surfaces are enabling the better wearing comfort because of enhanced capillary sweat transfer and threw the fiber fineness of conditionally higher potential of absorption on the fiber surface.

3. A THERMO PHYSIOLOGICAL COMFORT OF THE CLOTHING

Clothes with good thermo physiological characteristics, under different conditions of a climate and a user’s different physical activities, must allow thermo-physiological balance under minimal body effort, which means that while wearing it, individual is not sensing neither heat nor cold but the thermo physiological comfort. Comfort that is felt during wearing of the clothes is a key criterion for the evaluation of the use value of certain clothing items. (Grujić D. et al., 2010)

The physiology of clothing is interdisciplinary science and it is based on the foundations of physics, chemistry, medicine, physiology, psychology and textile engineering. Her key competence areas of the research are:

- Study of the interaction between the body, environment and clothing system
- Study of the influence of textile's and garment's contruction parameters (the type of used fibers, construction of the thread and the textile's surface products, superficial textile's features, form of the cut, seating of the clothes etc.) on the transfer of the heat and moisture from the skin surface to the ambient
- Study of the proposals for an optimal design of clothing for the specific type of usage
- Study of the influence of clothing on the humans organism with a possibility of increasing comfort, health and hygiene of a user.

Body temperature is regulated by exchange of heat between the body and the environment and it is conditioned with the state of dynamic balance between produced heat and heat that is lost in the environment. (Mecheels J., 1977).

The significant influence, on the balancing of body temperature, has a choice of the suitable clothing that corresponds to the climate and physical activity in a way that is accomplishing the thermal balance. The way of regulating body temperature with suitable clothing is named as „managing of the thermoregulation“, with whom man relaxes an autonomic nervous system and thus significantly reduces the thermal load of the body. (Ilmarinen R., 1978).

Clothing creates a special microclimate between the body and the ambient, that is, it behaves like a barrier to the transfer of heat and moisture between the skin and the environment. (Geršak J. et al., 2008).

Basically, clothing prevents evaporation of the sweat from the skin surface, and this insufficient evaporation while wearing clothes creates a feeling of an uncomfort very often. (Kim J.O., 1999).
For objective evaluation of clothing's comfort features series of the experiments and analysis in the study of the dynamic flow process of the heat and the moisture were made, as well as rating of thermal-moisture comfort properties of fabrics in terms of wearing. (Yang K. et al., 2008).

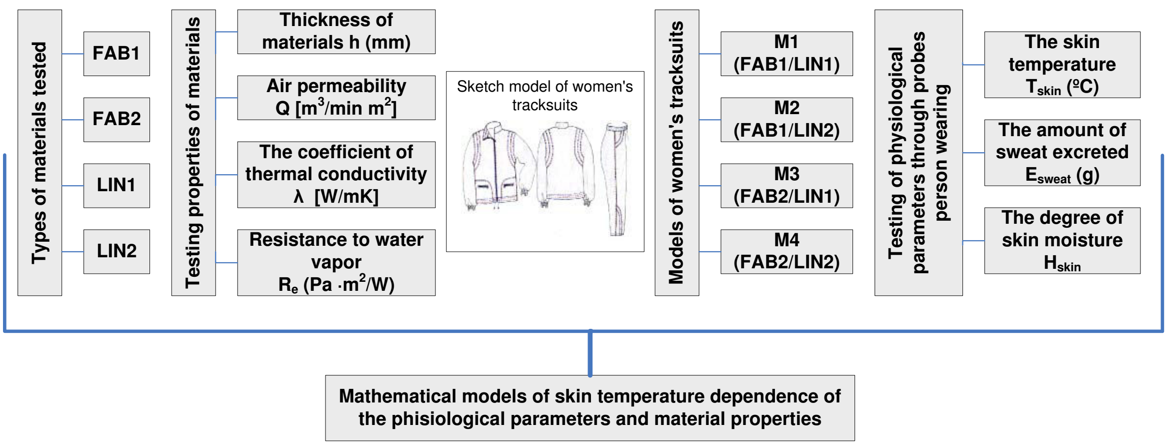
3. THE EXPERIMENTAL PART

For making of the four female's sweat suits, two polyester fabrics and two knitwears of a different material composition and interlacements, whose bacis features are given in table 1., were used.

Table 1: Basic features of selected materials for making of female's sweatsuits

Oznaka uzorka	Vrsta prepletaja	Vrsta pređe	Finoća pređe [dtex]	Gustina žica (očica) [cm^{-1}]		Površinska masa [g/m^2]
FAB 1	platno	PES mikrofilament	Osnova: 100/160x1 Potka: 150/240x1	55	32	146
FAB 2	platno	PES mikrofilament	Osnova: 90/160x1 Potka: 160/240x1	56	43	119
LIN 1	interlok	Pamučna pređa	1900x1	15	17,5	152
LIN 2	til	PES filament	50/10x1	18	11,1	36

Testing of the material's characteristics and physiological parameters of the individuals (8 girls of the same age and approximatly the same weight) who wore models of female's sweat suits under different climate condition (relative humidity RH = 65 %, air temperature Ta = 15, 20 i 25ºC, wind speed v = 0,5 m/s) and certain physical activity (the movement speed 4km /h on the flat ground and lofty ground – rise 5º) were carried out in the order shown on Picture 2.



Picture 2: Plan of experiment

To determine the subjective feeling of the a thermal comfort while wearing slothes in different climatic conditions and different physical workloading tests, persons evaluated the thermal comfort of the female sweatsuit on the basis of questionnaries and scales with marks, according to ISO 10551 standards.

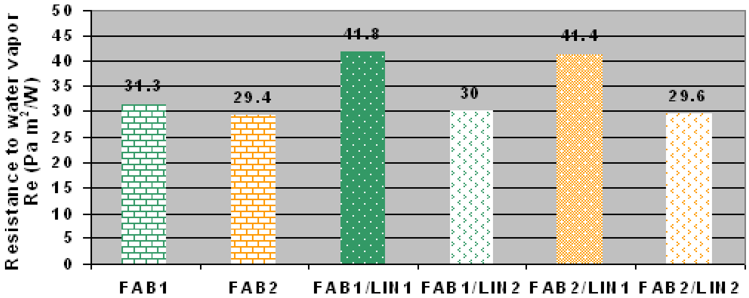
Temperature of the skin was measured on eight measuring points, according to ISO 9886, and from the values measured, the mean ponderated skin temperature has been calculated.
The amount of evaporated sweat was determined from the difference in the mass of questioned persons and after the testing in a climate chamber, according to ISO 7933.

4. RESULTS AND DISCUSSION

The test results of the material's features that are significant for the defining of thermal characteristics and comfort of sports wear, such as thickness, air permeability and thermal conductivity coefficient are given in Table 2, and the resistance to the water vapor flow and combination of fabric/knitwear on the Picture 3.

Table 2: Materials characteristics that are significant for defining of the thermal clothes features

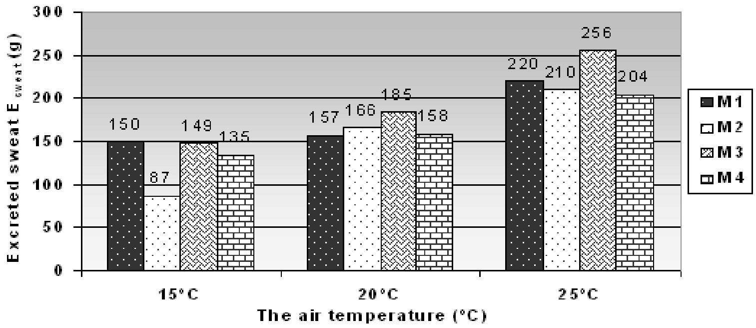
Oznaka uzorka	Debljina [mm]	**Vazdušna propustljivost** Q [m^3/min m^2]	Koeficijent toplotne provodljivosti λ [W/mK]
FAB 1	0,35	5,56	0,2765
FAB 2	0,28	3,26	0,1130
LIN 1	0,92	31,83	0,2799
LIN 2	0,36	Nemjerljivo	0,0997



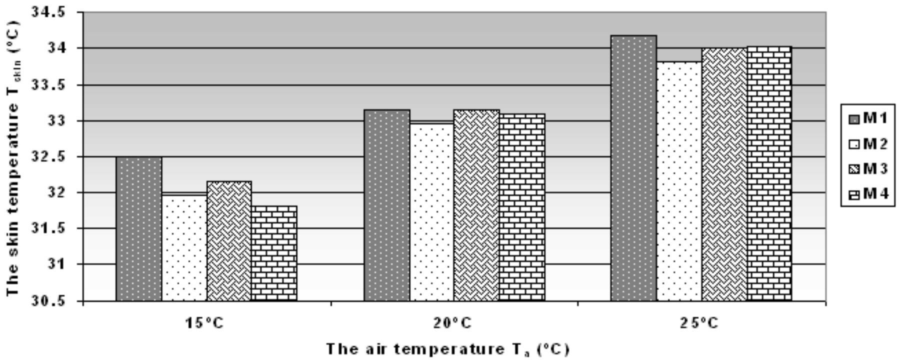
Picture 3: Dependance of material's resistance to the water vapor flow from the number of layers in a clothing system

Based on the test results that are shown in the table 2. and on the picture 3., it can be seen that the fabric marked as FAB1 has higher values for the air permeability, thermal conductivity coefficient and the ressistance to the water vapor flow, compared to the FAB2 fabric.

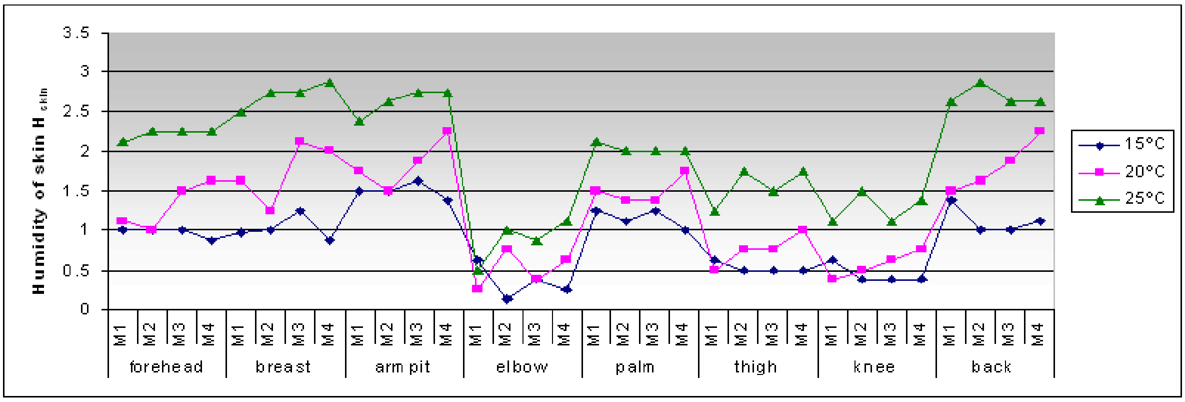
When we look at the test results of the resistance to the water vapor flow for different combinations of materials, that correspond to the models of tested female's sweat suits, it can be seen that the maximum value of the specific parameter is for the combination of FAB1 material (basic fabric) and knitwear LIN1 (lining), while the minimum value is observed in FAB2/LIN2 combination.
The test results of physiological parameters of persons that wore tested female sweat suit models, such as the amount of evaporated sweat, temperature and the degree of skin moisture are given on the Pictures 4, 5 and 6.



Picture 4: Dependence of the amount of evaporated sweat of persons who wore clothing models from the climatic conditions



Picture 5: Dependence of the skin temperature of persons who wore clothing models from the climatic conditions



Picture 6:Dependence of the degree of skin moisture in certain body parts of persons who wore clothing models from the climatic conditions

When we look at the test results of physiologycal parameters of persons who wore tested female sweat suit models in artificialy produced climatic conditions, pictures 4-6, we can see that:

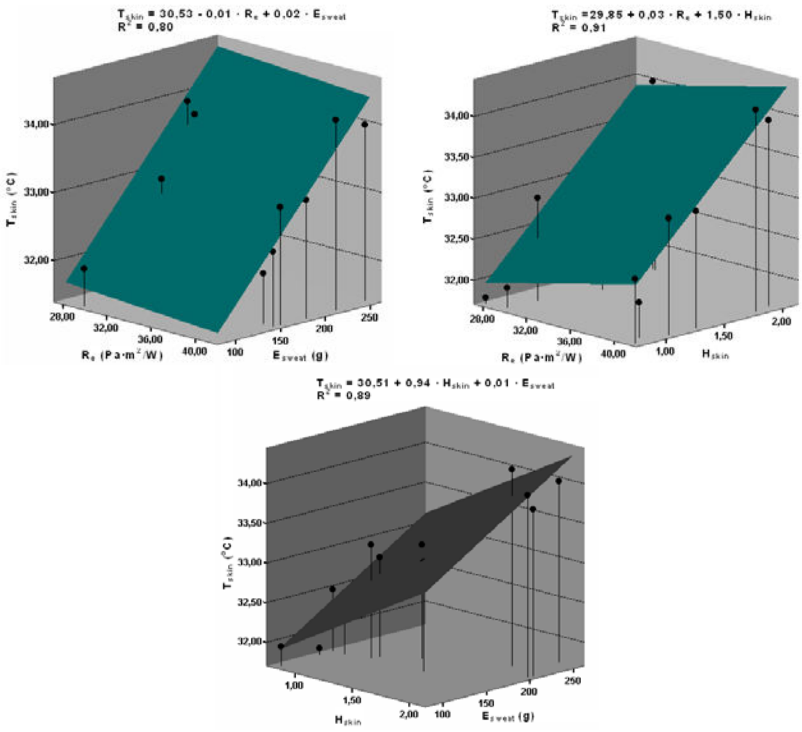
- The amount of evaporated sweat is highest on the air temperature of 25 ºC, while persons wore M3 model, and lowest for M2 model on the air temperature of 15 ºC, picture 4
- The skin temperature reaches maximum value on the air temperature of 25 ºC while persons wore M1 model (34, 19ºC), and lowest value is for the M4 model (31, 80ºC) on the air temperature of 15 ºC which belongs to the zone of discomfort
- The degree of skin moisture for certain body parts reaches value (3), that is, the skin is „wet“ on the air temperature of 25 ºC, while for the air temperature of 15ºC and 20ºC, value of skin moisture mostly below (2), except for the breasts, the armpit and the back.

To determine the dependence of skin temperature from the physiological parameters of persons and materials features a multiple linear regression analysis was used (Komić J., 2000).

The multiple linear regression coefficients for obtained mathematical models od dependance of skin temperature of tested individuals for specific clothing models depending from the physiological parameters (the amount of evaporated sweat and the degree of skin moisture) and characteristics of material (the resistance to the water vapor flow) are given in the table 3, and graphical display of dependency on the picture 7.

Table 3: The multiple linear regression coefficients for obtained mathematical models

T_{skin} (ºC) = 30,53 – 0,01 · R_e (Pa·m²/W) + 0,02 · E_{sweat} (g)										
Koefic. višestr. regres.	Std. greš. regres.	b_o = 30,535			b_1 = - 0,0122			b_2 = 0,01708		
R^2	s	std.gr.	t	p	std.gr.	t	p	std.gr.	t	p
0,8050	0,4054	0,746	40,912	0	0,002	-0,593	0,568	0,003	5,937	0
T_{skin} (ºC) = 29,85 + 0,03 · R_e (Pa·m²/W) + 1,50 · H_{skin}										
Koefic. višestr. regres.	Std. greš. regres.	b_o = 29,852			b_1 = 0,03321			b_2 = 1,498		
R^2	s	std.gr.	t	p	std.gr.	t	p	std.gr.	t	p
0,912	0,2719	0,526	56,805	0	0,013	2,542	0,032	0,158	9,455	0
T_{skin} (ºC) = 30,51 + 0,94 · H_{skin} + 0,01 · E_{sweat} (g)										
Koefic. višestr. regres.	Std. greš. regres.	b_o = 30,514			b_1 = 0,937			b_2 = 0,0074		
R^2	s	std.gr.	t	p	std.gr.	t	p	std.gr.	t	p
0,894	0,2992	0,376	81,20	0	0,328	2,858	0,019	0,004	1,941	0,084



a) b) c)

Picture 7: Graphical display of skin temperature dependency for obtained mathematical model depending from
a) the resistance to the water vapor flow and the amount of evaporated sweat
b) the resistance to the water vapor flow and the degree of skin moisture
c) the amount of evaporated sweat and the degree of skin moisture

5. CONCLUSION

Sport's clothing comfort while wearing is dependant from the climatic conditions, physical activity of individuals, cut construction and numebr of clothing layers, as well as from characteristics of materials that it is made of. Some of the material's features, such as air permeability, heat conductivity and

resistance to the water vapor flow are very significantfor defining of the thermal comfort of the sportswear.
Very high air permeability and low value of heat conductivity coefficient (0,0997W/mK) at LIN2 knitwear, which was incorporated in female sweat suit models M2 and M4, has caused lower skin temperature (below 32ºC – the discomfort zone) at persons that wore these clothing models at the air temperature of 15ºC.
Based on the results of the research of dependance of the female's sweat suit comfort while wearing from the features of materials and physiological parameters of individuals, it was found that there is statisticly reliable dependance between the skin temperature – T_{skin} and resistance to the water vapor flow – R_e, the amount of evaporated sweat – E_{sweat} and the degree of the skin moisture – H_{skin}, at the air temperature from 15ºC to 25 ºC and relative air humidity at 65%.

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OPTIMIZATION OF CUTTING PATTERNS USING CAD SYSTEM ON THE EXAMPLE OF CHILDREN'S CLOTHES

V. Petrović, M. Stanković, A.Zdravković, I. Stamatović, J. Danikov.

Apstract: *Modern business conditions impose that development of manufacturing companies going toward the level where they will be able to respond to market demands in a very short period of time. In this paper it is analysed the application of modern CAD software solutions for fitting cutting pictures. The analysis is based on a sample of four different models of children`s clothes KS1, KS2, KS3. From the obtained results we can see that computer constructional preparation is almost three times faster then. The results show that time for fitting cutting patterns was reduced to 86% for model KS1 - children t-shirt, for model KS2 – children's trousers, the time was reduced by 84.94% and for model KS3 – children's dress, time was reduced by 83.34%. Despite the good results obtained using the CAD system, it was concluded that a large number of enterprises in Serbia today is not equipped with CAD systems due to high financial investment for this type equipment for production.*

Key words: *optimization of production, clothes, production of clothes on time, CAD system, fitting of multiple sized cutting patterns.*

1. INTRODUCTION

Equipment level of companies for apparel production, which in Serbia has around 950, is different. The environment and conditions under which these firms were established in the last few decades have led that large number of firms was not based on the engineering knowledge, which follows the production of clothing. Clothing industry has big problems especially in countries which are in transition. Nowadays, it is common to hear that the Clothing and Textile industries are in crisis, that production is reduced, sales is reduced, working hours are reduced, and that those industries are operating with losses. Those facts indicate that textile companies have difficulties to adapt to new business conditions, i.e. environment gives them less opportunity to do business successfully. It is evident that certain number of companies can not manage in the new conditions [1,2].

Where we should seek the reasons for poor conditions in Serbian textile industry, once with very successful companies? Newly created economic circumstances and problems, which follow them, have certainly big influence on production process. The most common issues on which encounter manufacturers of apparel are:

- need for a wider collections and frequent changes of samples
- changes in consumer demands,
- changes of dressing tradition,
- emergence of market saturation
- pressure from imported goods,
- changes in rhythm ordering of the traders, etc.

For getting out of this situation it should be used the experience of those who had the same or similar problems and who had successfully solved those problems. All solutions are mainly based on impressive reduction of costs of all participants in the textile chain. To start solving the problems, it is usually taken analysis of current situation of the company. The analysis usually indicates that there is a fatigue in the functioning of the company. For recovery, it is usually offered the following solutions [1,2]:

- implementation of manufacturing strategy Just-in-Time for resolving unnecessary inventories in stock;
- evenly supply of materials in accordance with the needs of the firms;
- introduction of the CIM concept with electronic computers in the management and flexible manufacturing at all stages;
- introduction of Total Quality Management for a comprehensive quality assurance;

- implementation of integrated marketing for completely guidance all operational functions according to market needs, etc.

Modern business conditions impose that development of manufacturing companies going toward the level where they will be able to respond to market demands in a very short period of time. In accordance with that, the companies have the all-new and very strict organizational and production conditions because in a very short time, they must prepare the production process, to adapt production lines, machinery and equipment and workers for the sudden and rapid changes. To satisfied this requirements, it is necessary that company has modern equipment [3]. Survival on market and success in the competition, is forcing companies to always invent new solutions and to take steps for reducing costs impressively, both in the production and with all the participants in textile chain [1,2].

Therefore, today is resorting to new strategies of apparel production. QRS is a strategy for rapid response to market requirements, for identification of needs and desires of clothing consumers, spotting fashion trends, evidence of increasing demand or lack of certain items on the market. This strategy should ensure responsiveness to market demands for a few days [1].

Besides QRS strategies, a special kind of manufacturing strategy - a JIT strategy - just in time or in the given timeframe is imposed on garment manufacturers. This strategy has set completely new and very strict organizational and production conditions for modern garment industry, which are reflected in the preparation of the production process in a very short period of time, and in adapting production lines, machinery, equipment and personnel for the sudden and rapid changes, which are extra impeded small production series. In this way, activities for production preparation represent a significant factor in these strategies [3].

We have witnessed a numerous of projects in countries in transition which aim at entrepreneurship development. One of these projects in Serbia was the USAID / SEDP project. The goal of SEDP project was to reduce production costs by applying engineering techniques in garment manufacturing with retain quality standards.

Different phases of the project included establishing the order of production operations for all apparel models , definition of appearance of the most efficient work space, establishing the most effective methods of management of making the time study for each operation in order to achieve the correct standard, calculating the number of machines required by the type of machines, setting machines in production lines in the order certain operations, preparing the method for the development of training for each operator and Education checklist for the daily performance of each machine or workstation.

BENEFITS	
IN GENERAL	SPECIFICALLY
Improved focus on consumer needs. Improved communication. Higher quality standards. Improved efficiency, i.e. Purchasing/distribution.	Improved distribution. Easier recording Shorter lead and response times. Improved sales forecasts. Fewer retail markdowns.

RESULTS
Lower costs. Increased sales. Higher profit margins. Improved flexibility through smaller orders. Higher returns on investments.

Figure 1. The benefits of using a CAD system

The project included dozens of private apparel companies in Serbia. Project results are reflected in reduction of time required for garments production ranging from 5%, and in some cases up to 40%. Average reduction time for clothes production was ranged around 12%, for all companies in the project. The authors were the participants of USAID / SEDP project. However, it is difficult to present how it was reached to these results , because approach to the problem solving to each company was primarily subjective, and it was based both on the engineering knowledge and personal experience. In addition, each Clothing company was faced with its characteristic problems in their operations and therefore is difficult to make a comprehensive systematization in solving those problems. Figure 1. showes the benefits of using a CAD system.

Therefore, in this paper will be considered a small segment in constructional preparation of clothes on representative example of middle companies. Changes in efficacy of constructional preparation when company equips its production with CAD system for fitting cutting patterns of garment will be shown . The same workers who worked on fitting cutting patterns in traditional way were trained for using the CAD system.

2. MATERIJAL I METODE

By increasing the level of technical equipment of constructional preparation, worker's fatigue is significantly reduced, with a significant increase of productivity. The influence of competition led to a new tendency in making clothes, it is reflected in the reduction in running time of technological operations while maintaining quality, because productivity, production capacity and price garment depend on that. For this reason, during design of clothing products it is necessery to take care about raw material's composition and material properties, as well as the technology of its processing [5-12]. Therefore, in the work it was monitored fitting of cutting patterns for several clothing products before and after introducing CAD systems for fitting cutting patterns into the product line. During analysis it was used French company's software Lectra, more precisely their software package Diamino [4].

Diamino is a program for making - fitting cutting patterns from models made in Modaris program , and with high-speed performance it provides the reduction of material consumption. It allows fitting of cutting patterns for every type of material and cutting layers. tailoring files for each type of material and debris (open, folded, in the gut, so called open. "face to face"), and operators use it to quickly locate the most effective way of fitting cutting patterns by testing different combinations to find the most usable appearance of cutting patterns and by use of clearly defined rules for the positioning of the cutting parts. All information is printed on cutting parts, fitting process is shown on the screen and it can be continuously monitored. At any moment the cost of material can be seen like and the modifying the quantity, size, and display of all parameters of cutting patterns [4].

The program provides matching cutting patterns on designed (check) materials and accurate positioning of cutting parts according to pre-defined points that are used for matching. In order to achieve fine cutting on each cutting part, it can be added some enlargement (abandon) in centimeters, different spacing from other cutting parts and their grouping for easy fitting.

Figure 2: Display of cutting parts on Diamino desktop

During creation of cutting pattern, more patterns could be made at once with different so called restrictions in relation to the material or to the cutting parts (allowed or not turning parts, variants, position of cutting parts for overlap and hose materials) which is used to ensure true parameters in the cutting pattern and to reduce the possibility of error.
Before each memorising of cutting pattern, it is automatic analysed if the cutting parts are mutual overlapped and if there is cutting part which is not incorporated. Special mini keyboard was build for this program, with purpose to speed up the fitting process, which increases speed of execution and increases productivity in the development of cutting patterns.

Diamino is directly linked with other Lectra's applications, primarily Modarisom which is used for modeling. It allows that during modification of the model, all cutting patterns which contain that model automatic include new modification.

Directly from program cutting pattern can be sent to the printing, the automatic spreading or cutting. Program also contains functions for preparation of cutting on the automatic material cutters (cutter), it allows the determination of the starting point, direction of cutting, and optimization of cutting process.

Diamino program includes the following features:

- features and tools that enable creation and easy modification of high-quality embedded cutting patterns from models created in Modaris
- maximum flexibility during fitting of cutting parts, flexibility in changes of quantities, dimensions, displaying and in parameters for each of creating process
- The process of testing a lot of different combinations in order to find the most usable appearance of cutting pattern
- creating of so-called limitations of fitting in order to fit exactly by defined rules
- increasing the parts of the cutting pattern, and fast change of measures for partial or entire displaying of cutting pattern
- automatic recognition of folded parts before saving
- creation of cutting parts on patterned materials, and precise positioning of the cutting parts according to defined matching points
- adding so called leaving on the cutting parts for the sampled materials or for fine cutting
- so called profiles that can store parameters of cutting pattern, and thereby saving time in preparing the following cutting pattern with the same parameters
- special software for fast creating of cutting pattern, which separates processes of creating and fitting
- cutting of cutting pattern at exactly defined position with determined spacing on the cutting spot (it is used for spacing of cutting parts for slitting the so-called. "Progress" tester), as well as cutting the cutting parts in the cutting pattern to get a better utilization
- printing the properties of the cutting pattern for further calculations
- convert of cutting pattern in so-called cutfile for printing and cutting on systems that are not Lectra
- saving several cutting patterns in one file in so called .MKX format for faster sending by e-mail

In this study, tasks of fitting cutting patterns were observed for three different clothing items (shown on Figure 3) in multiple sizes cutting patterns including: wrapover vest (cutting pattern KS1), skirts (cutting pattern KS2) and pants (cutting pattern KS3). T-shirt and trousers are made from 100% cotton, dress from cloth of mixtures of 97% cotton and 3% elastane. Tables 1 and 2 show the duration of the tasks of the traditional fitting of cutting patterns, and fitting of cutting patterns with the use of CAD systems. The observed workers on jobs of fitting of cutting patterns were with approximately the same working experience. Workers have had great experience in the traditional way of fitting cutting patterns, and their training to work with the CAD system lasted 4-5 months, which is a short period of time for workers to acquire a maximum of all program options offered by the software package Diamino.

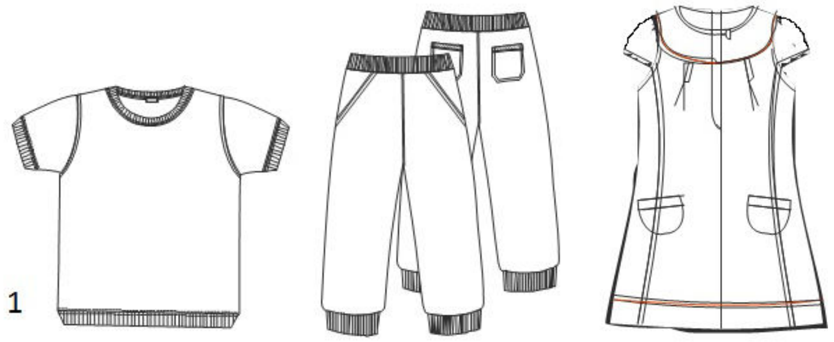

Figure 3: Tecnichal drawings of models used for cutting patterns

Table 1: Duration time of the tasks of traditional fitting of multiple sized cutting patterns

The observed activities	Time [min]		
	KS1	KS2	KS3
Fitting of cutting patterns	90	99,6	120

Tabela 2: Duration time of fitting multiple sized cutting patterns with the use of CAD systems

The observed activities	Time [min]		
	KS1	KS2	KS3
Fitting of cutting patterns	12,6	15	20

Marks in tables 1 and 2 have this meaning:

KS1 – cutting pattern 1- children's T-shirt,
KS2 – cutting pattern 2 – childrens's trousers,
KS3 – cutting pattern 3 – children's dress.

Figures 4, 5 and 6 present the advantages of using CAD systems to the traditional way of fitting cutting patterns of models for presented clothes.

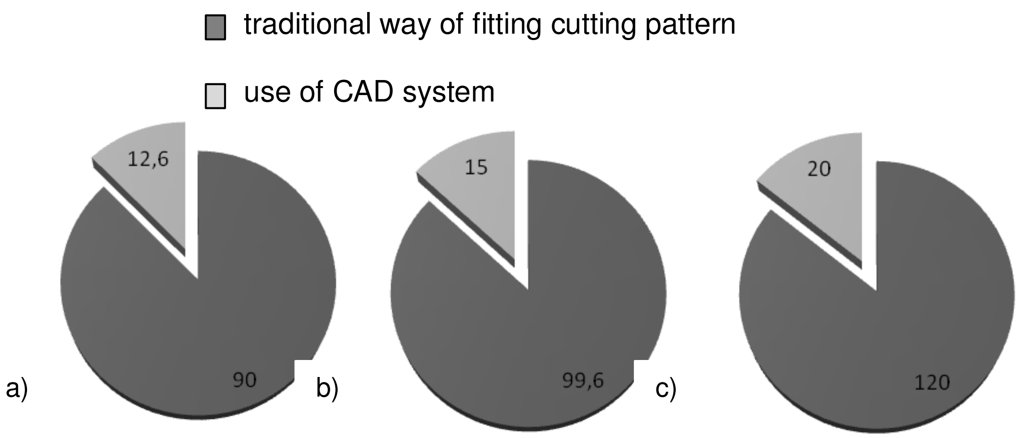

Figure 4. Comparative duration (in minutes) of fitting cutting pattern for a) t-shirt, b) trousers, c) dress

3. CONCLUSION

Work in the clothing industry is devided on a large number of technological operations of making clothes. Every technological operation is time limited and requires considerable mental and physical involvement of employees. The success of the production of clothing largely depends on the structure and time duration of technological processes. Therefore, in this work fitting of cutting patterns was observed, because it has big influence on the speed of production, ie. on the speed of production response to market demand. The observed workers, who worked on fitting cutting patterns were with approximately the same working experience. Workers have had great experience in the traditional way of fitting cutting patterns, and their training to work with the CAD system lasted 4-5 months, which is a short period of time for workers to acquire a maximum of all program options offered by the software package Diamino. Regardless of this fact, the same employees achieve significantly better performance using a CAD system. The results show that for KS1 – children's T-shirt, time for fitting cutting patterns was reduced by 86%, for KS2 – children's trousers, the time was reduced to 84.94% for KS3 – children's dress, time was reduced by 83.34%. This time can be significantly reduced by using advanced software functions available in software package Diamino. The results show that using of CAD systems can significantly speed up the production preparation, which is very important in order to satisfy requirements of large consumer markets of clothes that have a constant tendency to reduce the time of making clothes.

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FROM IDEA TO ACTUAL PRODUCT

Snezana Milosevic

Abstract: *It could not be more simple; the idea at the beginning, the actual product at the end. The endless combination possibilities between.Sometimes, it's a long way towards a creation, when the idea becomes a real product, when the magic of dreams turns into reality, i.e. into the rational thinking of: the form, the way of life, the mood and the certain needs.*
Sometimes, it is a present idea, reaction (explosion), always looking for something more unexpected and exciting. The clothing is much more than clothes, for someone who wears it, it provides more. The clothing is a lofty language that conveys how you want to be perceived by the others, it transmits emotions.

Key words*: trends, idea, information, the act of creation, inspiration, collection.*

1. INTRODUCTION

Fashion is an important part of life, there is a reason why it exists; because in fashion we can find new expressions; suddenly, we just feel something like a real thing and the trend is born! Figuratively speaking, trends are like bubbles that float on the surface, we have plenty of time to catch them before they scatter.

2. COLLECTION DEVELOPMENT

The collection development process for the next season is consisted of several stages:

- Information
- The act of creation
- Communications

3. INFORMATION- FASHION FORECAST

Informing begins with the information on fashion trends for the season for which the collection is anticipated, the second information step contains information about the capabilities, machines capacities that factories possess; the third information step is about the market needs with regard to the current economic and social life conditions, such as the purchasing power of consumers. Each season brings certain principles: color, shape, pattern, samples...

The basic ideas of the inspiration are repeated and common for the most designers from New York, Paris, London to Milan. After hundreds of fashion shows, recognizing trends in four fashion centers looks simple. The question is how to get on the same track with different inspirations. It is absolutely true that the fashion designers always set trends. It is also true - even though a little bit mysterious - that a sufficient number of designers will decide, at first glance independently, that particular color, shape, size or style are the look of the moment, and it will launch that look directly on top of the ruling trends list of the season.

Fashion trend for upcoming season includes several fashion themes where one of them is a new, main and that one indicates changes in fashion, a new tendency, while the rest of them are the extension of the themes from the previous season. There are several practical reasons why certain trend can suddenly to flood the runways in four different fashion capitals. The similarities of many designers come from the work of the textile industry. The industry that produces fabrics must anticipate which the color will be the trend even further in the future than the fashion houses do. A lot of the designers order the materials, the auxiliary supplies and the other necessary details from the same factories and manufacturers.

The teams, involved in predicting which colors will dominate the runways, operate on that up to two years before the current season. A team of experts investigate the consumers' attitudes to two years in advance - color palettes and trends for which there are the tendencies to be consumed and developed further into the micro-trends for which is needed about 18 months developing before the fabric manufacturers get orders. In other words, even now it is known what will be trendy in the next year, maybe not precise the print but the color and fabric type of course.

Delivered goods, fabrics in this case continue to affect what the designer will be able to make of them, but before models designing, inspiration-mood-board, choice of fabric and determining the general atmosphere of the collection, those that predict trends - the trend forecasters have an important role to play. There are several exclusive consulting agencies that deal with predicting the trends today. They readily capture trends in its very conception and determine the direction in which the design will go. The creativity is left to designers and the agencies are not in charge to make up the trend but they should document information at the right time and classified them in a certain way. The key of their work is in constant scanning of the world, observing the people behavior and their habits, and learning general mood and spirit of the time. First of all, the professionals rely on their own intuition and in every moment they follow the ongoing changes in society and the political situations. All these conclusions are usually classified into the book about the season, in which there are recommendations for the color, inspirational images, keywords and samples of materials. The book printing is limited by the number of copies and has a high cost.

In this era of informatics, when the information and its flow speed are so powerful, those involved in forecasting trends are included in the relentless race against time. Although this is the profession taught at several universities around the world, a personal feeling remains the primary tool. Those who first feel the true track and get the information are those who dictate the rules of the game. The rest of the world is sentenced on hold. Only after more than a year, the trends could be seen on the runways.
This explains the seasonal interflow of ideas in fashion shows and thus, to some extent, gives the answer to the question: why so many apparently original ideas look similar.

4. CREATIVE ACT

The creative act is consisted of the ideas, imagination and the rational part, in fact creating a model of visual elements on the basis of visual laws and the criteria of esthetics as well as the talent to harmonize these two components and present them at the highest level of esthetics.

The idea about the model, about the season collection arises at the moment of inspiration. It fits into a fashion trend or derives from it, while it adjusts to the visual laws in the model realization and to market needs. The cooperation of the experts team consisted of the technologists, designers, technicians as well as the production possibilities consideration are essential in order to realize the models - collection more efficiently and more successfully. Another important collaboration is the collaboration between the designer, the commercial team and marketing team in order that collection will be accepted by the market and to communicate successfully with the potential users.

5. COMMUNICATION AND TREND ACCEPTANCE

However, the key element in the trend creation is another, less catcheable element. It has nothing to do with the creativity of designers, but it deals with his ability to put on a great platform important notifications about the things which are going on. The people who just observe are the innovators. The behavior patterns within the design, fashion, the industry of beauty and culture could be explained by an extensive research, by the study about that how ideas get their practical usable base and become a public good, until they end up getting lost in the everyday and ordinary life. When it comes to the presentation of new concepts, the consumer’s trends can be single out in four categories:

- Launchers - innovators
- People in fashion
- Classic types
- People out of fashion

Innovators, those who adapt quickly, those who early adopt changes and in the end the majority that is the last to adopt the trends. Each group feeds by what the previous group consumes, on each individual consumer someone influenced who has bought some of the goods that belong into the category of the next big thing, except innovators, who are able to guess what would be cool. These people are almost excommunicated from the crowd, a trend becomes the mainstream only if you single out something that is different and you make it wearable and receptive to everyone. Everyday dressed passers-by might look at them and wonder, but right from the weird and wonderful styles of these small society groups, designers draw their inspiration. This is true for any dominating look.

COLLECTION Fall / Winter 2012-2013

The collection is inspired by the sixties of the last century, the fashion icon of that period and now eternal inspiration Jacqueline Kennedy, the influence of pop art and its creator Andy Warhol. The artwork Warhol's "Sixteen Jackies" was the initial inspiration for the collection development, as well as finding connection between the various elements of artistic movements and the current fashion trend elements.

By studying the trend and basic inspiration ideas in the collection are introduced elegant materials: silk, viscose, cotton, jacquard fabrics for elegant blazers ¾ sleeves, the fabrics of rich raw material composition that enable to eternal Chanel costume to look so immaculate, lace, leather details. The present colors: range of purple hues, dark tones of pink, metallic gray, elegant brown, beige and glamorous black.

Within the model form the inspirational link with Jackie Kennedy style could be seen. She enjoyed the Chanel suits, cocktail dresses, elegant skirts, blouses and she was synonym for the elegance, glamour and simplicity at the same time.

INSPIRATION; this collection begins with mood boards, these "mood boards" unite all the initial elements of the inspirational ideas. The models sketches that are, through cooperation with the expert team of designers and technologists, turned into a real product.

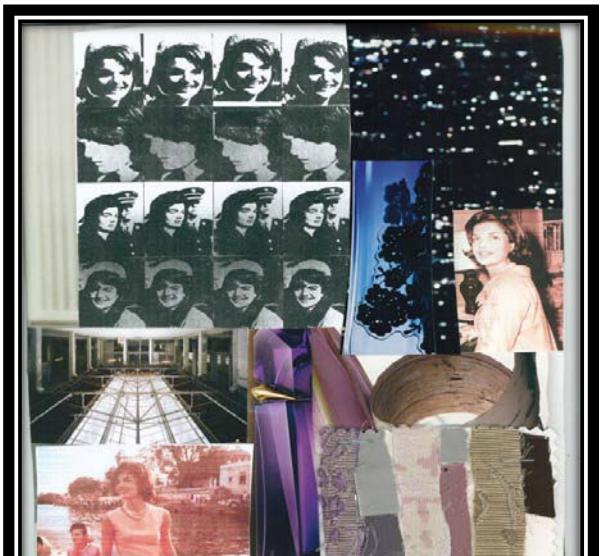

Figure 1 . Inspiration

Figure 2. Chanel costume

Figure 3. Cocktail dress

Figure 4. Coctail dress

6. CONCLUSION

By studying this subject I have considered more finding and trend forecasting, collecting information on the style, forms of models, colors and materials for the upcoming season; because, the whole process and the creative act start from that point .
The conclusion after these studies is that the trend is a multiple phenomenon that has certain meaning, but in reality it has sense as much as it is accepted.

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EFFECTS OF FABRIC STRUCTURE ON THERMAL CONDUCTIVITY OF COTTON WOVEN FABRIC

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***Abstract**: Heat and moisture occur as a result of body activity and have to be transferred through the fabric in order to possess thermal comfort attribute. It is essential to have high thermal resistance for protection of low ambient temperature and high breathability to achieve effective heat transfer (Marmarali A. et al., 2006). A thermally comfortable textile enables the temperature and moisture balance of the body by adequate air and water vapor transfer through the fabric (Bhattacharjee D. et al., 2008).*

The thermal comfort ability of a fabric is influenced by several factors: the type of the fabric structure, the design of a woven fabric, the warp and weft density, the amount of twist in yarns, the size of the yarns, the fiber type and also thickness and unit weight of the fabric (Weidong W. et al., 2006). In this study two main factors (the weave design and unit weight-thickness of the fabrics) were mainly considered that are expected to be related with comfort property. In order to identify thermal comfort parameters; hydrophilicity, water vapor permeability, air permeability and thermal resistance of three different cotton woven fabrics (sateen, twill and plain weave) were measured.

***Key words:** Comfort, Thermal Conductivity, Thermal resistance, Breathability*

1. INTRODUCTION

The water vapor permeability and air permeability is a measure for breathability and for a textile's ability to transfer moisture (Guo, J., 2003). The air permeability is a significant factor for textile products especially in comfort necessary. The air permeability is mainly dependent upon the fabrics' weight and construction. Woven fabrics are manufactured by interlacing warp and weft yarn. There exist some porosity in the structure of the fabric according to warp and weft density and yarn structure. The air permeability together with vapor permeability have a major role in variety of consumer and industrial applications, including apparel comfort, flammability and thermal insulation efficiency.

In literature researches are mainly about the control of thermal comfort of fabrics related to fiber type or fabric structure. Oglakcıoglu and Marmara were published a research about comparison of different fiber types for the aspect of thermal comfort parameters (Oglakcioglu N. et al., 2010). In that study fabrics consist of polyamide, cotton, viscose and modal were compared according to their air permeability, vapor permeability and thermal conductivity values considering the fabrics' thickness and unit weight. This research focuses on the determination and changes on thermal comfort parameters with regard to fiber type, weight and thickness variables (Weidong W. et al., 2006). Bhattacharjee and Kothari compare the thermal comfort properties of three different woven fabrics and indicated that plain weave fabrics have the highest thermal conductivity (Guo J., 2003).

To the best of our knowledge in literature thermal comfort properties in relation with unit weight and weave design have not studied yet. This research was undertaken to investigate the effect of weave design, fabric thickness and fabric unit weight to the thermal comfort properties. In order to identify thermal comfort parameters; hydrophilicity, water vapor permeability, air permeability and thermal resistance of three different cotton woven fabrics (sateen, twill and plain weave) were measured.

2. EXPERIMENTAL STUDY

In order to determine the fabric structure effect to the comfort properties of fabrics, physical thermal comfort tests are achieved which are air permeability, hyrophilicity, thermal resistance and water vapor permeability. Hydrophilicity test was achieved properly TS 866,1985 and repeated 10 times for each specimen. Air permeability test was achieved according to TS 391 EN ISO 9237,1999 and air permeability, R (mm/s), was evaluated using following equations.

$$R = (q_v / A) \times 167 \qquad (1)$$

In that equation;
q_v; The arithmetic mean of air flow rate,(l/min),
A; The area of tested fabric, (cm²),
167; unit conversion factor.

Water vapor permeability test, BS 7209, 1990; was used in order to identify water vapor permeability of the fabrics. The experimental study was achieved under the ambient temperature of 20 ± 2ºC and relative humidity of 65 ± 2% . Vapor permeability is evaluated in terms of (WVP) g/ m²/ day using the following equation:

$$WVP = 24M / (A.t) \qquad (2)$$

In equation 2;
M; Weight loss in t time period (g),
T; Time between two weight measurement (h),
A; The area of tested fabric (cm^2).

Thermal resistance of the fabrics is measured according to TS EN 31092,2000, at least three times for each specimen. Thermal resistance R_{ct} was evaluated using following equation:

$$R_{ct} = [(T_m - T_a) . A / (H - \Delta H_c)] - R_{ct0} \qquad (3)$$

R_{ct}; Thermal resistance m².K/Watt
R_{ct0}; Device constant, m².K/W
A; Measurement unit area, m²
T_a; air temperature during measurement, °C
T_m; Temperature of measurement unit, °C
ΔH; Heating power of measurement unit, W
ΔH_c; Correction factor

3. FINDINGS & DISCUSSION

Thermal comfort tests were applied to eight different fabrics that have three different weave design, except plain weave each of them consist of three weight variance; low, medium and high (see also Table 1). Plain weave fabric has only low and medium weight types. In Table 1 it is obvious that fabric density increases from plain weave to sateen weave. Air permeability results are illustrated in Figure 1a, according to results air permeability decreases as the fabric unit weight increases. This indicates that, fabric unit weight for the same fabric, decreases porosity resulting decrease in air permeability. On the other hand, air permeability has its highest value on sateen. Water vapor permeability increases as the fabric density decreases and it decreases as the unit weight increases (see Figure 1b). Figure 1b shows that plain weave fabric has the highest water vapor permeability. As the fabric density decreases thermal resistance of the fabric decreases (see Figure 2). For the same fabric type, the thermal resistance decreases adversely as the fabric unit weight increases.

Table 1: 100 % Cotton fabrics' properties used in the study.

No	Fabric structure	Yarn count (Ne)	Unit weight (g/m²)	Warp x Weft density (1/cm)
		Warp-Weft yarn		
1	Plain	20/1-20/1	194.2	40x20
2	Plain	20/1-16/1	220.4	41x21
3 4	3/1 Twill	20/1-20/1	200	41x21
5	3/1 Twill	20/1-16/1	230	41x26
	3/1 Twill	20/1-12/1	270	41x25
6 7	Sateen	20/1-20/1	210	45x22
8	Sateen	20/1-20/1	230	45x27
	Sateen	20/1-16/1	270	45x32

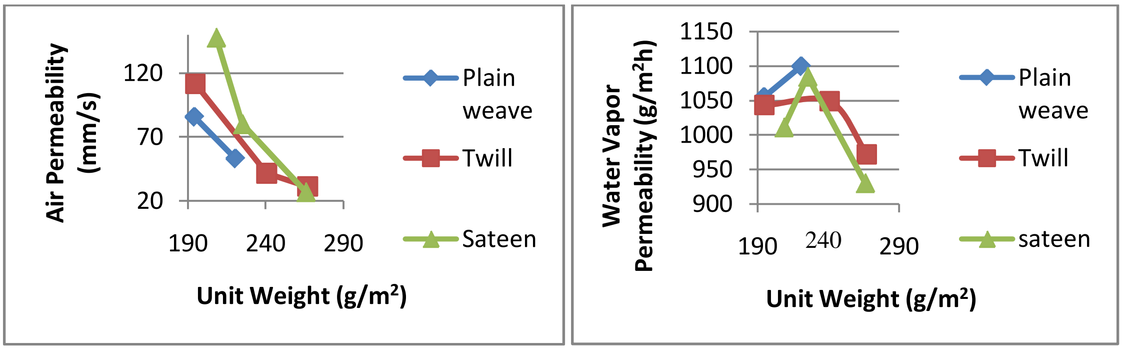

Figure 1: a) Air permeability, b) Water vapor permeability of the fabrics.

The results show that fabric structure affects water vapor permeability significantly. Fabric density increases from plain weave to sateen, respectively. Moreover the decrease in unit weight and fabric density causes an increase in water vapor permeability due to increasing porosity. Water vapor permeability and air permeability have an adverse effect on thermal resistance properties of the fabrics. Decrease in permeability causes an increase in thermal resistance of the fabrics.

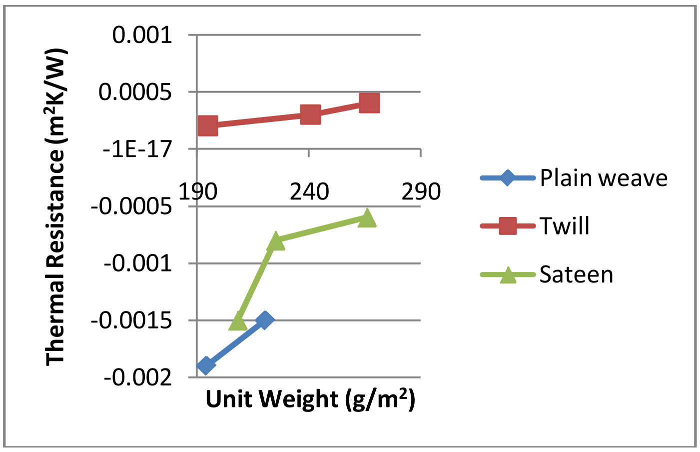

Figure 2: Thermal resistance of the fabrics.

4. CONCLUSION

Cotton possesses satisfactory thermal comfort properties, inherently. On the other hand thermal comfort is an attribute that occur as a result of fiber type together with fabric structure. The porosity, density and thickness of the fabric affect air permeability, so the change in air permeation causes a change in thermal conductivity. In this study, three types of fabric structure with different unit weights was chosen and assessed, the results indicated that plain weave fabric structure with the lowest unit weight has highest thermal conductivity that means lowest thermal resistance.

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RESEARCH OFTHERMO-PHYSIOLOGICAL COMFORT OF SINGLE JERSEYKNITTED STRUCTURES WITH METHOD OF THERMO-VISION ANALYSIS

Sonja J0RDEVA, Sonja KJORTOSEVA, Nikola KALOJANOV

Abstract: *The term comfort is defined as "the absence of displeasure or discomfort" or "a neutral state compared to the more active state of pleasure". Clothing comfort includes three main considerations: psychological, sensorial and thermo-physiological comfort. The thermo-physiological comfort, entails both thermoregulation and moisture management. It is known that fiber type, yarn properties, fabric structure, finishing treatments and clothing conditions are the main factors affecting thermo-physiological comfort.In this paper, the influence of structural propertiesand characteristics of the fiber on the air and water vapor permeability, thermal properties (thermo-physiological comfort), of single jersey knitted fabricswas investigated.Thermal conductivity of knitted fabrics was determined according to new method of thermo-vision analysis developed by researchers. The main advantage of the method is the possibility of non contact determination of the temperature change rate coefficient of the knitted fabric. The results indicate more significant influence of structural characteristics on thermo-physiological comfort, compared with thecharacteristics of the fibers. Knitted fabric of 50/50%PAN/cottonwith the highest density and mass per unit areahas lower air and water vaporpermeability, thermal conductivity and higher thermal resistance compared with knitted fabrics of 100% wool and 100% PAN.*

Key words: single jersey, thermo-physiological comfort, airpermeability, water vapor permeability,thermo-vision analysis

1. INTRODUCTION

The term comfort is defined as "the absence of displeasure or discomfort" or "a neutral state compared to the more active state of pleasure". Clothing comfort includes three main considerations: psychological, sensorial and thermo-physiological comfort. The thermo-physiological comfort, the subject of this research, entails both thermoregulation and moisture management. It is known that fiber type, yarn properties, fabric structure, finishing treatments and clothing conditions are the main factors affecting thermo-physiological comfort (N. Oglakcioglu, A. Marmarali, 2007),[1].

Over the last few years many studies have been conducted for thermal comfort properties of textile fabrics. Anand (Anand S. 2003), reported that the open construction has better water vaporpermeability than micromesh, pique, and rib structures,[2].

Milenkovic (Milenkovic L. et al, 1999), proved that fabric thickness, enclosed still air and external air movement are the major factors that affect the heat transfer through fabric. Greyson andHavenith, mentioned that heat and water vapor resistance increases with the increment of material thickness and air entrapped,[1].

Hes, et.al developed a new functional knitted fabric possessing double layers by using different yarn components(like polypropylene and cotton) in order to maximize the transport moisture,[3].Thermal properties of 1×1, 2×2 и 3×3 rib knit fabrics were compared by Ucar and Yilmaz (UcarN., YilmazT., 2007).They noted that a decrease in rib number leads to a decrease in heat loss; the use of 1×1 rib and tight structure would provide better thermal insulation,[4].The mathematical models developed by several researchers (Maxwell 1904; Vary 1952; Kunii and Smith 1960; Woodside and Messmer 1961; Zenner and Schlûder 1970; Bauer et al. 1991; Bogaty and Collar 1987; Fricke 1993) show that the relation between the thermal conductivity of porous surrounding and its thermo-physical properties are non-linear,[5].

Investigation of thermal comfort properties of double layered knitted fabrics with different yarn componentsshow that thermal resistance depends more on synthetic thread type than on natural fiber yarns,[6]. It was found that the structure of the knitting fabric (the knitting pattern structure)highly influences the heat transfer process as distinct from the rawmaterial content of knitted fabric.Investigations were carried out on double- layered knitted fabrics made from cotton or man-made bambooyarns in the outer (located outer from the skin) layer and PP, PA, PES yarns in the inner (located next to the skin layer),[7].

Thermal conductivityis an intensive property of material that indicates its ability to conduct heat**,** [8].***Thermal resistance*** is a measure of the thermal insulationof the material. It is defined as the quantity of heat transmitted through a unit thickness in a direction normal to a surface of unit area, due to a unit temperature gradient under steady state conditions, and when the heat transfer is dependent only on temperature.As we can see from the definition, it is necessary to know the rate of heat transfer through the material in order to be measured its thermal resistance, [9].

In this paper, the influence of structural characteristics and raw material content of single jersey knittedfabrics on the air and water vapor permeability, thermal properties (thermo-physiological comfort), was investigated.
Thermal conductivityof knitted fabrics was determined according to new method of thermo-vision analysis developed by researchers.

2. EXPERIMENTAL

2.1.Materials

Single jersey structures were knitted using 100 % PAN (acrylic), 50/50% PAN/cotton and 100 % wool. Knitting process of the single jersey knitted fabrics was performed on an flat knitting machine STOLL CMS 12. All knitted fabrics are made of yarn count T_t=33x2x2 tex.

a) b)

Figure 1-Single jersey structure a)faceb)back

2.2. Methods and instruments

2.2.1. Structural properties of knitted fabrics

Structural properties of knitted fabric (course density,D_h,cm^{-1} andwale density,D_v,cm^{-1}), fabric thickness, ***h****(mm)* mass per unit area ***m*** *(g/m$^{2)}$*, loop length,***l***) are determined according to standard methods. Tigtness factorTF and porosityP are calculated according to the equations (1,2):

$$TF = \frac{\sqrt{T_t}}{l} \quad (tex^{1/2}cm^{-1})(1) \quad P = \left(1 - \frac{m}{\rho \cdot h}\right)100(\%)(2)$$

where:
T_t–yarn count (tex),***l***-loop length *(mm)*,***ρ***–mass density *(kg/m)*^{3},***h***-fabric thickness *(mm)*

2.2.2. Air permeability

Investigation of the air permeability was performed according to the standard EN ISO 9237:1999. An FF-12 Metrimpex instrument was used with difference in contact pressure of 20 Paand area of the sample10cm^2,[10].

2.2.3. Water vapor permeability

The investigation of water vapor permeabilitywas performed on a sample with 15x15cm dimensions. All the measurements were done under standard climatic conditions with apparatus consisting of thermostat and glass with 62cm^2 surface (internal diameter 89mm).Water is put in the glass untill the level of water rises up to 35mm below the upper glass edge. The glass is covered with the sample and is put under the influence of water vapor with temperature of 50 ^{0}C forfour hours. After 4 hours the loss of water is determined and the mass increment of the sample, P_v, and the procedure is repeated under the same conditions for four more hours. According to the given results the water vapor permeability is calculated with the following relation, [11]:(3)

$$PVP = m_v - \frac{P_v}{A \cdot t} \cdot 100\ (\%)(\ mg/cm^2h\ ) \quad (3)$$

where :$\boldsymbol{m}_v$ – loss of water in the glass*(g)*; ***Pv***- increment of the mass of the sample*(g)*; ***A***-active surface of the sample*(cm^2)*; ***t*** –time of procedure*(h)*
The results are the average value from three measurements in each sample.

2.2.4. Thermal conductivity

In order to measure the thermal conductivity coefficient of the knitted fabrics *λ(W/mK)*the method of thermo-vision analysis is used. The apparatus (figure 2) consists of:

- *infrared camera) FLIR P-45;*
- *temperature measurement instrumentand online software monitoring:TESTO 635-2;*
- *heating and cooling thermostat.*

The measuring was conducted according to the following procedure:

- samples of knitted fabrics with 250x250mm dimensionsare put on the thermostat;
- the infrared camera is set to a 15 min interval and 5 pictures are captured every 3 minutes;
- the online monitoring software generates data that is automatically noted while the shooting takes place. Data is generated for: the exact time of each picture, temperature, air relative humidity rH(%), and the temperature plate of the thermostat $\boldsymbol{T_w}$;
- the investigations are conducted with air temperature of 22,0 + 0,3 ^{0}C and the air relative humidity of 63,4±0,5%;
- during the picture capturing the thermograms are generated for each sample;
- the pictures taken are processed with special software – FLIR;
- the temperature in the center of the sample is displayed on the thermogram *($\boldsymbol{T_{sp1}}$)*(°C). Also, the temperature of another dot (*$\boldsymbol{T_{sp2}}$)*(°C) located outside the square area is displayed. Finally, the thermogram displays the average temperature $\boldsymbol{T_{arp1}}$(°C) of the fabric squared area. The temperature change dependence from the time of capture for each sample diagrams are drown T_{sp1},$T_{arp1}$and $T_{w.}$ The values of the time in hours-**t** (3/60), are applied on the **x-**axis, while the values of natural logarithmLn(T_{sp1},T_{arp1}, T_w) of the temperature are applied on the y-axis.;
- the temperature change rate coefficient of the knitted fabric $\mathbf{m_1}$ is determined from the linear line equation for average value of the temperature of the knitted fabric T_{arp1}, i.e.y=ax +b, where**y =** $\mathbf{T_{arp1}}$and**a =**$\mathbf{m_1}$.

Figure 2-Thermo-vision device

The determining of the thermal conductivity coefficient λ, according to the thermo-vision analysis is based on the theory of the regular temperature regime, i.e. on Kondratievs' second theorem [12]: (4) and(5)

$$m_1 = K \cdot a \ (4) \qquad a = \frac{m_1}{K} (5) \quad \text{and} \quad a = \frac{\lambda}{c \cdot \rho} \qquad (6)$$

where:$\boldsymbol{m_1}$–temperature change rate coefficient (heating or cooling of the material(s^{-1});$\boldsymbol{K}$ – proportionality coefficient; **a**- thermal diffusion *(m^2/s);* $\boldsymbol{\rho}$- fabric density (kg/m^3); ***c***- specific heatcapacity *(J/kgK)*

$m_1$coeficient depends on the physical characteristics, the dimensions and the geometry of the material.K coefficient depends only on the geometry of the material and for flat plate is calculated according to the formula (7)

$$K = \left(\frac{\pi}{2h}\right)^2 \qquad (7)$$

where:***h***- thickness of the material (mm)

The specific heat capacity of more component fabrics is calculated according to the equation (8).

$$c = \sum_{i=1}^{i=n} c_i \cdot p_i \quad (J/kgK) \qquad (8)$$

where:$\boldsymbol{c_i}$- components' specific heat capacity; $\boldsymbol{p_i}$ - mass percentage of the component

The volume mass or the fabric density ρ is calculated according to the equation (9).

$$\rho = \frac{m}{h} \quad \left(\frac{kg}{m^3}\right) \qquad (9)$$

where:***h***- fabric thickness *(m);* ***m***- mass per unit area of the fabric *(kg/m^2).*
(ρ for more component fabrics is calculated considering the mass percentage of the components).

The thermal resistance is defined with the equation (10).

$$R_{ct} = \frac{h}{\lambda} \left(\frac{m^2 K}{W}\right) \qquad (10)$$

where: R_{ct}–thermal resistance (m^2K/W); h–fabric thickness (m); λ–thermal conductivity (W/mK).

3. RESULTS AND DISCUSSION

3.1. Structural characteristics

In Table 1 the structural characteristic of single-jersey fabrics with different raw material content are given (figure 3).

Table 1 *- Structural characteristics of the single jersey knitted fabrics with different raw material content*

No.	Raw material content (%)		D_h (cm^{-1})	D_v (cm^{-1})	D (cm^{-2})	l (mm)	m (g/m^2)	h (mm)	TF $(tex^{1/2}cm^{-1})$	P (%)
1	100 PAN	$\bar{x}$ Cv(%)	5,50 (0,55)	7,75 (0,45)	42,6	7,30 (3,20)	412 (3,54)	1,245 (3,75)	15,7	71,0
2	50/50 PAN/cotton	$\bar{x}$ Cv(%)	5,75 (0,45)	9,00 (0,71)	51,7	6,90 (2,40)	472 (4,23)	1,280 (1,27)	16,6	71,0
3	100 Wool	$\bar{x}$ Cv(%)	6,00 (0,45)	8,00 (0,55)	48,0	6,95 (3,40)	440 (4,10)	1,314 (1,25)	16,5	73,9

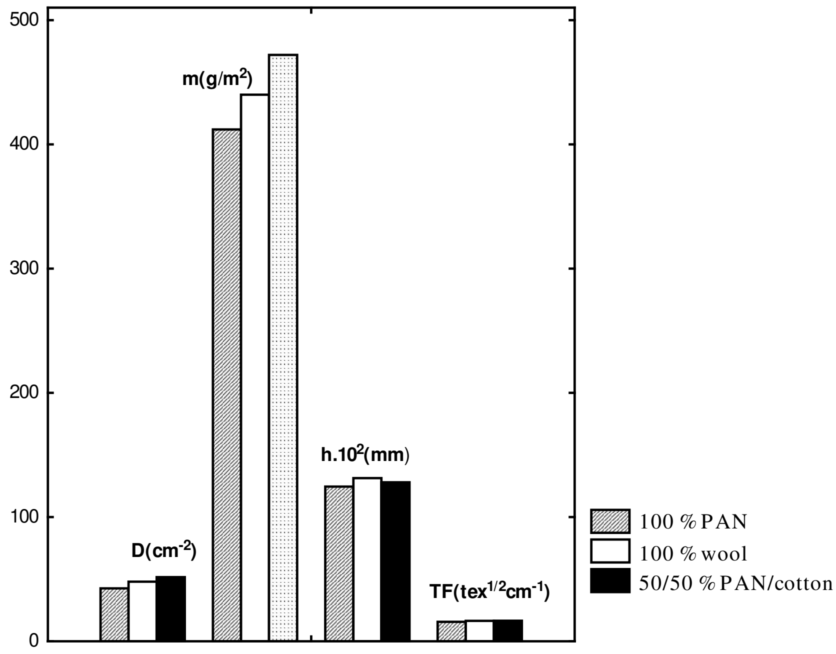

Figure 3 -Density(D),mass per unit area (g/m²), thicknes(h) and tightness factor(TF) of the single jersey knitted fabrics with different raw material content

As the density ***(D)*** increases, the mass per unit area ***(m)*** and tigtness factor ***(TF)*** also increase, but not the thickness as a result of the different raw material content of the fabrics.

3.2. AIR AND WATER VAPOUR PERMEABILITY

In table 2 air and water vapor permeability values are given (figure 4a and 4b.)

Table 2-Air and water vapor permeability of the single jersey knitted fabrics with different raw material content

No.	***Raw material content (%)***	***Air permeability Q (dm³/h)***	***Coefficient of variation Cv(%)***	***Coefficient of air permeability $B_{\Delta p}$ (m/s)***	***Water vapor permeability 4 hours (PVP,4h)***	***Water vapor permeability 8 hours (PVP,8h)***
1	100 PAN	1640	3,1	0,455	62,90	55,03
2	50/50 PAN/cotton	355	5,5	0,098	52,34	46,80
3	100 Wool	1110	4,4	0,308	62,31	53,95

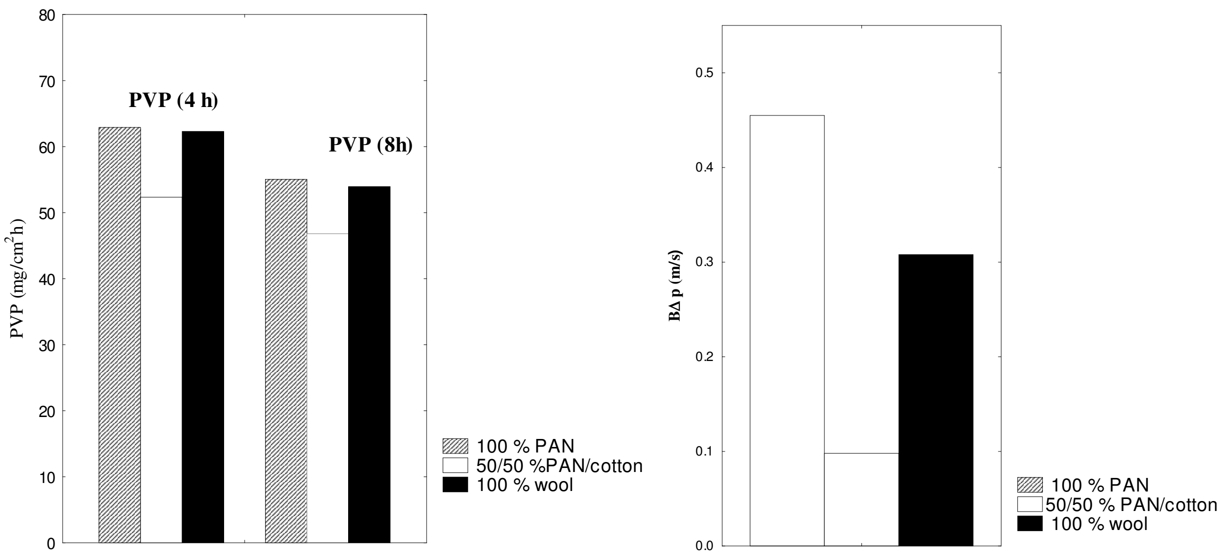

Figure 4: a)water vapor permeability(PVP 4 and 8hours) and b) coefficient of air permeability($B_{\Delta p}$)

Air permeability($B_{\Delta p}$)and water vapor permeability (PVPfor 4 and 8 hours) have the same trend of increase, i.e. their value decreases as the mass per unit area and tightness factor TF of the fabric increase. More dominant influence of the structural characteristics on the air and water vapor permeability compared to raw material content is noticeable.

3.3. Thermalcharacteristics

On figure 5 a thermogram for one sample of the examined fabrics is given. The values obtained from the thermograms of all samples and their natural logarithms are given in Table 3.

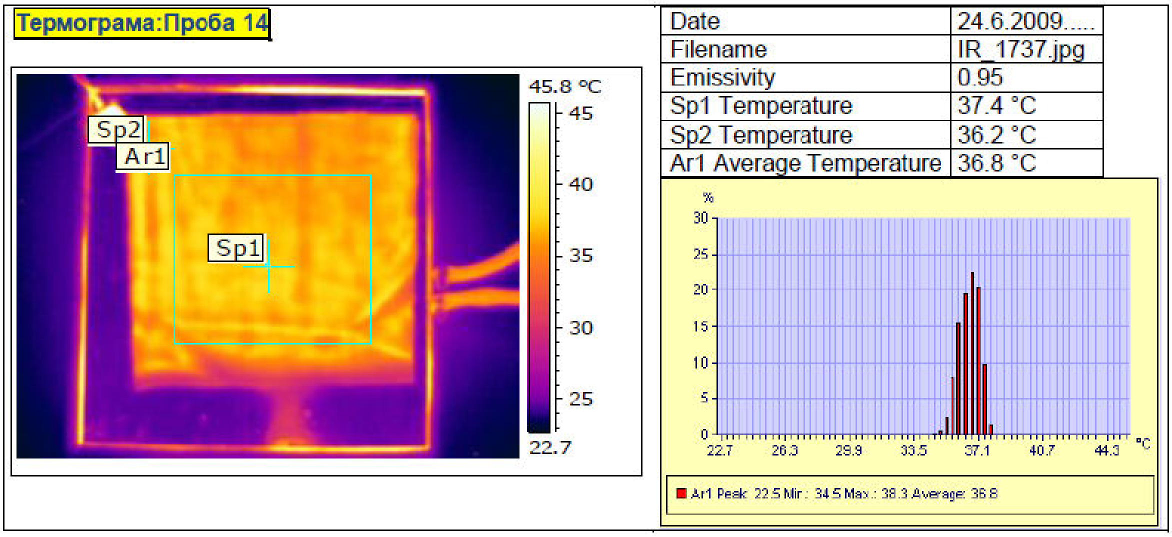

Figure 5- Thermogram for single jersey of 100% PAN

Table 3-*Data obtained from thermograms (Tsp_1u $Tarp_1$u T_w) for single jersey knitted fabrics with different raw material content and the temperature of the plate(Tw)*

Raw material content (%)	***Picture number***	***Tw (°C)***	***Tsp_1 (°C)***	***Tsp_2 (°C)***	***$Tarp_1$ (°C)***	***ln Tw***	***ln Tsp_1***	***ln $Tarp_1$***
PAN 100	1	47.38	37.4	36.2	36.8	3.8582	3.6217	3.6055
	2	46.01	37.0	35.8	36.6	3.8289	3.6109	3.6000
	3	44.44	36.1	35.0	36.0	3.7941	3.5863	3.5835
	4	42.91	35.9	34.3	35.4	3.7591	3.5807	3.5667
	5	41.46	35.0	34.0	34.7	3.7247	3.5553	3.5467
PAN/cotton 50/50	1	34.19	30.2	30.5	30.1	3.5319	3.4078	3.4045
	2	33.57	30.5	30.6	30.5	3.5136	3.4177	3.4177
	3	33.07	30.0	30.4	30.2	3.4986	3.4012	3.4078
	4	32.57	29.7	30.1	29.8	3.4834	3.3911	3.3945
	5	32.05	29.4	29.5	29.5	3.4673	3.3810	3.3844
Wool 100	1	51.75	35.5	38.4	35.8	3.9464	3.5695	3.5779
	2	51.03	37.3	39.9	37.1	3.9324	3.6190	3.6136
	3	49.80	37.4	40.2	37.7	3.9080	3.6217	3.6296
	4	48.22	37.3	40.0	37.4	3.8758	3.6199	3.6217
	5	46.79	36.9	39.4	37.3	3.8450	3.6082	3.6189

In figures 6, 7 and 8 the linear line equation of the examined fabrics are given, based on which the coefficient for temperature change rate $\mathbf{m_1}$ is determined.

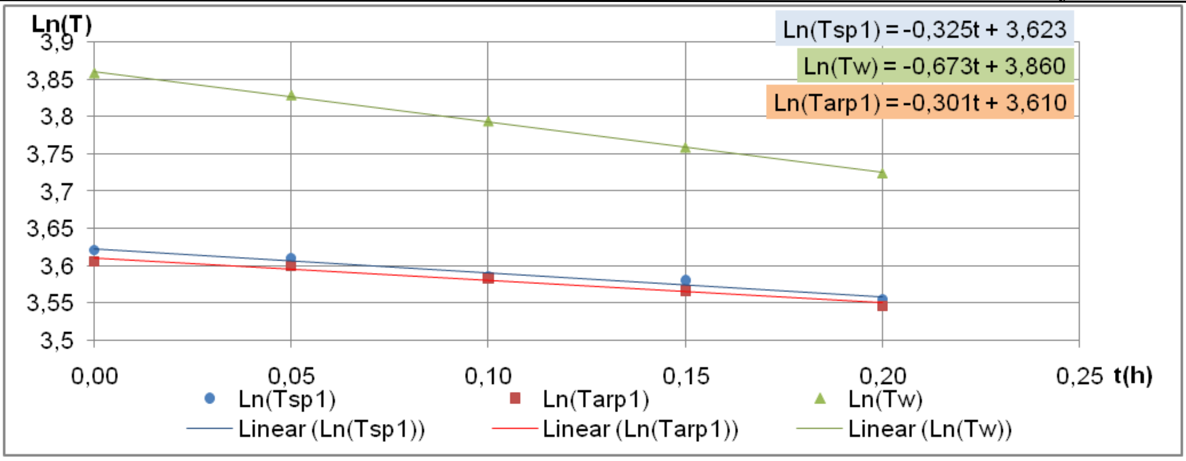

Figure6 – The temperature change dependence from the time of capture T_{sp1}, T_{arp1} and T_w for single jersey of 100% PAN

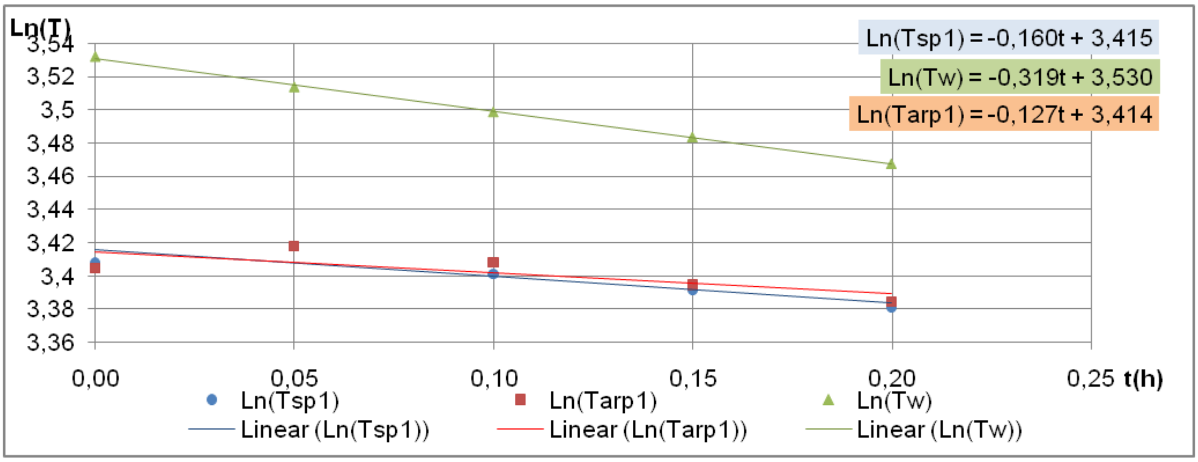

Figure7– The temperature change dependence from the time of captureT_{sp1}, T_{arp1} and T_w for single jersey of 50/50% PAN/cotton

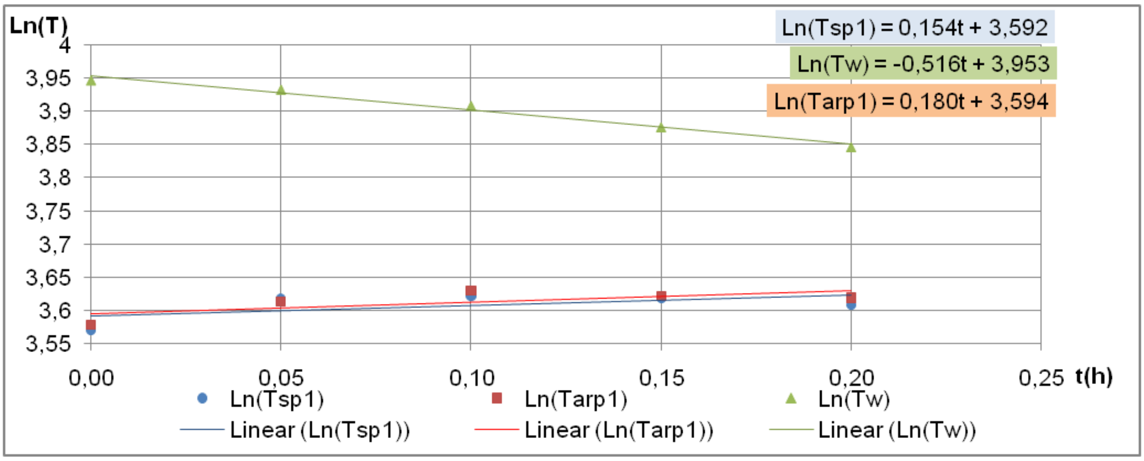

Figure8 – The temperature change dependence from the time of captureT_{sp1}, T_{arp1} and T_w for single jersey of 100% wool

Based on the thermograms and the linear line equations the coefficient of the temperature change dependence from the time of capture $m_1$is determined. After that the coefficient K is calculated. This data is needed to determine the thermal conductivity λ and thermal resistance R_{ct}(table 4).

***Table4**–Thermal characteristics of single jersey knitted fabrics with different yarn components*

No.	*Yarn component (%)*	$K=(\pi/2h)^2$	m_1	*c (J/kgK)*	ρ *(kg/m³)*	λ *(W/mK)*	R_{ct} *(m²K/W)*
1	100 PAN	1591823	0,3017	1200	331	0,0753	0,0165
2	50/50 PAN/cotton	1505960	0,1270	1270	369	0,0395	0,0324
3	100 Wool	1429035	0,1803	1300	335	0,0549	0,0239

It can be noticed that the thermal conductivity decreases as the density and mass per unit area of the fabric increase, while the thermal resistance rises respectively. The fabric made of 100% PAN, which has the highest air and water vapor permeability, also has the highest thermal conductivity, i.e. the lowest thermal resistance.

4. CONCLUSION

The results indicate that the structural characteristics of the knitted fabric have dominant influence on thermo-physiological comfort, as opposed from the rawmaterial content. The density, mass per unit area and tightness factor of the knitted fabrics determine the air and water vapor permeability and thermal characteristics. The final assessment of the thermo-physiological comfort depends on the wearing conditions. According to this, a single jersey made of50/50%PAN-cotton will provide the best comfort when being worn on lower temperatures, while a single jersey of 100%PAN on higher temperatures. The single jersey made of 100%wool did not show the highest thermal resistance as expected because of its raw material content, which is a result of the structural characteristics i.e. lower density of the fabric.
One of the aims of the investigation was to check the possibility for using the method of thermo-vision analysis when investigating the thermal properties of knitted fabrics as important element of thermo-physiological comfort. The results from this research provide a huge area for further investigation.

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ANALYSIS OF TEXTILE AND OTHER MATERIALS INFLUENCE ON THE SLEEPING COMFORT

Vasilije PETROVIC, Jovan STEPANOVIC, Aleksandra ZDRAVKOVIC, Vojin KERLETA

Apstract: *This work considers the development of new products that could contribute to the comfort of sleeping. First of all, it discusses the possibility of breeding bedclothes with natural materials and natural herbs. Within this framework, aero aromatic and mechanical (elastic-dynamic) influence were considered. It is primarily focused on the area of the air composition compared to the aerated water and essential oils in order to achieve functional atmosphere (no pathogens in the air during sleep). Exchange of energy and matter between the body and environment was observed in terms of human thermodynamics and engineering physiology. There are examples of connection between respiratory and digestive system during sleep.*

Key words: *sleeping comfort, new textile product, breed bedclothes, human thermodynamics, natural herbs*

1. INTRODUCTION

Textile industry is particularly sensitive to the recession. Overflow of the market with cheap textile materials and expansion of production in asian countries have led to crisis in textile industry, especially in the countries in transition. Industry of textile in Serbia, one of the countries in transition, has suffered a catastrophic decline in production. One of the conditions that the state in this case could take in the direction of exit from this situation is certainly providing an adequate environment and conditions for new development. This is primarily related to the adequate training of highly educated creative human resources that should offer solutions and development of new technologies and products that are capable to handle strong competition on the world market. Developed countries as a solution to the challenge of unloyal textile competition from populous countries have focused their production on high fashion and in greatest measure on newly developed area of – technical textile [1-2].

2. FUNCTIONAL TEXTILES

Technical textiles include textile materials and products manufactured more because of their technical performance but because of their esthetic or decorative characteristics. Area of technical textiles today is one of the most dynamic and wide areas of modern textiles, materials processes, products and applications. What makes technical textiles often called functional textiles is development of new products according to the market requirements to meet the specific kind of needs. That is why their development is directly dependent on innovation, research, new patents and it requires an organized system of institutions and lot of funds that are enabling production growth. On the other hand, since the technical textiles are incorporated in almost all branches of industry, their development initiates intensive growth of entire industry in the country. This kind of approach is actually a response of Western Europe and U.S.A. on the market overflow with mass of textiles from Asian countries.

This work considers laminated sheets as a new functional product. In that direction, an attempt to respond to what objective and comparable parameters that enables customers to choose bedclothes according to their needs has been made.

3. SLEEPING COMFORT

Approximately one third of our life we spend in a dream. Its refreshing effects are very well known. The best cure for fatigue is sleep. True health is impossible without this natural mean for strengthening. Healthy, relaxing dream that rests muscles, nerves and brain is one of the best youth elixirs. During a period of rest and sleep, body repairs, restores energy and prepares for new activities.

To life, dream is equally important as air, water and food. Generally, we accept dream as something normal, but when we miss it, we yearn for him more then for all the treasures of the world.
People rarely spend time thinking about sleep and they are looking at it only as a period during which organism is inactive. Thinking that nights are less important then day is wrong. During the dream hours, when we seem most passive, intense activity takes place and charges our batteries for the next day. When we are active we consume energy; when we appear inactive we collect it. The brain and nervous system work on the basis of neural energy in the form of electricity. The organism, like an electric car, must be charged during night. Sleep is a partial shut down for the sake of filling. Following tasks were set to the science. Is the dream reversible period of life? What is the role of the blood and lymphatic system during sleep? What are the changes in respiratory system during sleep? What are the changes in the subcutaneous tissue during sleep? How much heat is emitted during sleep? What is the speed of the arterial blood flow during sleep? Does the heart work with the same capacity during sleep and in reality? How big is the change of the blood pH during sleep? Is the same ratio of oxygen and carbon dioxide used during sleep?

The primary purpose of sleep is neuron regeneration. Vitality of organism also renews. During sleep, it is full of activity – tissue repairmen, healing, adding fuel to organs and cells, replacement of old cells that have lost their vitality wit new ones (cell reproduction during sleep occurs more then twice as fast then during awake period). The hear pumps blood in order to collect waste materials and particles that were left uneliminated previous day and took them do the elimination canal. Muscles tense, heart rate, body temperature and blood pressure rises and falls; our senses evoke one whole world of sights and sounds. Just one part of our brain is asleep, because nervous system continues to implement billions of processes.

3.1. THE QUALITY OF BEDDING

Sleeping comfort largely depends on the quality of bedding. Therefore it is essential to define bedding with comparable and objective parameters. It could be said that sleeping comfort is capability to maintain a comfortable body temperature during sleep, while body sweat is quickly and efficiently taken. For the vitality of the organism, support to physiological processes that occur in the body while person sleeps is very significant. The basic elements of good sleep are: temperature balance between the body and ambient, heat and management of moisture i.e. sweating on the bed. Bedding should provide possibility of taking excess heat and sweat from the body of a sleeping person. In order to optimize these conditions during the process of bedding design, it is necessary to measure these parameters. Device for testing moisture absorption and transport of textile materials is shown on the Picture 1 [3].

Figure 1. The device for testing moisture absorption and transport of textile materials

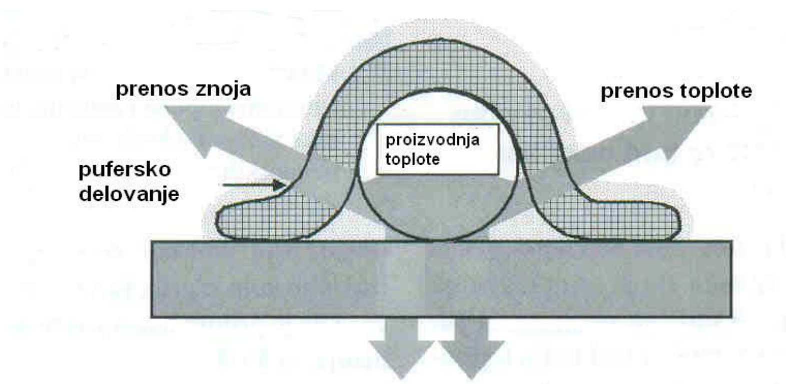
First line of bedding parameters that determine comfortable and restful sleep are composition of material and its structure. Quality bedding is primarily achieved by optimizing the structure of the materials bedding is made of and composition of that material. These basic parameters are affecting the moisture permeability ie. its characteristic activity of breathing the material. For measuring moisture permeability, skin model that complies with EN31092 and ISO11092 standards is mainly used.

Quality bedding must have adequate thermal isolation effects to properly manage the heat. Until recently, the prevailin opinion was that good thermal isolation is achieved by making thicker and weighter blanket. Modern research are directed to the optimization of structural and raw material parametars to make in order to gain cover that has lesser mass and thermal isolation exacly tailored to a specific person.

During sleep 0.25 liters of sweat is released from a persons body. This ammount of sweat, bedding needs to transport. In doing so, level of heat must be stable even if the ambient temperature varies. In testing of thermophysiological characteristics of cover, heat segmented dummy „Charlie" is usualy used and it is shown on the Picture 2 [3].

Figure 2. Heat segmented dummy „Charlie"

These features are usually tested in climate chambers which are used to simulate different ambient temperatures. For the confirmation of the laboratory results, additional tests are used on representative set of people who are of bedding. Conditions can be described and schematically shown as in the Picture 3 [3].



Figureure 3. Schematic representation of heat and sweat transport during sleep

According to research [3], a diagram of the sleep comfort reviews shown in picture 4 has been made. By using this chart thermal isolation that is best for consumers can be determined in a simple way. Namely, for the appropriate room temperature and body mass of a person, thermal isolation is determined. For example, the lower bedroom temperature and lower body mass of a sleeping person then the thermal isolation must be higher. This is due to a fact that a person weighting 50 kg produces

62W of heat energy and a person that weights 110 kg produces 101W. To maintain body functions and sense of comfort during sleep both persons must have the same skin temperature. From this condition follows the request that thermal isolation of a cover must be higher for a less weighted people.

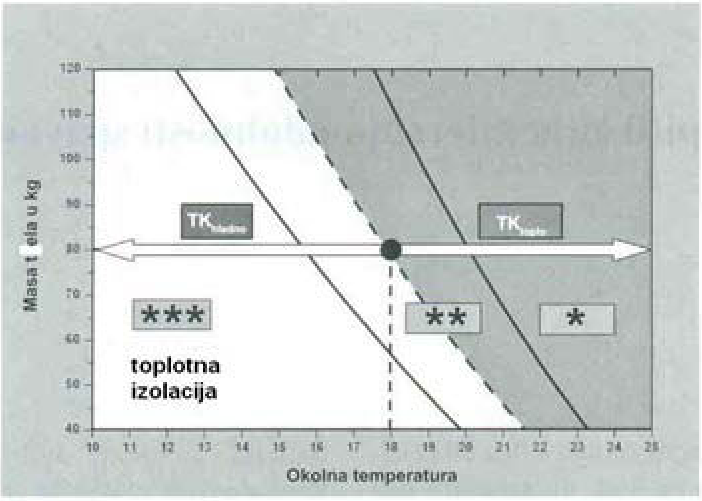


Figure 4. Diagram of the sleep comfort reviews on a basis of person using blanket weight and the average bedroom temperature

According to the diagram shown in Picture 4. review of sleeping comfort can be made in warm and cold conditions of sleep, depending on a body weight of a sleeping person. From the diagram it can be seen that for a person of average body weight of 80 kg to the most appropriate is geographic area which has average annual temperature around 18°C.

3.2. PRODUCTION PROJECT OF ECOLOGICAL MATTRESS COASTER WITH MEDICINAL HERBS

In order to meet preconditions for a good nights sleep, bedroom is very significant. The atmosphere in the room, the composition of air, and then the bed itself. A great contribution for quality sleep gives relaxing bedding. Our idea is to get, under the sheet and above the mattress set a coaster made of impregnated dried herbs. This coaster has multiple importance. It maintains the air composition in a way that doesn't allow development of pathogen microorganisms. Aromatic atmosphere has stimulating effect on both, the nervous and hormonal system. Coaster itself can be made of pressed straw and a mixture of herbs. The natural environment of body, mild skin stimulants made of tree plants have relaxing effect on nervous and hormonal system. Pressed straw next to a porosity, elasticity and capacity for some gases has a positive influence on the quality of sleep.

In addition to relaxing bedding in bedroom, bags with herbs, clay and zeolites can hang in order to maintain air atmosphere in desired limits. Cases can be made from goat hair.

In this way we are setting preconditions for the air composition to be antiviral. Moisture in the air enables keeping of the aromatic herbs components.

Today we obtain undoubtedly, exactly proven evidence that native plant species and their communities can have a positive influence on environmental sanitation. In combination with autochthonous plant species in other climates is possible that such mixtures are very important for life and health of a man – to stop the development of many disease provocateurs, stimulate the central nervous system and have especially beneficial effects on respiration, heart-vascular system and sympathetic system of man because they activate important physiological functions in the body.

Introduction of aroma therapy in one of the most important physiological parts of life – dream, effects that are already used in many civilizations can be achieved.

Our research is aimed at developing new products for the bedroom and move towards the study of partial pressures of oxygen and carbon dioxide in the air at the proper humidity.
Based on the basic physiological need for sleep course of preliminary design mattress coasters with a porous filling of herbs and minerals is planned. This combination will allow you during sleep in the bedding when the temperature close to the body is around 32 °C, essential oils evaporate and act positively on the process of sleep. During the day, when the temperature of bedding drops on lower temperature, absorption - bonding of water vapor and oxygen which are used at night to breathe occurs. So this process is reversible with appropriate hysteresis loop.

Coasters above the mattress will be made of two parts. Outer part will be made of natural fibers, and it will be permanent and washable. The inner part - filling will be replaceable. Its lifetime will amount to 6 months, from the time of use. Restorations will be made of natural materials and medicinal plants, which in addition will have aero aromatic and mechanical effect. Mixture of plant species has regulatory action with respect to water vapor. As the body during sleep and lose up to 750 ml of fluid, and the heat energy, they need to be transported through the bedding, in our case, mattress pads, sheets and pillows. Position neck and spinal cord, as well as the position of the limb - leg will be perceived from microcirculatory aspect, and internal moisture. The spine and cervical vertebrae during sleep is additionally moisturized thereby energizing the daily activity. Their humidity dictates subcutaneous tissue microcirculation, which is in conjunction with the hormonal system. This will encourage increased concentration of oxygen partial pressure in the breathing zone, and essential oils that have been inflicted on the natural adsorbent will have relaxing effect on the body. Urban environments, static electricity and associated positive charge negatively affect the overall state of the organism. The best proof of this are electrocardiograms and electroencephalograms that register waves emitted by the heart and brain. Negative ions, which catalyze the essential oils can lead to some mental and physical relaxation, affect our good sleep and rejuvenation. Their organic effect is so great that it is sometimes popularly referred to as vitamins from the atmosphere. Essential oils kill germs and bacteria, have a strong effect fungicide on mites and insects. Essential oils with negative ions influence the rational utilization of oxygen from the atmosphere. They provide additional energy to overcome oxygen pulmonary alveolar membrane and enters to the blood. In one word, with essential oils, an atmosphere of a bedroom can be close up to the meadows and forest areas.

Product structure:
1. Insole is an active component, made of cellulose natural materials with filler made of pressed medical herb. Merger of plants and cellulose tapes will be made with new combination of minerals and apian products. Selection of mixtures can be changed according to purpose
2. The case is made from natural materials with Velcro. Case can be washed out after the implant is removed.
3. Implant duration is 6 month.

Product characteristics:
Mattress coaster is natural relaxing product that creates aero aromatic conditions during sleep. He affects the atmosphere surrounding body, providing a natural field. With mild mechanical effect and elastic dynamic characteristics he provides adequate spine posture. Mild scented effect has stimulating effect on sleep and provides optimal air composition. On the one hand, it emits fragrance of plant materials, and on the other hand provides the optimal balance of oxygen and water vapor that are necessary for the breathing process.

Product uses:
1. Vast population of people of all ages as a preventive, because active component of insole will not have strong sedative effect (mix will not contain valerian and hop)
2. Special appliance to the patients on the recovery at home

3. Especially important for the people whose day is extremely intellectually active because active components have stimulating effect on the quality of sleep
4. It may be significant in terms of lacking washing water, as active components of plants with selected minerals (bentonite and zeolite) do not permit intensive processes of mites and other oxidative processes in bedding, which prevents rancidity.
5. Mineral components fulfill a positive impact on the characteristics of the frequent skin characteristics (aura)

4. CONCLUSION

Textile industry corresponds to the challenges of today by focusing on the high fashion and mostly on the new developed area – functional textiles. Therefore, in this paper, the development of new products that contribute to the comfort of sleep has been considered. First of all, it discusses the possibilities of breeding material and linen natural herbs. The proposed project is the development of ecological mattress coaster with herbs. Mattress coaster is a natural product that creates a relaxing aero aromatic sleeping conditions. For the proposed product, its structure, characteristics and uses are given.

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ANALYSIS OF WATER VAPOUR AND AIR PERMEABILITY AS "COMFORT-FACTORS" THAT AFFECT ON COMFORT OF CLOTHING MADE FROM DOUBLE-LAYERED KNITTED FABRICS

Marija Savic, Dusan Trajkovic, Tatjana Sarac, Stanislava Sindjelic

Abstract: *The paper analyzes the water vapour permeability (without temperature gradients F_0) and air permeability of double-layered knitted fabrics, where only a part can be considered as factors "comfort". It is necessary to measure the moisture permeability with temperature gradients F_T , where take into account the defined temperature differences on both side of knitwear, as well as the thermal effect of this moisture transport. The test was performed on four double interlock fabric of the same interlacement and cotton-polyester composition but different mass per unit area and density of knitting. The correlation between mass per unit area, density values of knitting with water vapour and air permeability of cotton-polyester face and polyester-cotton structure was shown. Based on the obtained results it can be concluded that the permeability of cotton-polyester structure is lower than the permeability of polyester-cotton, which means that the clothes made of such materials should be with polyester to the skin in order to get greater wearing comfort.*

Keywords: *"comfort-factors", water vapour permeability, air permeability, double-layered knitted fabrics*

1. INTRODUCTION

One of the most important tasks of clothes is support of temperature regulation in human body [1]. In the past, the functional effect of clothing on the man was determined intuitively, because there were no methods for the measurement and evaluation. With the advanced of science, people handled with the factors derived from clothing, participate in the man-cloth-environment system, the factors which are responsible for "comfort". These factors are called "comfort-factors".

Microclimate that is created between the surface of the skin and layer of the cloth, on one side depends on the release of the heat and moisture of the skin (workload of man), and on the other side depends on surrounding environment, moisture permeability and heat of cloth. The mechanisms for the transfer of heat and moisture between the organism and the environment are: radiation, transmission, conduction, transpiration of sweat from the skin surface and transpiration from the lungs. If the skin temperature is higher than the temperature of the surrounding air, heat passes from the skin surface with conduction and convection process (heat passes). In that case, the amount of released heat depends on the temperature and air velocity. The second part of the heat transfers from the surface of the skin in the form of thermal radiation, which depends on the temperature of radiation in environment.

2. CHARACTERISTICS OF CLOTH AND CLOTHING MATERIALS-"COMFORT-FACTORS"

All characteristics of cloth that affect on created microclimate between the surface of the skin and layer of cloth fall into the "comfort -factors". The most important of these are:

- Heat insulation of used textile materials,
- Moisture permeability of used textile materials,
- Heat insulation of interlayers within and under the clothes,
- Moisture permeability of interlayers within and under the clothes,
- Garment ventilation with heat convection,
- Garment ventilation with forced convection during body movements,
- Reflection, ie. absorption of radiation through the clothes [2].

Of these the most important factors „comfort", ie. characteristics of cloth and textile materials that may affect on the regulation of body temperature, can be single out:

1) the ability of materials to facilitate the evaporation of sweat
2) air changes.

Moisture permeability of used textile materials is conditioned by a number of factors (type of material, material composition, physical and mechanical properties, etc.). What is important to note is that beside of water vapour permeability in the form of diffusion, we have the evaporation and re-occurrence of condensation. In this way, the cloth has a particular relationship where an important role is played by flows capillary permeability, surface configuration of fibrous material and its swelling. Therefore, for the evaluation of moisture permeability of textile layers, must be made the difference between water vapour permeability without temperature gradients F_0 and moisture permeability with temperature gradients F_T. In the first case, the measurement is performed under isometric conditions, and in the second case defined temperature differences on both side of knitwear is considered. In both cases, the amount of water vapour that passes through textile material is measured. Beside of the surface and the time, the review is made on difference of vapour pressure of air between both sides of the material. Since the moisture transport through textile layers is not consist only in the transportation of large quantities of water and measuring only of real moisture transport F_0 or F_T, it is necessary to measure the thermal effect of this moisture transport.

In the most clothing models, exchange the air with the environment beside the convection within the clothes, carried out through the holes in the clothes. These values can be determined by wearing the clothes on the body or on the model of man. Air exchanges with the environment can be reduced or increased by applying appropriate models pattern.

3. TRANSFER OF WATER VAPOUR THROUGH THE TEXTILE STRUCTURE

For the transfer of water vapour through the textile structure the following mechanisms are significant: diffusion of water vapour, absorption and desorption of water vapour in the fibres and convection [3]. The diffusion of water vapour through the textile structure can be carried out through the holes in the textile structure that are filled with the air or between the fibres [4]. It can be expressed with the equation, Fick's law: [5].

$$J = D_{AB}\frac{dCA}{dx} \quad (1)$$

where:
J – moisture flux, mol $m^{-2}\,s^{-1}$
D_{AB} – diffusion coefficient, $m^2\,s^{-1}$
dC_A/dx – concentration gradient, mol m^{-4}

For hydrophilic fibres diffusion takes place in two stages. The first stage is according to Fick's law (equation 1), and the other stage, much slower, taking place with regard to the relationship between the concentration gradient and water vapour flux [6].

In comparing with natural fibres, the fibres made from synthetic polymers have less ability to absorb. For these materials an important role has only adsorption on the surface of fibrous material. The hydrophilic fibres (mainly natural fibres) can easily adsorb moisture on its surface, while hydrophobic fibres (mainly synthetic fibres) heavily adsorb moisture. Depending on what kind of fibres material is made, water in textile material can be absorbed into the fiber, retained in the pores or can be unbound. The transfer of moisture by convection depends on the difference of water vapour concentrations on the surface of the fabric and in the air.

4. DOUBLE-LAYERED KNITTED FABRICS

The tested materials fall into the group of new products, so-called, double-layered knitted fabrics usually made of cotton, wool and polypropylene. These knitted fabrics are elastic, well absorb the sweat, dry fast and have good insulation properties, so whit these characteristics they are suitable for the production of cloth of special purpose (t-shirts that are worn under uniform, etc.) Also, in this fabrics it can be achieved that one layer absorb moisture well, and the second to be water repellent. Usually, knitted layer that is next to the body is made from polypropylene yarn because it gives the permeability and water repellency to the knitwear. The outer layer is usually made of cotton, wool or cotton and wool fibres, which makes this layer hydrophilic. With this structure is avoided an appearance of poor permeability of knitted fabrics made of natural fibres. Namely, the natural fibres, at intense body sweating, occupy the free spaces in knitwear by their swelling and thus reduce its permeability. In this way, there is a barrier between the skin and the layer made of cotton fibres, which prevents a direct contact of skin with evaporated sweat. Therefore, the products of double-layered knitted fabrics are comfortable to wear. Figure 1 presents double-layered knitted fabric with dots of absorption where knitted layer made of polypropylene yarn PP is presented as white layer and knitted layer made of cotton or wool yarn is presented with shading. The absorption dots can be seen on the PP layer and in the cross section of knitwear (Figure 1).

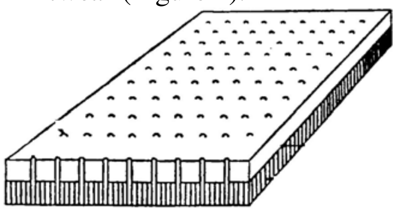

Figure 1. Double-layered knitted fabric (knitted layer made of PP yarn, knitted layer made of cotton or wool yarn and absorption dots)

The advantage of a double-layered knitted fabrics can be reflected in the relative humidity at the surface of the knitwear, which in this case is different from the inside and the outside. The classic knitwears have the same relative humidity on both side.

5. THE MATERIALS AND THE METHODS USED IN TESTING

The review of the tested samples of double-layered knitted fabrics, their properties and designations are shown in Tables 1 and 2. The tested samples have the same composition (cotton-polyester), the same interlacement (interlock), but different mass per unit area and different densities of knitting.

Table 1. Review of knitting samples

No	Designation of knitwear		Composition
1.	Knitwear I combination	P1	Cotton-PES
2.	Knitwear II combination	P2	Cotton-PES
3.	Knitwear III combination	P3	Cotton-PES
4.	Knitwear IV combination	P4	Cotton-PES

Table 2. Characteristics and designations of knitting samples

No	Designation of knitwear		Total width (cm)	Interlacement
1.	Knitwear I combination PES-CO	P1	159	interlock
2.	Knitwear II combination PES-CO	P2	160	interlock
3.	Knitwear III combination PES-CO	P3	158	interlock
4.	Knitwear IV combination PES-CO	P4	158	interlock

6. RESULTS AND DISCUSSION

According to standard SRPS F.S2.016, the obtained mass per unit area of knitwear is presented in Table 3. The first tested sample P1 has the highest mass per unit area, and the sample P4 has the smallest.

Table 3. The testing results of mass per unit area of the knitwear samples

No	Designation of knitwear	Mass per unit area (g/m ^{2})
1.	P1	313,7
2.	P2	283,8
3.	P3	256,4
4.	P4	245,2

The obtained density of knitting (number of courses along the length and number of wales along the width), according to standard SRPS F.S.013 is shown in Table 4. The number of courses for all three samples is different, while the number of wales at the sample P2, P3 and P4 is the same.

Table 4. The tested results of density of the knitwear samples

No	Designation of knitwear	Density of wire: number of courses (p/10cm)	Density of wire: number of wales (p/10cm)
1.	P1	155	105
2.	P2	145	115
3.	P3	140	115
4.	P4	135	115

According to standard ASTM E-96, the obtained results of water vapour permeability of knitted fabrics with cotton and polyester face of fabric is shown in Table 5. Water vapour permeability of polyester/cotton structure is highest in comparing with cotton/polyester structure where cotton is the face of fabric. This situation is the same at all four samples that will be explained through results analysis.

Table 5. The tested results of water vapour permeability from the Cotton face and from the PES face of the knitwear samples

No	Designation of knitwear	Water vapour permeability face cotton/polyester ($g/m^2/24^h$)	Water vapour permeability face polyester/cotton ($g/m^2/24^h$)
1.	P1	5547,8	5849,36
2.	P2	5487,5	5668,45
3.	P3	4311,64	4521,7
4.	P4	3125,1	3345,8

Air permeability of knitted fabrics face cotton and face polyester is presented in Table 6. The obtained results of testing for all samples, shown that air permeability is higher with polyester/cotton structure than combination where cotton is the face of fabric.

Table 6. The tested results of air permeability of cotton and PES face of fabric

No	Designation of knitwear	Air permeability face cotton/polyester (mm/s)	Air permeability face polyester/cotton (mm/s)
1.	P1	181,61	190,65
2.	P2	269,98	278,33
3.	P3	342,35	370,18
4.	P4	391.6	422.3

The tested results of mass per unit area and density of knitting (number of courses and wales) was compared with the values of water vapour and air permeability from the both side of textile material (knitwear).
Based on obtained results it can be presented the correlation between the values of mass per unit area and water vapour permeability face cotton/polyester and polyester/cotton. That is presented in Figure

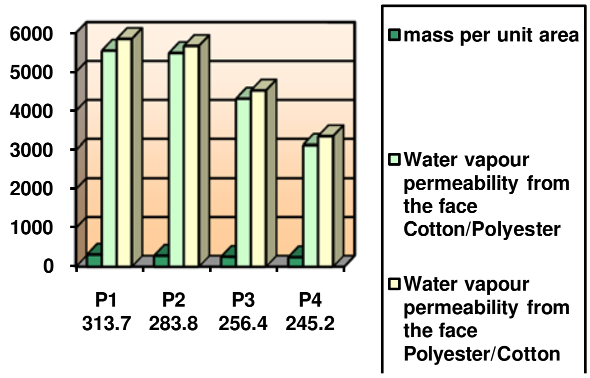

Figure 2. Corelation of the values of mass per unit area (g/m^2) and water vapour permability from the face Cotton/PES and PES/Cotton (g/m^2/24^h)

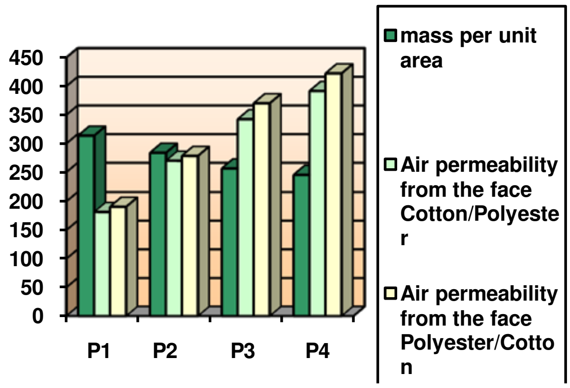

Figure 3. Correlation of the values of mass per unit area (g/m^2) and air permeability from the ace Cotton/PES and PES/Cotton (mm/s)

Based on obtained results it can be presented the correlation between the mass per unit area and air permeability from the face of the fabric cotton/polyester and polyester/cotton. This is shown in Figure 3.
Air permeability on both sides of the face (polyester/cotton and cotton/polyester), increases with decreasing of mass per unit area (Figure 3). Namely, at compatible structure of tested samples and at smaller mass per unit area, there are bigger holes in the structure, which enables greater permeability.

The sample P1 has the highest value of water vapour permeability on both sides of the face (polyester/cotton and cotton/polyester), as well as the mass per unit area (Figure 2). For samples P2, P3 and P4 with decreasing of mass, water vapour permeability is also reduced. What is important to note is that beside of water vapour permeability in the form of diffusion, it can occur condensation and re-evaporation. So, in this section there is a need for further investigation.

Based on the obtained results, it can be presented the correlation between the values of density (number of courses along the length and number of wales along the width) - (p/10cm) and water vapour permeability from the face of fabric cotton / polyester and polyester / cotton. This is shown in Figure 4.

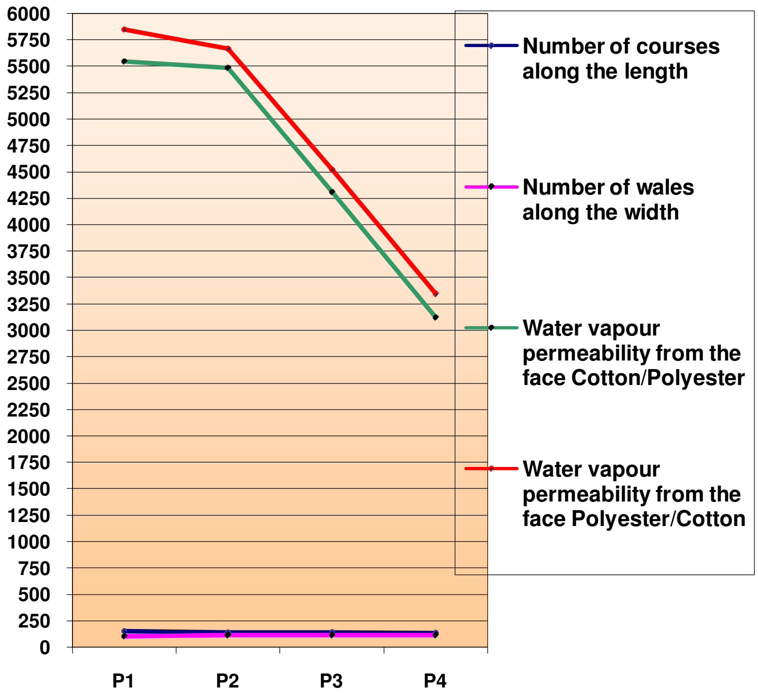

Figure 4. Correlation of density of knitting (number of courses along the length and wales along the width) and water vapour permeability from the face Cotton/PES and PES/Cotton ($g/m^2/24^h$)

Based on the obtained results, it can be presented correlation between the values of density (number of courses along the length and number of wales along the width) - (p/10cm) and air permeability from the face of material cotton / polyester and polyester / cotton. This is shown in Figure 5.

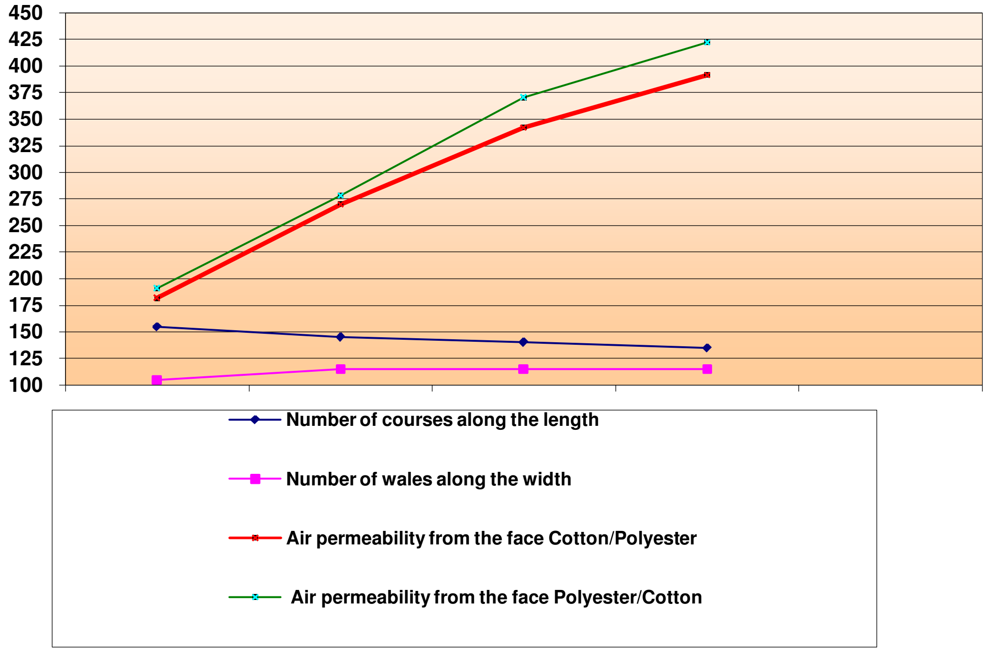

Figure 5. Correlation of density of knitting (number of courses along the length and wales along the width) and air permeability from the face Cotton/PES and PES/Cotton (mm/s)

7. CONCLUSION

The paper defines the basic factors of "comfort", i.e. the properties of textile materials that affect on microclimate. Therefore, water vapour and air permeability in double-layered knitted fabrics were analyzed. Their correlation with the values of mass per unit area and density of knitting (number of courses along the length and number of wales along the width) was shown. Water vapour permeability and air permeability were observed on both sides of the material, polyester/cotton and cotton/polyester. It was concluded that the layer of knitted fabric made of PES gives permeability to the knitwear, while the layer made of cotton is less permeability, but it is hydrophilic. Namely, at water vapour permeability investigation, cotton layer of knitwear with its swelling, occupies the free space in knitwear and reduce its permeability. In this way, it was concluded that polyester layer of knittwear is much comfortable to wear next to the body than the cotton layer, which will be good absorbent of moisture and also will be on the outside of the cloth. In this kind of double-layered knitted fabric, one layer makes hydrophilic fibres (natural origin) and second layer synthetic fibres. Thanks to its structure and composition, comfort of wearing the clothes made of these materials was achieved.

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[10] ASTM E-96 – Testing water vapour permeability
[11] SRPS F.S2.016 – Determination of mass per unit length and mass per unit area
[12] SRPS F.S.013 – Defining wire density,i.e. rows and wales
[13] ASTM E-96 – Testing water vapour permeability

THE FUTURE OF THE TEXTILE PROCESSING GEOTEXTILE STRUCTURES AND ROBOTICS SIDED STITCHING

Vojisalv Gligorijević, Jovan Stepanović, Nenad Ćirković, Vojin Kerleta

Apstract: *Richness of textile structure is available for a wide range of geotechnical applications. Understanding the dynamic interaction between the textile structure and the geotechnical environment is essential in the design and selection of textile materials for geotextile applications. Fundamentals multiaxial knitted structure and tensile structure (cross-woven) are presented as examples of this understanding while showing their potential as multifunctional structural Fleece.*

This paper presents an overview of a new way of accessing geotextile of unilateral robotic quilting technology and testing the implications of new technologies for the next generation of nanofiber geotextiles.

Geometric features and performance yarn for knitted fabric and fiber-to-woven structures in the form of performance maps are shown in Figures 2-5. These performance maps show that geometric parameters play an important role in the structural and physical properties of materials. The fiber fineness geometrijaski is a key factor.

Keywords: *knitting, textile structures, geotextile, nanofiber, multiaxial, geosynthetic.*

1. INTRODUCTION

Geotextile is a non-woven textile that technology is making getting runes from high quality synthetic fiber polyester (PES) and polypropylene (PP) and mechanically fastened, stitching ie creating loops or fiber in solid mixing creation similar to felt.

In 1982, the first time they researched new "multiaxial Basics knitted textile structures" - small twists, which illustrate the hybrid concept for more multifunctional geotextiles.
Geotextiles can be the next material composition:
- 100% polypropylene fibers, PP 150 to 1200 g/m²;
- 100% polyester fiber PES 150-1200 g/m².

Name of Professor Robert Koerner is synonymous with geotextiles and geosynthetics. His name has been associated with pioneering developments in the 1970s, stimulated by his tireless offering a range of courses in the geotextile in Philadelphia, the club engineers the U.S. and the world. At Drexel, he played a leading role in encouraging the formation of perfect different centers in 1986, which officially began a steady rise in the geotextile Research Institute (GRI) in the leading R & D center for geosynthetics.

Structural composites, stimulate usage multi axial basics of knitted fabrics for airplane wings and tensile structure (cross-woven) for stiffening. Many TSCs like plaited composites have also found their way back to the application in geotechnical reinforcement of concrete (concrete) and a reinforcing core columns.

For geotextiles can say that is a subset of industrial textiles or technical textiles. According to the late Kaswell [2], industrial textiles can be categorized according to the form and manner of textile structures that are used for.
• Composite Industrial Textiles-prepared textile coating (coating), impregnating, laminating or other processes usually are not undertaken in the textile industry.
Examples of products in this category include the reinforcement of rubber, reinforced plastics, metals, ceramics, and organic matrix, abrasive materials, asphalt, impregnation, etc.
• Processing Industrial textiles - textile structures are used as components in the production process. Examples include filtration fabrics such as paper, felt (felt), polishing cloth, apron washing machines, etc.

• Direct benefits of industrial textiles - textile structures that are manufactured or built directly into finished products such as awnings, marine equipment, outer furniture, sporting goods, cotton bags, linings for shoes, etc.

Geotextiles are the first and third categories. For many years, the textile industry has been known as a 'mechanical fabric' as described by Haven in 1932 his thesis focusing on rubber fabrics, balloon fabrics and woven fabrics of cotton sash cord as the primary material [3]. Many industrial textiles are traditionally produced by members of the Association of cloth products (CPA) in the U.S. in diversification (a revision) of the fiber material and the extension requested by canopy on geotechnical and other industrial applications, as well as the trend of globalization of markets in 1970, led to the reorganization of the CPC in the industrial association fibers International (IFAI), who played an important role in promoting geotextiles. This transition is accentuated by the introduction of the list of industrial textiles in 1982 [4]. Industrial Fiber manufacturers like Owens Corning Fiberglas, DuPont, Celanese, Allied and Union Carbide and Dow Corning have played an important role in facilitating the development of materials and processing technologies that support industrial growth in the textile market.

There are a large family of textile structures available for geotextiles. Figure 1 shows examples of these structures. In the past two decades, in addition to traditional fabric, diversification (diversification) in different forms, there has been a switch to a special non-woven fabric material. A special type of textile structures that have been discovered and suffered a great development for advanced composites and many other industrial applications is the 3-D the rhythm [5].

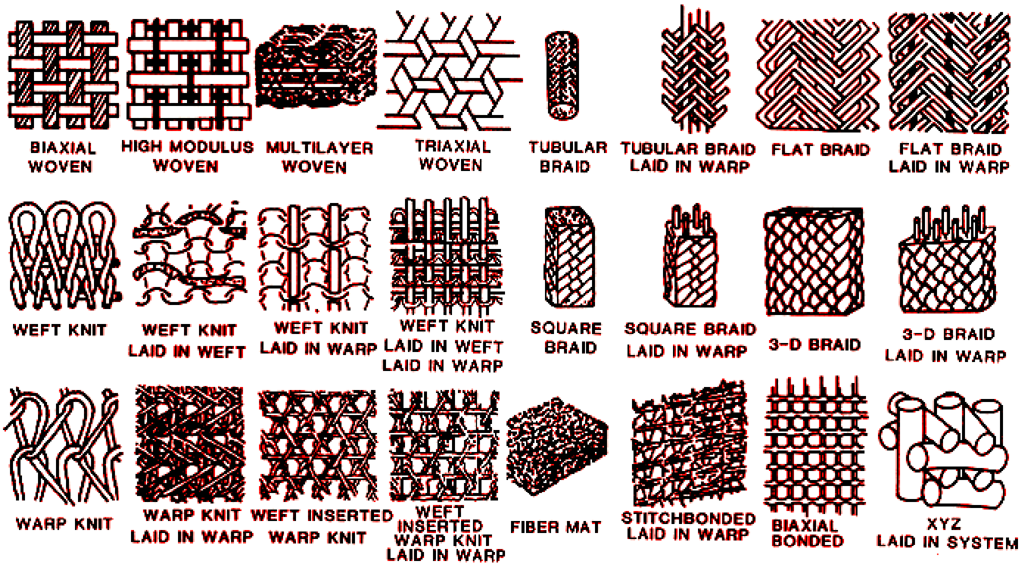

Figure 1. Textile structure for geotechnical applications

2. KNITTED PERFORMANCE CHARACTERISTICS

Knitted performance characteristics are the result of interactions between fibers (material properties), yarn and fabric geometry and finish. Textile fabrics shaped structure (product yarn-to-fabric, such as woven and knitted fabric or fiber-to-fabric processes such as nonwoven fabrics) can be described in terms of geometry and performance characteristics. Performance maps provide insight into the range of behaviors of different twists depending on four geometric parameters and four performance fabrics.

2.1. The geometrical parameters of knitted structures

The geometrical parameter knitted structures include:

1) Porosity: the amount of open space per unit volume of twists. As fiber diameter and yarn diameter increases, the structure tends to be porous. Porosity of the twists is inversely proportional to the comprehensiveness or surface covering factor twists. Porous fabrics tend to be lighter and more permeable.

2) Surface Texture: Surface geometry is characterized by smooth fabric surface, which in turn is regulated by fiber and yarn diameter. Modularity fiber or yarn length geometric repeating unit twists.

3) Puffiness: a reflection on the extensiveness of the knitting for a particular surface density (mass per unit area). Knitting tends to be more voluminous if the diameter of the fiber/yarn greater freedom and mobility of fibers in the geometric repeating unit is great. Puffiness is directly associated with the density of fibers in this voluminous material tends to be thicker.

4) Thickness twists: just as large in volume, thickness twists concerning the diameter of the fibers and yarns. The larger the diameter of the fiber and yarn, thicker and bulky knitting.

2.2. Executive parameters of knitted fabric

The executive parameter knitted structures include:

1) Throughput: simple passage of air or fluid through knitting. Throughput twists is higher when the high porosity fabric. Porosity and fiber volume fraction (1-porosity) related to the efficiency of the package, which is under the influence of fiber diameter and fiber geometry of the intersection. Permeability is a strong function of fiber or yarn diameter for a given fiber architecture (fiber orientation).

2) Compressibility: the ability of materials to resist transverse (through the thickness) compression. Voluminous material tends to be more compresses. On the other hand, the compressibility decreases stiffness fibers and yarns, which significantly increases fiber diameter. When the diameter of the fiber increases, the bending stiffness and axial compression stiffness of fibers increases geometrically.

3) Extensibility of twists: A measure of the ability of twists to stretch the line. Resilience twists affect the geometry of the twists and inextricably bending the fiber elongation. Yarn which is composed of finer fibers tends to have a greater potential to expand the fabric.

4) Toughness twists: A measure of life twists. As can be seen in the areas under the stress-strain curves of some twists, twists high strength with high elongation typically give high toughness Meshes that have high compatibility and extensibility are usually stronger and thicker.

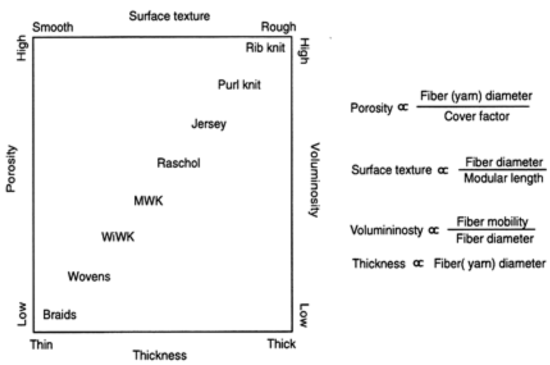

Figure 2. Geometrical properties of yarns for knitted structures

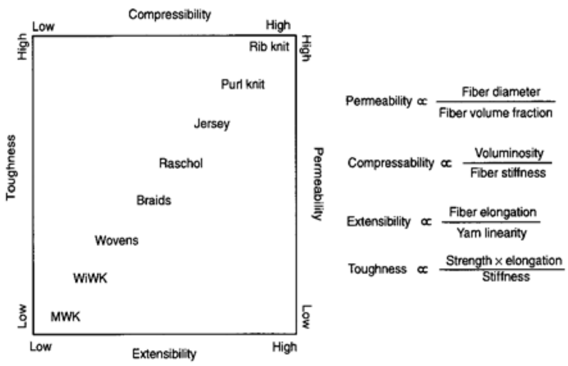

Figure 3. Performance (final) yarn for knitted structures

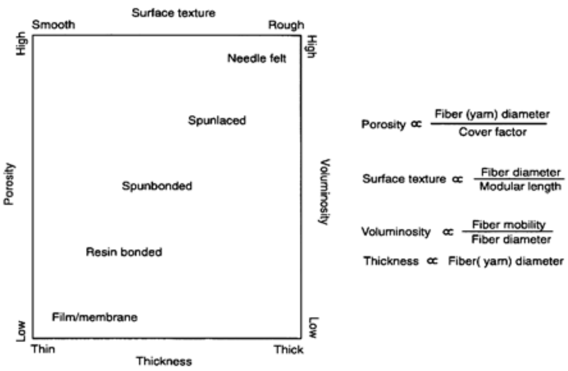

Figure 4. Geometrical properties of fiber knitted structures (woven textiles)

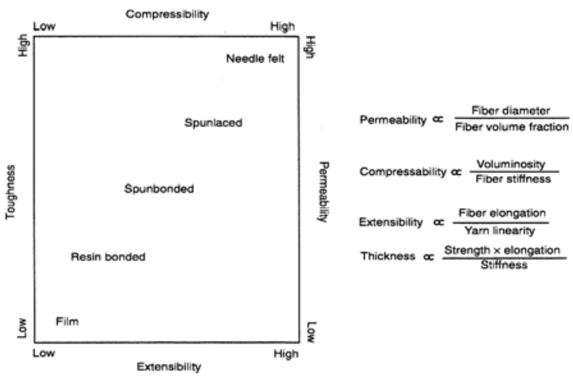

Figure 5. The performance characteristics of fiber knitted structures (woven textiles)

3. ROBOTIC QUALITING SYSTEM

Joining of geotextiles in the area is well-established practice of using traditional sewing machines. New single sewing (quilting) technology is now available in Germany. Altin system, shown in Figure 6, is composed of many systems of industrial robot arms, head sewing and programmed control module. In contrast to traditional sewing machines, which require access to the knitting and the top and bottom (which thus limits the size and shape of the fabric that will be sewn), quilting formation using robotic sided quilting (RJP) technology can only be realized on top of the shield .
Different geometries loops (including chain loop (fringes), the loop is always used (brick knitted loops) and elongated traps with loops) can be used.

Figure 7 shows the formation of chains with two pins that come from the same (top) side twists. Ross is recognized as important emerging technologies of advanced composite deformation and protect the textile industry, due to programming robotic arm and one-sided approach knitting, ROSS can join in a highly complex structures over large areas. It may also provide a means to put themselves locally through-thickness reinforcement for composite structures. Keeping in mind the unique capabilities of one sided stitching, Boeing has purchased a similar ROSS unit for its program of composite wing manufacturing program (wherein boned trimmed with leather wing structure for the production of 737 wings). ROSS at Drexel is one of only two systems in the U.S. Considering diversity of sewing head, it is quite conceivable that a field robot can be equipped with the OSS unit to perform
automatic sewing fields.

Types of stitches: one sewing-simple necklace point

Two tools for sewing and needle catcher
Sewing Technology "on one side with the sewing block on the upper surface of the workpiece
Angular adjustment from sewing tools, 45^0

The requirement for the formation of points needed within the workpiece

Transient movement of the stylus with the common mixing of below the workpiece.

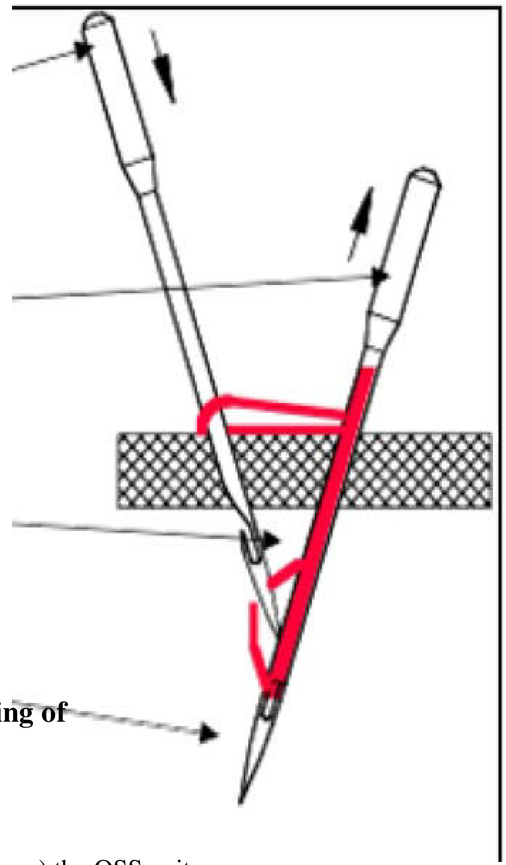

Figure 7. The formation of fringe (resa) the OSS unit

4. NANOFIBER TECHNOLOGY FOR FUTURE GENERATIONS OF TEXTILE

When looking at future generations of geotextiles, examining the role of nanotechnology in the functional improvement of geotextiles is fine. Decreasing diameter of the fiber to the nanoscale, it is possible a huge increase in the specific surface area at the level of 1000 m^2/g This reduction in size and increase the surface area to a great extent influence the chemical and / biological reactivity and electrical activity of the polymer fibers.

Due to the extreme fineness of fibers (as shown qualitatively in figures 8a – 8b) there is a general effect on the geometric, and thus the success traits twists. There is explosive growth in worldwide research efforts recognizing the potential nanoeffect that will be created when the fibers are reduced to the nanoscale.

Briefly, nanofiber technology is the synthesis, processing, manufacturing and application of fiber nano degress. By definition, nanofibers are fibers with a diameter equal to or less than 100 nm. Due to demand and manufacturing capacity constraints, some industries tend to consider all submicron diameter fibers to be "nanofibers".

The rapid growth of nanofiber technology in the last few years can be attributed to the re-discovery of electrostatic spinning (or electrospinning) technology initially (originally) developed 1930 years This technique is used to produce high-performance filters, portable electronics and scaffolds for tissue engineering to use a high surface area of a single fiber. Schematic drawing of the process of spinning electro shown in Figure 8a, where the high electric field is created in a polymer fluid contained in a glass syringe with a capillary tip and metal collecting screen. When the voltage reaches a critical value, the electric field overcomes the surface tension of the deformed drop of polymer solution formed conditionally on top of a syringe and ultra-fine fibers are produced. Electrically charged stream passes through a series of electric-induction bending unstable during its passage collected on the screen as a result of the hyper-Extend jet. This stretching process is accompanied by rapid evaporation of solvent molecules, which reduces the diameter of the jet cone radius. Dry fibers accumulate on the surface of an aggregate (collection) screens, resulting in non-woven twists of nanometers to microns diameter fibers.

The process can be adjusted to control the fiber diameter variation of a strong electric field and the concentration of the polymer solution, and the duration of the electrical control of spinning fiber deposition thickness. Nanofibers in the yarn linear or planar nonwoven mat form can be produced by appropriate control electrodes.

Huge specific surface area of these assemblies nanofibers can make them outstanding in relation to the collection and routing of greenhouse covering landfill gas in the system. Controlling the porosity and the appropriate choice of polymer systems, barrier membranes can be produced selectively failure characteristics similar to those used in Hem / Bio-protective barriers.

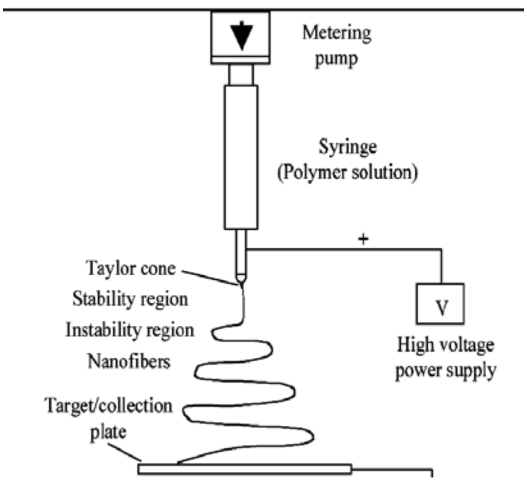

Figure 8a. Schematic drawing

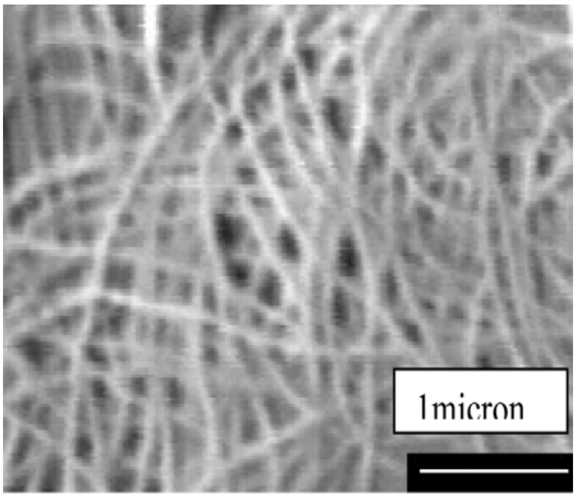

Figure 8b. Electro spun nanofiber membrane electro spun processes

5. SUMMARY AND CONCLUSIONS

The pioneering efforts of Professor Koerner in the new field of geotextiles has established a solid base of knowledge for engineering design and creative use of textiles for geotechnical applications. This has led to enormous economic growth for chemicals, fiber and complex geotechnical industries worldwide. And if there is a large family of textile structures available for geotechnical applications, a basic understanding of the dynamic interaction between the textile structure and the geotechnical environment is essential for the proper design and selection of geotextiles for a specific application. Basis for evaluation of various fiber architectures for geotextiles are the geometrical characteristics and performance of different textile structures are shown in terms of performance charts. Specific examples of textile technologies suitable for linear and planar multiaxial reinforcement are shown together with the introduction of new robotic technology sewing basics. The paper concludes with a geotextile between nanofibers generation technologies that can play a useful role in strengthening nanocomposites, hydraulic, geographic living areas of mining and energy applications.

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APPLICATION OF GEOSYNTHETIC CLAY IN THE GEOTEXTILE, GEOMEMBRANE AND GEOGRID

Vojislav Gligorijević, Jovan Stepanović, Nenad Ćirković, Jelena Danikov

Apstract: *Geosynthetic clay is a natural waterproofing material that in contact with groundwater produces waterproofing membrane that is retained between the geotextile filling small cracks and unevenness thus preventing access to water. The principal setting for bentonite concrete walls along the diaphragm or existing facilities. Extruding high density polyethylene (HDPE) or very low density polyethylene (VLDPE) yielded geomembrane with smooth and rough surfaces.Rougheningnot affect the basic mechanical properties of the material, but only increases the friction in contact with other materials. Shows the honeycomb structure that is made from strips of high density polyethylene (HDPE) connected by means of ultrasound.*
Woven polyester fiber networks are obtained for the reinforcement of asphalt, bitumen application that provides its finish from terminal with asphalt. With tolerances, have declared properties and can be used for reinforcement in repair of deteriorated asphalt surfaces of roads with asphalt or concrete surfacing.

Key words*: Geosynthetic clay, geomembrane, honeycomb structures, geotextile ,reinforcement.*

1. INTRODUCTION

Geosynthetic clay or bentonite carpet waterproofing material that is used to prevent the penetration of occasional or regular water. It consists of three basic elements:
- Bentonite as an insulating material,
- Lining of geotextile containing bentonite
- Woven geotextile, carrier drift.

Bentonite is a natural material, the type of clay of volcanic origin, which has the ability to swell when in contact with water. In contact with ground water, dried clay turns into a gel-sealed, and thus creating a waterproof membrane, which is retained between the geotextile, geosynthetic mat makes optimal and stable material foreseeable long-term performance. There use to protect reinforced concrete structures, horizontal and vertical, the primary role of preventing the penetration of intermittent or permanent water.

Bentonite carpet is installed so that the bottom layer of reinforced laid on the ground, gravel or concrete with the flaps of 20 cm over the entire area where the bentonite blending with surface reinforced concrete structures. In contact with water, sodium bentonite is impregnated into the outer surface of the geotextile, swell and fill small cracks and bumps, thereby preventing access to water.
Particles of bentonite powder currently impregnated when they come into contact with water, thus reducing the time of activation of bentonite. It is this feature, provides good insulation in the valleys and in the variant when bentotex cut to measure or circumcised around the ledge.

Horizontal setup
Once properly prepared surfaces, bentonite mat is placed simply unwinding roll and cutting to the required measure. Watertightness isolation is achieved by overlapping rolls, with a width of 15-20 cm overlap.

Vertical setting
Concrete walls with a diaphragm or existing facilities. Bentonite carpet attached to the previously constructed wall, with a breadth of 15 cm overlap. Must use fasteners every 30 inches. Set the armature and unilateral plating and pave a new wall.

Setting the formwork
Bentonite mat is placed inside of a number of externals shell to hang or attach sporadically until pave.

To have concrete walls
Bentonite carpet fasteners are attached to the wall with a width of 10 cm overlap.

Benefits of Bentonite mat during installation
Bentonite mat is very flexible and can be used in all types of reinforced concrete sections of solving the insulation on the edges and holes. Although we recommend the installation of the product bentonite carpet in the dry state, it has been used in several construction projects in the form of bentonite was previously mixed with water before coming in contact with the structure or the ground. Needle-punched construction of this product prevents the bentonite is removed from the coating.
Despite this, apply the powder should be avoided, for example, if you walk across the membrane is wet. Table 1 presents the dimensions of Bentonite mat for small, medium and large rolls with their implementation.

Table 1. Dimensions Bentonite mat

Name	Dimenzions	Width overlap on application	Application
Small roll	1x2m	10-15cm	*fill horizontal areas *for vertical applications
Mean roll	2x20m	10-15cm	*to cover the area where there are several obstacles *for areas with limited access
large roll	4x20m	20-30cm	*for covering large open areas such as floor slabs

Application of Bentonite mat is possible in isolation floor slab of reinforced concrete, insulation pillars, construction of vertical walls, cover and closure of contaminated ground, coating the bottom of the landfill, two minds, canals and riverbeds, construction of the underground garage, basement space, swimming pools and so forth.

Geomembrane

It is a material that is produced by extrusion, high density polyethylene (HDPE) or very low density polyethylene (VLDPE). It can have a smooth or rough surface.
Rougheningnot affect the basic mechanical properties of the material, but only increases the friction in contact with other materials. Texture can be unilateral (mark with T) or duplex (code number with TT).
Geomembrane can be applied in ensuring waterproofing reservoirs, reservoirs, dams, canals, making the base and cover layers of impermeable landfill, isolation tunnels, parts of buildings and flat roofs.
In Table 2 are given the dimensions of the geomembrane with the width, length, area and weight of the roll.

Table 2. Dimensions geomembrane

The thickness of the geomembrane	mm	0,75	1,00	1,50	2,00	2,50
Roll width	**m**	**5,10**	**5,10**	**5,10**	**5,10**	**5,10**
Length of roll	**m**	**250**	**200**	**150**	**120**	**100**
Surface rolls	**m^2**	**1275**	**1020**	**765**	**612**	**1310**
Roll weight, gross	**kg**	**1090**	**1090**	**1195**	**1275**	**1310**

In figure 1, given the isolation of the landfill bottom in Stara Pazova.

Figure 1. Isolation landfill bottom in Stara Pazova

Installation of geomembrane can be weld ed seams and edges connecting edges STICKERS geomembrane. Geomembrane welding edges can be hot key (with preheating) and hot air welding.

In figure 2, given the overlap of the two cheats in figure 3, with one seal .. Figure 4 shows the anchoring geomembranes.

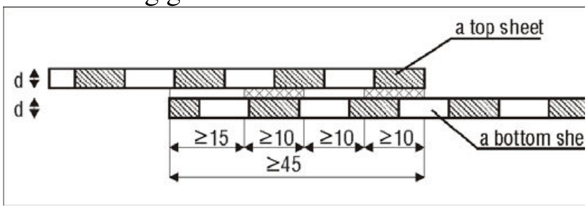


Figure2. Overlap the two cheats

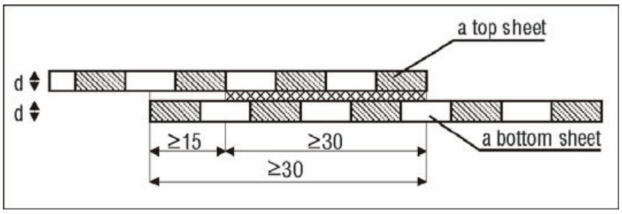
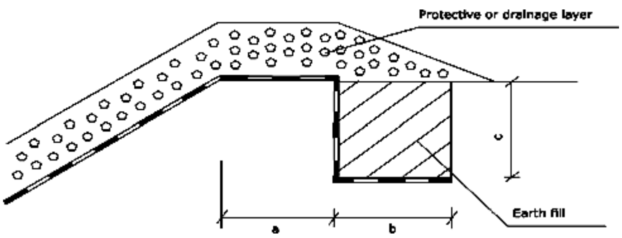


Figure 3. Overlap with one seal



Slope (m)	a(m)	b(m)	c(m)
<10	0,5	0,5	0,5
10-30	0,8	0,6	0,6
<30	1,0	0,8	0,8

Figure 4. Anchoring geomembrane

Honeycomb HDPE structure

Honeycomb structure is produced from strips high density polyethylene (HDPE) is connected by means of ultrasound. Comes in panels of various sizes (depths 50, 75, 100, 150, 200, 250mm) and various sizes of cells. HDPE honeycomb structure with tolerances, have declared properties and can be used to:

protection of embankments from erosion and incision, protection and channel streams, artificial lakes, construction of roads on subbases little bearing land, construction of retaining walls, building leafy lot.

Figure 5 shows the appearance of honeycomb structure and its setting.

Geogrids

Geogrids are made from polymers - high density polyethylene (HDPE) or polypropylene (PP) by a special extrusion technology. This is achieved by orientation of polymer molecules, a sort of pre-stressing, which significantly increases the mechanical properties of the material. Nodes are an integral part of the structure of the network and provides rigidity in all directions in the plane.

Geogrids, with tolerances, have declared properties and can be used in decorating little soft soil reinforcement layers Embankment, construction of retaining walls and embankment soil reinforcement, the reinforcement of asphalt in the construction of new and reconstruction of old road surface, erosion protection, construction of drainage systems.

Biaxial geogrid

Partly pass through the unit allows bi axial geogrid reinforcement effect of incarceration and the weak soil. Clamp helps prevent lateral movement and dilation of the aggregate particles so that the angle of shear resistance is very high. Applied to the weak foundation soil bearing capacity, in roads, railways, foundations on piles.

Table 3 presents the main data two axial and one axial geogrid. Depending on the applied raw surface mass in kg/m^2 is different.

Figure 5. Installation Sacco structure

Table 3. Basic parameters of the two axial and one axial geogrid

Geogrids E-Grid	Raw material	Surface mass (kg/m^2) EN 965	Slot size (mm)	Strength max. long./ trans. (kN / m) ISO 10319	Strength at 2% def. long./ trans. (kN / m) ISO 10319	Strength at 5% def. long./ trans. (kN / m) ISO 10319	Dimensions roll (m)
Two axial							
EG2020	PP	0.2	40x40	20/20	7/7	14/14	50x4
EG3030	PP	0.3	40x40	30/30	10,5/10,5	21/21	50x4
EG4040	PP	0.45	33x33	40/40	14/14	28/28	30x4
Monoaxial							
EG170R	HDPE	1.24	-	173/-	52,5/-	103/-	30x1~1.2
EG130R	HDPE	0.94	-	138/-	38/-	75.5/-	50x1~1.2
EG90R	HDPE	0.6	-	88/-	23.7/-	45.2-	50x1~1.2
EG65R	HDPE	0.4	-	64/-	16.1/-	30.9/-	50x1~
EG50R	HDPE	0.29	-	52.5/-	12.7/-	24.7/-	50x1~1.2

Monoaxial network

Are used for reinforcement of retaining walls and embankments. Figure 6 shows an example of reinforcing retaining walls. Figure 7 shows the reinforcement of asphalt two axial networks in repair worn surfaces.

Network for reinforcing asphalt

Network for reinforcing asphalt products are woven polyester fibers, bitumen and causing its finish to ensure contact with the asphalt. With tolerances, have declared properties and can be used for reinforcement in repair of deteriorated asphalt surfaces of roads with asphalt or concrete surfacing. Figure 8 shows the grid for reinforcing asphalt.

Application of Geogrid to reconstruct tioning of existing roads, enable both: preventing reflection cracks in asphalt layers of roads, expansion of roads, increase the load-bearing layers pathways of unbound granular materials this year, separated butions underground roads, rehabilitation of roads digs.

Geogrids MAT

Produced by extrusion of polypropylene (PP) fiber (Figure 9). In this way we get the three-dimensional structure of thickness 10 - 20mm. Due to the relatively low strength of the bed, and composites manufactured with different geogrids to increase capacity.

Materials with tolerances, have declared properties and can be used to protect against erosion and stabilize slopes and embankments, and the reinforcement of topsoil and ensuring the development of vegetation. Macmat is geocomposite (Figure 10), which has a bearing part with galvanized or powder coated hexagonal grid, and filling of polypropylene fiber three-dimensional structure of MAT.

Figure 6. Reinforcing retaining walls and embankments Figure 7. Reinforcement in repair of deteriorated asphalt surfaces

Figure 8. Network for reinforcing asphalt

Design using EKG PVC Drains and Reinforcement

Consolidation

Electro-kinetic geosynthetic prefabricated vertical drains (e-PVC) are installed in a conventional manner (Pugh *et al.* 2000). During electro-osmotic consolidation pore water is removed at the anode and little consolidation occurs at the cathode. The resulting consolidation is non-uniform. The problem can be resolved using reverse polarity provided both the anode and cathode can provide drainage.

The calculation of the consolidation settlement and the consolidation time may be carried out by either of two methods, based upon either the quantity of water removed (Q) or upon the magnitude of negative pore water pressure generated. The reduction in the water content of the soil increases the shear strength. The strength gained during the treatment can be estimated from two correlations: the ratio of shear strength to effective consolidation pressure, and the relationship between effective consolidation pressure and moisture content (Bjerrum 1967). An example of the design of an e-PVC installation based upon the quantity of water to be removed is shown in Table 4.


Figure 9. Appearance Mat - networks   Figure 10. Appearance Macmat networks

Table 4. Design of EKG prefabricated band drains (after Hamir 1997)

Step	Action	
1	**Volume of soil requiring treatment**	**2000 m³**
2	**Reduction in moisture content required** (i)	**3.4 per cent**
3	**Quantity of water to be removed (Q) (from Steps 1 & 2)**	**100 m³ (108 cm³)**
4	**Time for treatment (t) (assumed)**	**30 days (2.6 x 106 seconds)**
5	**Electro-osmotic permeability of soil (k_e) (measured)**	**2 x 10-5 cm/s per Volt/cm**
6	**Soil resistivity** (□) (measured)	**4700 ohms/cm**
7	**Current required (I) based upon Q/t = k_e**□□ I f(t,cv)(ii)	**410 amps**
8	**Applied voltage (V) (assumed)**	**50 Volts**
9	**Total resistance (Rt) (from Steps 7 & 8)**	**50/410 = 0.12 ohms**
10	**Resistance of individual electrodes (R_i) (known)**	**11.6 ohms**
11	**Number of EKG electrodes required (R_i/R_e)**	**11.6/0.12 = 96**
12	**Quantity of water discharged per e-PVC (calculated)**	**12.5 m³/year**

Notes:
(i) Based upon relationship between content, consolidation pressure and undrained shear strength (see Bjerrum 1967).
(ii) The consolidation function f (t,cv) will be unity at the start of the treatment and approaching zero at
the end.

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OPTIMIZATION OF CLOTHES CONSTRUCTIONAL PREPARATION USING CAD SYSTEM

S. Đurđević, V. Petrović, M. Stanković, I. Skoko, A. Zdravković, S. Stefanović, D. Goševski

Abstract: *Modern business conditions impose that development of manufacturing companies going toward the level where they will be able to respond to market demands in a very short period of time. Therefore, in this paper it was observed constructional preparation of clothes before implementation of CAD system for construction, modeling, and grading of clothes in a real conditions of production in selected example of medium enterprise in Serbia. It was determined that less time is required for constructional preparation of various garment by using CAD system compared with traditional way of constructional preparation. The results show that time for constructional preparation was reduced* ***to*** *33.31% for model M1 - children t-shirt, for model M2 – children's sweatshirt, the time was reduced* ***by*** *61.64% and for model M3 – children's jacket, time was reduced by 65.35%. Despite the good results obtained using the CAD system, it was concluded that a large number of enterprises in Serbia today is not equipped with CAD systems due to high financial investment for this type equipment for production.*

Key words: *constructional preparation of clothes, clothes manufacturing, clothes production in time, CAD system for garment construction.*

1. INTRODUCTION

Equipment level of companies for apparel production, which in Serbia has around 950, is different. The environment and conditions under which these firms were established in the last few decades have led that large number of firms was not based on the engineering knowledge, which follows the production of clothing. Clothing industry has big problems especially in countries which are in transition. Nowadays, it is common to hear that the Clothing and Textile industries are in crisis, that production is reduced, sales is reduced, working hours are reduced, and that those industries are operating with losses. Those facts indicate that textile companies have difficulties to adapt to new business conditions, i.e. environment gives them less opportunity to do business successfully. It is evident that certain number of companies can not manage in the new conditions [1,2].

Where we should seek the reasons for poor conditions in Serbian textile industry, once with very successful companies? Newly created economic circumstances and problems, which follow them, have certainly big influence on production process. The most common issues on which encounter manufacturers of apparel are:

- need for a wider collections and frequent changes of samples
- changes in consumer demands,
- changes of dressing tradition,
- emergence of market saturation
- pressure from imported goods,
- changes in rhythm ordering of the traders, etc.

For getting out of this situation it should be used the experience of those who had the same or similar problems and who had successfully solved those problems. All solutions are mainly based on impressive reduction of costs of all participants in the textile chain. To start solving the problems, it is usually taken analysis of current situation of the company. The analysis usually indicates that there is a fatigue in the functioning of the company. For recovery, it is usually offered the following solutions [1,2]:

- implementation of manufacturing strategy Just-in-Time for resolving unnecessary inventories in stock;

- evenly supply of materials in accordance with the needs of the firms;
- introduction of the CIM concept with electronic computers in the management and flexible manufacturing at all stages;
- introduction of Total Quality Management for a comprehensive quality assurance;
- implementation of integrated marketing for completely guidance all operational functions according to market needs, etc.

Modern business conditions impose that development of manufacturing companies going toward the level where they will be able to respond to market demands in a very short period of time. In accordance with that, the companies have the all-new and very strict organizational and production conditions because in a very short time, they must prepare the production process, to adapt production lines, machinery and equipment and workers for the sudden and rapid changes. To satisfied this requirements, it is necessary that company has modern equipment [3]. Survival on market and success in the competition, is forcing companies to always invent new solutions and to take steps for reducing costs impressively, both in the production and with all the participants in textile chain [1,2].

Therefore, today is resorting to new strategies of apparel production. QRS is a strategy for rapid response to market requirements, for identification of needs and desires of clothing consumers, spotting fashion trends, evidence of increasing demand or lack of certain items on the market. This strategy should ensure responsiveness to market demands for a few days, as is schematically presented in Figure 1 [4], where is shown large difference of previous and contemporary aspirations in completion of garment production [1].

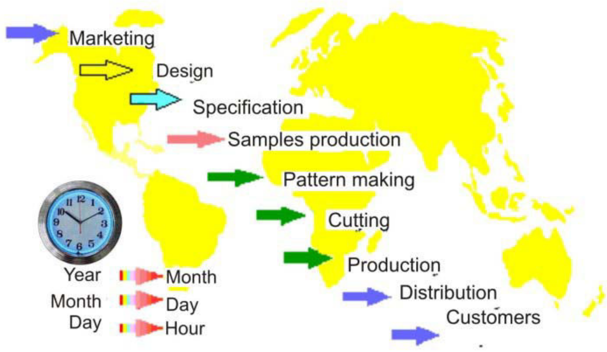

Fig 1: The tendency of reducing the cycle of production of garments

Besides QRS strategies, a special kind of manufacturing strategy - a JIT strategy - just in time or in the given timeframe is imposed on garment manufacturers. This strategy has set completely new and very strict organizational and production conditions for modern garment industry, which are reflected in the preparation of the production process in a very short period of time, and in adapting production lines, machinery, equipment and personnel for the sudden and rapid changes, which are extra impeded small production series. In this way, activities for production preparation represent a significant factor in these strategies [3].

We have witnessed a numerous of projects in countries in transition which aim at entrepreneurship development. One of these projects in Serbia was the USAID / SEDP project. The goal of SEDP project was to reduce production costs by applying engineering techniques in garment manufacturing with retain quality standards.

Different phases of the project included establishing the order of production operations for all apparel models, definition of appearance of the most efficient work space, establishing the most effective methods of management of making the time study for each operation in order to achieve the correct standard, calculating the number of machines required by the type of machines, setting machines in production lines in the order certain operations, preparing the method for the development of training for each operator and Education checklist for the daily performance of each machine or workstation.

The project included dozens of private apparel companies in Serbia. Project results are reflected in reduction of time required for garments production ranging from 5%, and in some cases up to 40%. Average reduction time for clothes production was ranged around 12%, for all companies in the project. The authors were the participants of USAID / SEDP project. However, it is difficult to present how it was reached to these results , because approach to the problem solving to each company was primarily subjective, and it was based both on the engineering knowledge and personal experience. In addition, each Clothing company was faced with its characteristic problems in their operations and therefore is difficult to make a comprehensive systematization in solving those problems. Therefore, in this paper will be considered a small segment in constructional preparation of clothes on representative example of middle companies.

3. MATERIALS AND METHODS

By increasing the level of technical equipment of constructional preparation, worker's fatigue is significantly reduced, with a significant increase of productivity. The influence of competition led to a new tendency in making clothes, it is reflected in the reduction in running time of technological operations while maintaining quality, because productivity, production capacity and price garment depend on that. For this reason, during design of clothing products it is necessery to take care about raw material's composition and material properties, as well as the technology of its processing [5-10]. Therefore, in the work it was monitored the differences in constructional prepare for several clothing products before and after introducing CAD systems for design, modeling, and grading into the product line. Analysis was done in into the same company. During analysis it was used French company's software Lectra, more precisely their software package Modaris [4].

Modaris is a program for creating, modeling and grading of cutted parts and assembling the final model. The program offers a fast digitizing of finished cut parts (the process of entering cuts into the existing paper-based templates in the computer), along with interactive monitoring of input process directly on the screen. Digitizing line is a precise and simple, with few points and all the details of the templates may be included in the program. Modaris enables the automatic creation of new cutting pieces from existing (eg, a simple and rapid preparation of linings, interlinings, etc.) or the construction of new cutting parts directly on the screen using a special function for the base construction using advanced drawing tools.

Creating different types of internal and external incisions, placement of various internal marks, special text printing within certain parts of the cut parts, advanced techniques of measurement and control, making creases are just a few of the many possibilities offered by this program. With its functions for quick and easy modification of existing cut parts depending on the current needs of the manufacturing process, Modaris contributes to the reduction of time for construction preparation and increases the productivity of associated department. The program allows you to work with the sewing lines or cutting lines, which provides more choices for special seam angles, and their mutual adjustment. Measurements by this program can be perform on the lines of cutting and/or on the sewing lines, and can be measured the volume and surface of the cut parts, and segment's angles. Dynamic table of measurement allows control of cut parts using various measuring formula for addition, subtraction, multiplication, division and graphical representation of each measurement. Using functions to create variants in the model, models are prepared for making cutting patterns. At that point, it is selected type of material and number of peaces that are used in the cutting pattern.

Playing the traditional method of grading, Modaris offers features for fast interactive grading, transfer of grading from already graded to ungraded cutting parts, automatic calculation of proportional grading, and orientation of grading in defined directions. Control of performed grading is simple and precise, and it can be done at each point and each size.

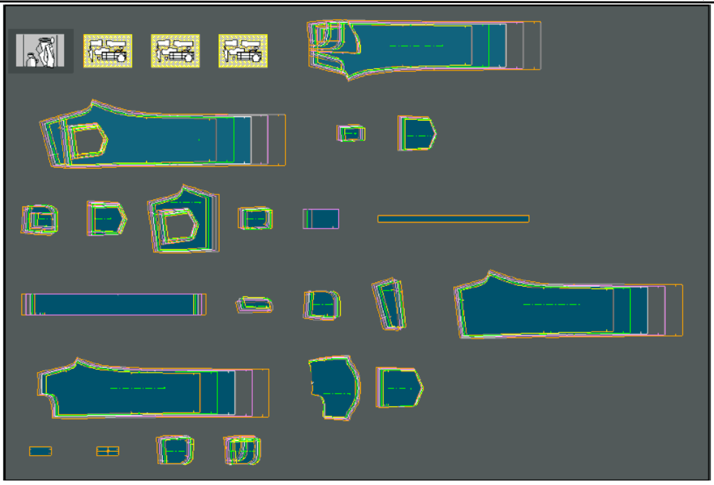

***Fig. 2** : Display of grading cutting part on Modaris desktop*

In this study, tasks of constructional preparing was observed for three different clothing items in five clothing sizes including: wrapover vest (model M1), skirts (model M2) and pants (model M3). Wrapover vest is made from 100% cotton, trousers and skirt from cloth of mixtures of 97% cotton and 3% elastane. Tables 1 and 2 show the duration of the tasks of the traditional constructional preparation and constructional preparation with the use of CAD systems. The observed workers in constructional preparation were with approximately the same working experience. Workers have had great experience in the traditional way of constructional preparation, and their training to work with the CAD system lasted 4-5 months, which is a short period of time for workers to acquire a maximum of all program options offered by the software package Modaris.

***Table 1.** Time (in minutes) of duration of the tasks of traditional constructional preparation*

The observed activities	Time[min], for models		
	M1	M2	M3
Construction of the basic pattern	20	52	82
Modeling	36	58	194
Completing	30	79	140
Grading	85	255	379
Total time in minutes	171	444	795

***Table 2:** Time (in minutes) duration of the constructional preparation with the use of CAD systems*

The observed activities	Time[min], for models		
	M1	M2	M3
Construction of the basic pattern	19	46	58
Modeling	18	30	114
Completing	21	63	120
Grading	16	25	32
Total time in minutes	74	164	324

Marks in tables 1 and 2 have this meaning

M1 – children's t-shirt,
M2 – children's sweatwear and
M3 – children's jacket model.

Figures 3, present the advantages of using CAD systems to the traditional way of the structural preparation of models for presented clothes.

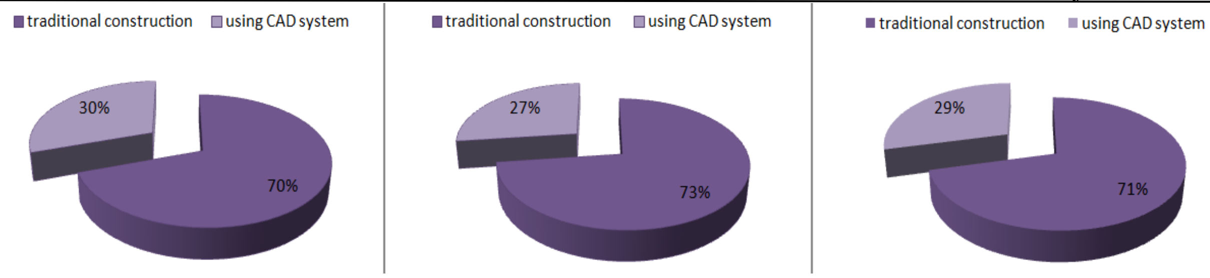

Fig. 3: Comparative duration (in minutes) constructional preparation of model M1, M2 and M3

3. CONCLUSION

Work in the clothing industry is devided on a large number of technological operations of making clothes. Every technological operation is time limited and requires considerable mental and physical involvement of employees. The success of the production of clothing largely depends on the structure and time duration of technological processes. Therefore, in this work the constructional preparation was observed, because it has big influence on the speed of production, ie. on the speed of production response to market demand. The observed workers in constructional preparation were with approximately the same working experience. Workers have had great experience in the traditional way of constructional preparation, and their training to work with the CAD system lasted 4-5 months, which is a short period of time for workers to acquire a maximum of all program options offered by the software package Modaris. Regardless of this fact, the same employees achieve significantly better performance using a CAD system. The results show that for the model M1 - wrapover vest, time for constructional preparation was reduced by 34.31%, for model M2 - skirt, the time was reduced to 61.64% for model M3 - trousers, time was reduced by 65.35%. This time can be significantly reduced by using advanced software functions available in software package Modaris. The results show that using of CAD systems can significantly speed up the production preparation, which is very important in order to satisfy requirements of large consumer markets of clothes that have a constant tendency to reduce the time of making clothes.

Despite the good results obtained using the CAD system, large number of enterprises in Serbia today is not fully equipped with these systems due to the high cost of CAD systems.

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CONFORMITY ASSESSMENT MULTIAXIAL FABRIC, LIKE A NEW PRODUCT ON THE EXAMPLE OF APPLYING SECONDARY RAW MATERIALS AT THE LANDFILL

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Apstract: *Evaluation of the compatibility of new products includes the fulfillment of specific requirements related to the product, process, system, person or body, and means testing, calibration, inspection and certification. In the implementation of technical legislation on the principle of the European Union, the manufacturer is responsible for compliance of their products with the essential requirements of the directives defined European harmonized standards.*

For many world-renowned manufacturers of various goods products compliance process can be a complicated and complex. For producers from Serbia this problem is particularly acute in the area, testing, inspection, certification of products and processes in the world is well regulated and impose strict requirements that must be met by national, regional and international regulations and standards, and rules of international certification scheme.

Multiaxial fabrics are widely used in the field of prevention in the construction of sections of roads and railways, tunnels, dams, canals, irrigation and drainage, sports, landslides, dumping raw materials, followed by the development of devices to filter waste water and gas, textiles protective suits for emergency teams in emergency situations, and many other applications.

In order for such a product with a wide range of application went into production and had access to the European market has to go through the entire process of compliance with international regulations and standards.

This paper provides a brief general overview importance of compliance products, with emphasis on the flow of technical regulations conformity multiaxial fabric, as a new product, the application of recyclable materials in landfills (waste).

Key words:*new product, compliance, standard, verification, procedures, multiaxial fabric, waste*

1. INTRODUCTION

In developing a new product, service or process, the main goal was the result of a specific product, service or process, with its functionally defined and measurable characteristics of the test methods. Technical regulations defining at least one of the following elements: technical requirements to be met by a product that is supplied, conformity assessment procedures, safety requirements during the lifetime of the product, regular and special examinations during the lifetime of the product, documents accompanying the product placed on the market or use of, the sign and labeling products, the requirements to be met by the body for conformity assessment requirements for packaging and labeling. Technical regulations and technical requirements contained herein shall be taken to protect the security, life and health, protection of animals and plants, the environment, consumer protection, property protection, and other users.

The overall goal of the realization of development multiaxial fabric, as a new product, the development, production and use of a completely new program for environmental purposes, resorts, health, application in the field of preventive control erosion, road and rail transport, agriculture, construction, water, forestry, and in the field of medicine, textile, automotive, aerospace industry and other economic sectors. The implementation of new manufacturing multiaxial fabric for lining landfills to achieve the following goals: winning new product with improved physical, chemical and biological characteristics compared to existing bonded fabrics, to make best use of technology in the production world, achieving a minimum negative impact on the working and living environment, with necessary resistance to UV-radiation, radiological safety and others. Conquering such a product would be achieved by: increasing competitiveness in the domestic and international market from existing similar fabric, long service life, create jobs, reduce imports and a gradual substitution of similar materials for a variety of applications, enhancing domestic production, increase exports and profits, achieving new business cooperation with companies of similar programs, an increase in gross national income and so on. [8]

2.LEGAL FRAMEWORK REGULATION OF TECHNICAL REQUIREMENTS FOR PRODUCTS IN SERBIA

2.1. Why and how to adopt technical regulations

Basic law for the definition of technical regulations for products and compliance assessment requirements ("The Official Gazette" of Serbia and Montenegro“, No. 44/05), which contains the following bylaws:
-Decree on the method of preparation and adoption of technical regulations and register with these („The Official Gazetteof Serbia and Montenegro“', No. 17/06).
-Decree on conformity assessment procedures ("The Official Gazette of Serbia and Montenegro“, No. 22/06).
-Regulation on accreditation of conformity assessment bodies, the register of authorized conformity assessment bodies, documents and records of compliance, conformity and signs of conformity assessment bodies, as well as the conditions for the application of technical regulations („The Official Gazette of Serbiaand Montenegro" , No. 22/06).
-Regulation on information and notification of technical regulations, standards and conformity assessment („The Official Gazette of Serbia", No. 126/07).

The main reason for the adoption of technical regulations and their products for the protection of life, health and safety of people, animals, plants, the environment, consumer protection, property protection, and other public interests. In addition to achieving safety in use, the technical regulations to ensure tidiness market these products, and often technical regulations provide protection to domestic producers prescribing technical and other requirements for additional testing or certification.

In the process of Serbia's accession to the EU, priority to the preparation of technical regulations, a transfer requirements of European directives into national legislation. This process is conducted in accordance with the National programme for integration of Serbia into the EU, and the end result of harmonization with the EU, is to raise the level of competitiveness of the domestic economy. Given the poor state of the Serbian economy, and many of the old rules apply, which is not ready to quickly apply the new rules, so it is very necessary to precisely define the transition periods for the implementation of the new regulations. According to the experiences of countries that have completed the process of EU, accession, the transitional period is necessary to provide a delayed/parallel implementation of the requirements of the existing technical regulations. If legitimate products sold in the market of a EU member, the remaining members must accept the sale of such products in your market, although some member states sometimes prescribe national technical requirements for the application (due to climate and other characteristics), which can be interpreted as a technical barrier for the products.

2.2. Aspect of product conformity and the importance of standardization

Requirements in terms of performance and machine safety are very important for manufacturers, distributors, and especially their customers, because the appropriate certificate must be provided for a way to prove compliance with defined technical regulations. Technical requirements for products and technical regulations, refer to the product group governing any of the following:

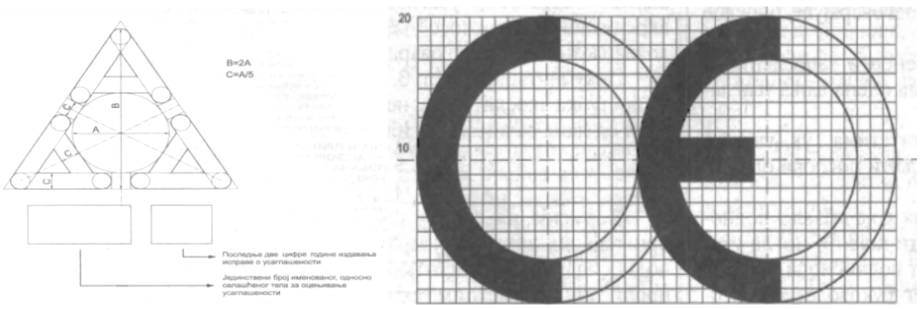
- the technical requirements to be met by the product being delivered,
- conformity assessment procedures,
- safety requirements during the life of the products,
- regular and special examinations during the lifetime of the product,
- the documents accompanying the product placed on the market or in use

- a sign and labeling of products,
-requirements to be met by the body for conformity assessment,
- requirements for packaging and labeling, etc..

Decree on the implementation and evaluation of conformity ((„The Official Gazette of Serbia", No. 98/2009.), the contents of documents, as well as the shape, appearance and content of a mark of conformity, provides a way of putting signs on products that comply with the requirements of technical regulations, before putting the product on the market or exploitation.

Conformity mark puts the manufacturer, importer or his representative in accordance with the technical regulations and conformity assessment after completion, or at the direction of self-appointed assessment bodies, which were conducted or participated in the assessment of conformity or an authorized body who performed the technical evaluation. The sign must be visible, legible and indelible, a place that is easily accessible for control. It is permitted, if for some reason you can put on the available space, the sign can be placed on its packaging or on a label or slings, and if it is impossible for a reason, the sign can be placed on documents.

Serbian conformity mark consists of three capital letters "A", linked to a well-known form of an equilateral triangle (3A), and international conformity mark 'CE', as shown in Fig. 1 (a, b).



(a) (b)

Figure. 1. The appearance of the Serbian and international product conformity mark (B=2A, C=A/5)

Character size is determined by the height (B=2A, C=A/5) and at least 5mm. The Serbian mark is put a unique number designated or authorized conformity assessment bodies from the register of appointed or authorized bodies, and the last two digits of the year of issue of the instrument of approval.

The European Union's legislation is based on a technical approach based on the New and Global approach and the sectoral approach certain areas of legal and related laws. Such approaches are based on product safety, and environmental protection, the environment and consumers, and to prove whether or not the manufacturer notified certifying organizations. That means the product complies with the CE (Conformité Européen) designation, as evidence that the product is legally on the market and must be accepted by each member State.

1.3. The importance of standardization in harmonization of product

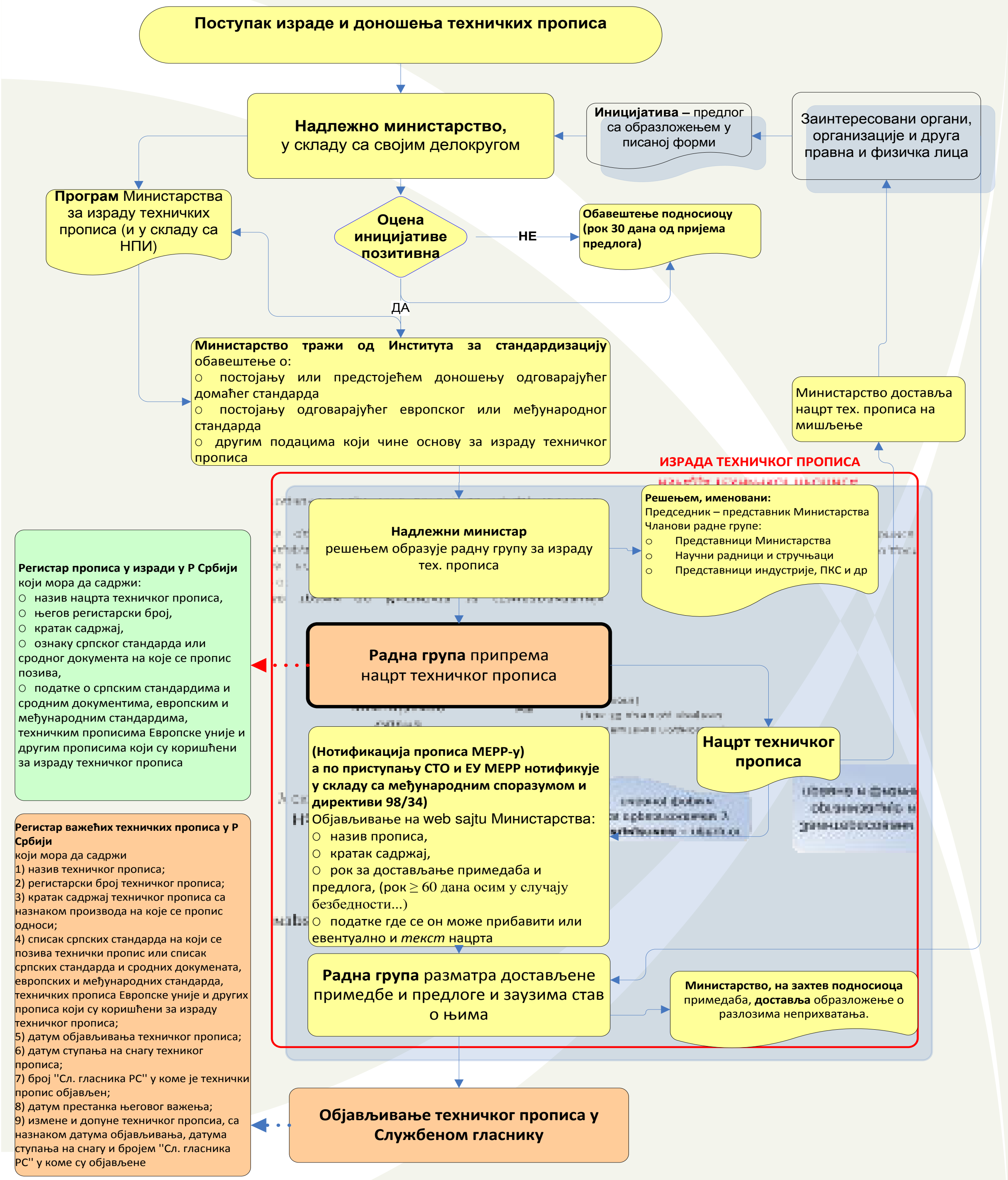
Under standardization can be considered, a set of coordinated activities on the adoption of standards and related documents. Standard is a publicly available document, established by consensus, adopted by a recognized body, which is for common and repeated use, rules, requirements, features, advice, recommendations or guidance for activities or their results, in order to achieve the optimum degree of order in a given area in relation the existing or potential problems.

Every country in the interests of their own and able to establish harmonized standards or the standards of other countries, usually at a higher stage of development.

Standardization of Serbia is based on the following principles („The Official Gazette of Serbia“, No. 36/2009.):

1) The right to participation of all stakeholders in decision-Serbian standards.
2) Consensus of interested parties.
3) Prevention of individual interests over the common interest of stakeholders.
4) Transparency and accessibility of public proceedings Serbian standards and related documents.
5) Mutual Serbian standards and compliance related documents.
6) Taking into account the state of development of techniques and rules of European and international standards organizations and relevant international agreements.
7) Equal treatment of foreign products or services in the same or similar line of local products or services in accordance with international agreements ratified, signed by Serbia.
8) Improving the environmental, health and safety of humans, animals and plants.
9) Improving the quality of process and services, their typing, compatibility and interchangeability.
10) Providing uniform technical basis.
11) Development and improvement of production and trade, works, or providing services through the development of internationally accepted standards for the efficient use of labor, materials and energy.
12) Improvement of international trafficking, prevention or elimination of unnecessary technical barriers and others.

To impose liability insight into the competent authorities in the drafting stages of the technical regulation, the regulation governing the application of regulations governed the preparation and general scheme is shown in Fig.2 and Fig.3, the scheme notification of draft technical regulations, which will be implemented after accession to the World Trade Organization (WTO) and the European Union (EU), with some possible minor changes that will dictate the time.



Производ се ставља у промет или употребу само ако је, у складу с прописаним техничким захтевима, његова усаглашеност оцењена према прописаном поступку и ако је производ означен у складу са прописима

Figure. 2. Way adopting technical regulations

If a technical regulation adopted pursuant to any other law-sector, the use of such methods for the preparation of technical regulations, and provisions related to application ie. notification of technical regulations in the preparation required to be observed in making all laws and regulations stipulating technical requirements for products, regardless of the legal basis for their decision.

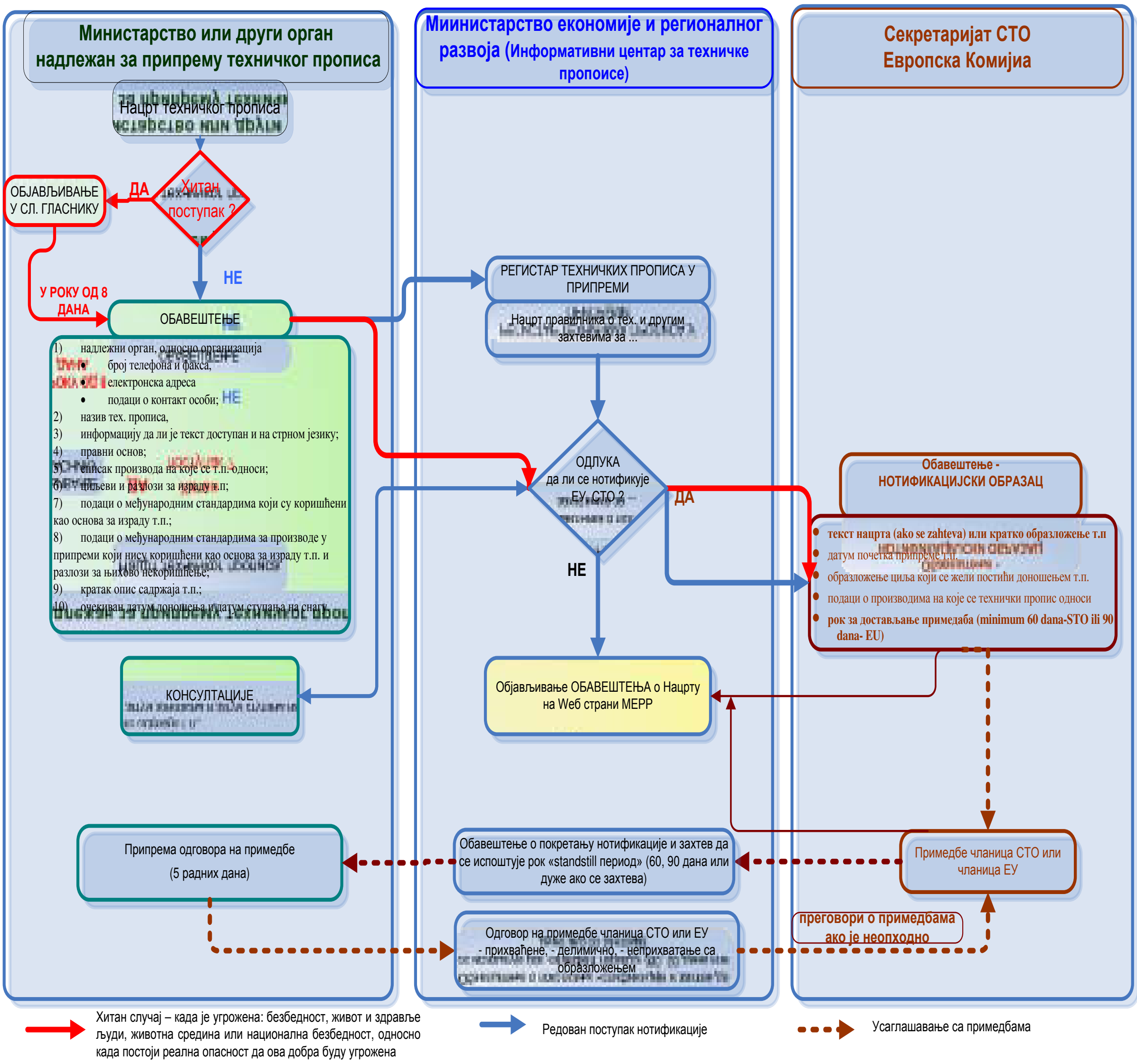


Figure. 3. Notification scheme (application) of draft technical regulations

The essential difference in the required notification in the preparation of regulations to the WTO and the EU to apply technical regulations for which estimates that could pose an unnecessary obstacle to trade and which are not based on the use of international standards, while the European Commission reporting rules must be implemented for all technical regulations for products from noharmonizedareas, but also for the technical requirements of the harmonized areas, provided that such regulations are in addition to requirements of European directives include a national benefit, ie. in terms of additional technical requirements. Besides the huge difference in the legal consequences in case of failure to make notification to the WTO and the EU, which are much higher in the case of notification to avoid the European Commission, because then adopt a technical regulation may not be applied to formally apply.

3.PRIMARY FUNCTIONS AND APPLICATIONS OF GEOSYNTHETIC MULTIAXIAL FABRIC

Waste materials are among the high-risk materials that daily threaten and pollute the environment, and to systematically approach the potential hazards, and environmental consequences if it continues to be ignored plans and programs within the strategy and legal provisions.

The use of geotextiles multiaxial an important part of the process of rounding in favor of prevention was to prevent any consequences. For example, the use of multiaxial fabrics in waste disposal, is very topical because of its features which provide decades of isolation and re-use for energy production (California landfill link the underground pipes which accumulate methane and other gases by implementing them directly in power plants). Showing some possible applications geotextiles multiaxial fabric, is given in Fig. 4.

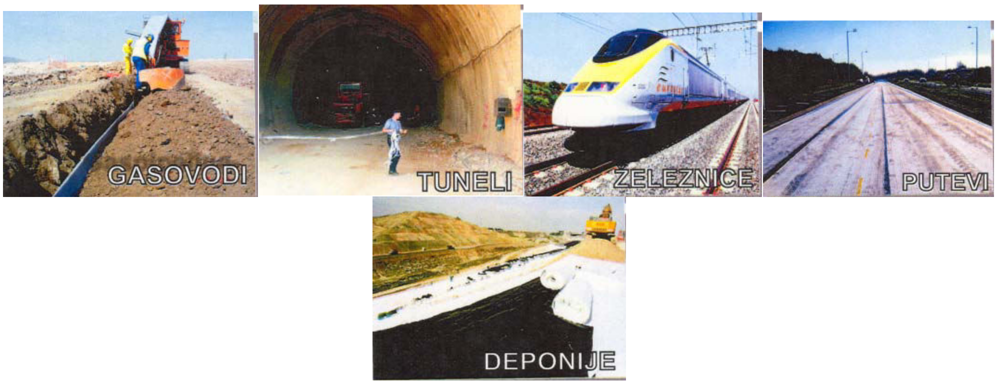


Figure. 4. Areas of possible application textile multiaxial

Response to the demands of European technical norms and standards for specific applications, in order to protect the environment from pollution and decomposition processes of waste on the sites of modern landfills, provides a complete isolation of the body and controlled landfill disposal of waste streams, resulting in the degradation process. Base isolation, and troughs formed slopes of the landfill is done in order to prevent penetration strainedlandfill gas and leachate into the soil, and the soil and leave their uncontrolled locations, which will result in the contamination of soil, air, groundwater and surface water, as well as the possible occurrence of gas in explosive concentrations and the undefined areas.

4. ILLUSTRATE PROPERTIES OF MULTIAXIAL FABRICS

Multiaxial fabrics (geotextiles), (Martin MAT-aramid, UHMWPE Martin MAT, MAT-carbon Martin, Martin MAT-glass, basalt Martin MAT), have excellent mechanical and physical properties and long life. Specificity multiaxial fabric is that it consists of two or more layers of fibers, slow at different angles. That kind of production, there has been less deformed, easy shaping and manipulating cloth.

For the production of geotextiles used in the following combinations of yarn: PP/PES/viles; PP/viles; PES/viles, PP/PES/glass, PP/glass; PES/glass, glass 100%, 100% PP, 100 % PES, 100% PP with viles, 100% PES with viles, with 100% glass viles; combination of fibers processed with resins flizom. Geotextiles multiaxial deposit is made (at angles in the range of (-22.5° to +22.5°) of yarns, so that the aforementioned fabric samples can be infinitely combined, from a combination of various yarn types and refinement, with or without viles or thermoviles, so that, in effect, given range of products.

Fig. 5, shows the visual appearance of a few of the many possible multiaxial combination of slow fibers.

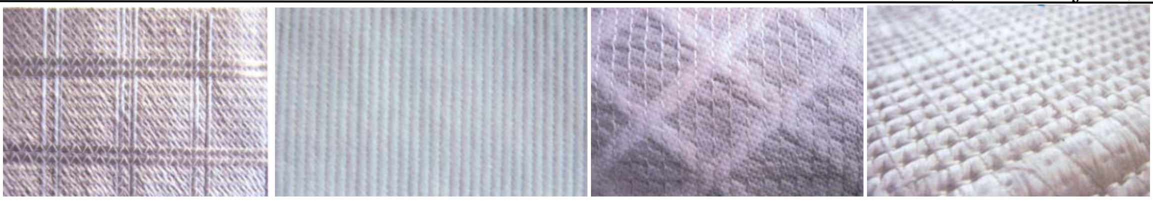


Figure. 5. The visual illustration of multiaxial fabrics and a combination of non-woven fabric layer multiaxial.

Application geotextiles multiaxial fabric is multifactorial, but when it comes to requirements in terms of stability of the field in different geographic areas and fields, they satisfy the following:

Separation-layer separation of the two land, which have different granularity in order to prevent the penetration of soft materials in carriage-drive segmentation times and prevent the fine particles of sub-layers times raise the basic layer of permeable granular carriage drive. (Fig. 6a)

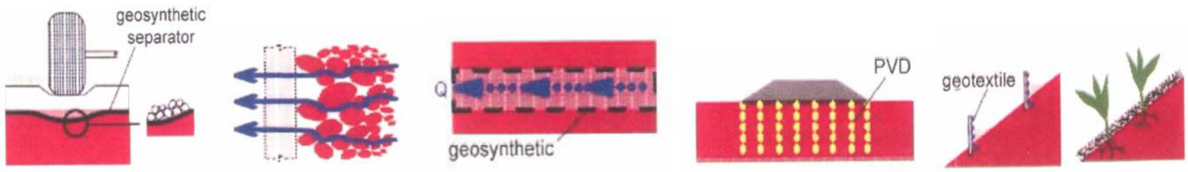
Filtration - geosynthetic prevent migration of fine particles in the land, or possibly a drainage layer placed gas pipes. Used for embankments of river banks to prevent erosion of the land. (Fig. 6b)
Drainage - Serves as a drain that conducts water flow through the less permeable soil and achieve more even distribution of pressure load of water on the roadway embankment. For stronger flows of water, the use geocomposite. Before fabricated drains PVD (Prefabricated Vertical Drains) are used for the consolidation of soft cohesive foundation soil beneath the embankment. (Fig. 6c)

Reinforcement-used as a reinforcing layer in the soil, improves soil which strength and deformability. Geotextile and geogrid soil improves tensile strength, thereby forming a reinforced soil wall. This allows the construction of embankment and through the soft and weak supporting surface or construction of embankments on steep angle, it can not be done with the land not reinforced. Geogrids can be used to bridge the voids that may appear below the base course for roads and railways as well as the cover layer in landfills.

Barrier for the liquid/gas - used as impermeable barriers to liquids and geosynthetic clay gases.
GCL geosynthetic clay material used as a barrier to the penetration of a fluid or gas in the ground, and the top layer of asphalt to prevent swelling of the land that might affect the top layer of asphalt. (Fig. 6d)

Erosion - Erosion geosynthetic prevents soil caused by the influence of precipitation and surface water runoff. Biomat and geomat placed over the top layer of soil on slopes. (Fig.6e)

Other functions - are used for reinforcement geogrid upper layers of asphalt, waterproofing and protection of geomembranes breakthrough, hydro insulation membranes ground concrete structures based on bentonite, various interlaminar barriers, some applications to mitigate noise and vibration in road construction etc..
As seen geosynthetics is the solution to a number of concrete problems faced by professionals in the fields of engineering, environment, transportation, urban planning and so on.



a) ***b)*** ***c)*** ***d)*** ***e)***

Figure. 6. Primary function geosynthetic fabric-multiaxial

Recapitulation application multiaxial fabric, it can be said that once again has the following applications, depending on the purpose: for retaining walls to prevent landslides and mudslides, the protection of agricultural land, protection and security long roads and railways, waterworks building, waterproofing tunnels, collecting and storing drinking water, irrigation water storage, transfer and conveyance of water, landfills and waste lagoons, etc..

5. VERIFICATION QUALITY OF INCOMING RAW MATERIALS, AND TESTING OF MECHANICAL AND HYDRAULIC CHARACTERISTICS MULTIAXIAL FABRIC

The quality of the finished product-multiaxial geotextiles, has a decisive influence quality raw materials. Each raw material passes through pre-determined acceptance testing:
a) the evaluation of the sample material (supplier data sheet, certificate of quality, visual control, internal analysis, analysis of certified laboratories),
b) after an internal control, the yarns the accredited laboratory provides: fineness of yarn (tex), breaking force (daN), elongation (%), raw material composition (%).

The primary characteristics of geotextiles depends on the purpose and function and is largely based on: filtration, separation, reinforcement and protection. On that basis, determine the following characteristics: tensile strength, elongation at maximum load, the static penetration test (CBR test), elongation at break, a check of the characteristic opening size, water permeability, durability, water flow capacity (for use in irrigating and dumps the liquid waste), the efficiency of care.

Analysis of mechanical properties of fabrics made according to the following standards:
- tensile strength (longitudinal), (min 40 kN/m), [EN ISO 10319],
- tensile strength (transverse), (min 40 kN/m), [EN ISO 10319],
- elongation at maximum force (longitudinal), (min 30%), [EN ISO 10319],
- elongation at maximum force (transverse), (min 30%), [EN ISO 10319],
- static penetration resistance (CDR) test-min 7000 N, [EN ISO 12236],
- thickness (according to EN ISO 9863 (min 3 mm)).

Testing of the hydraulic characteristics of the fabric according to the standards:
- vertical permeability fabrics (h=50 mm), (l/m^2s), [EN ISO 11058],
- with openings 0.90 (μ), [EN ISO 12956],
- thick fabric, (mm), [EN 964-1],
- specific weight, (g/m^2), [EN 965],
- water permeability (normal to the plane) - dh=50 mm, (EN ISO 11058),
- the speed of the water flow in the plane (ISO 12 958).

Declaration contains basic information about the product name of the manufacturer and product, surface fabric weight, width and length of the roll, the date of manufacture. [6].

5.1.Special order to conform multiaxial fabric

In the developed countries of Europe, the 70-ies started appreciable deterioration of the environment (increase in the landfill caused the contamination of groundwater and soil near roads and factories and other sites), so that the influence One is no longer related only to the immediate place of pollution, but the uncontrolled spread in ecosystems. Some waste materials are among the high risk that daily threaten and pollute the environment, and thus will be more conditions create potential environmental disaster if it continues to be ignored plans and programs monitoring for waste management.

Construction of new and rehabilitation of existing landfills is not conditional one way to preserve and improve the environment and reduce the risk to human health. The development of new technologies, materials and systems enabled the appropriate response and resolution of the growing problems in many areas where multiaxial fabrics may be applied. When it comes to building the adequate use of such fabrics, whether it is on a hard or soft ground, in plain or mountainous area, the ocean or a river, waste or waste water, multiaxial fabrics are an important link for surrounding the process and its decades of isolation or use for other purposes, such as energy production. In such an application with the strengthening of land and prevent soil erosion, reduce or completely eliminate the possibility of danger to human life or property, and to the rational exploitation of agricultural, forest and construction land.

Response to the demands of European technical norms and standards when disposing of waste in order to protect the environment from pollution caused by a variety of processes that the decomposition of waste in landfill sites contemporary, provides a complete isolation of the body and controlled landfill disposal of waste streams, resulting in the degradation process.

So winning the compatibility of new products or the application of multiaxial fabrics for lining landfills raw materials, has the following objectives:

- winning new products with improved characteristics compared to existing bonded fabrics,
- production of new fabrics with the required resistance to UV-radiation,
- production of new fabrics with the necessary degree of radiological safety,
- winning products that are cheaper than the existing fabric,
- the production of new materials with minimal adverse effects on labor and the environment
- 100% win-term domestic new products,
- improving the physical and mechanical properties compared to the existing bonded fabrics,
- longer service life,
- the conquest of competing products in the domestic and foreign markets,
- increasing employment and making profit from the sale of new products,
- reduce imports of foreign material for environmental protection,
- promoting domestic production and increase exports,
- contributing to the increase in gross domestic product.

6. BY FORMING THE DRAINAGE LAYER LANDFILL USING FABRIC MULTIAXIAL

In order to protect the environment from the possible consequences of the landfill, it is anticipated multilayer insulation on the bottom of the slope and formed "trough" of the landfill. There are many ways of forming a multi-layer insulation is one example of a solution consisting of the following elements:

1.Barrier layer 50cm thick clay (protect and waterproof foil insulation for leachate filtrate).
2. Frst geotextiles, 1.200g/m^2, minimum specific gravity and minimum thickness of 7.5 mm (the protection foil of any defects).
3. Barrier layer HDPE film thickness of 2 mm (for waterproofing leachate filtrate).
4. Other geotextiles, 1.200g/m^2, minimum specific gravity and minimum thickness of 7.5 mm, in order to protect the HDPE film from abrasive effects of sand and machinery.

Above the second layer of geotextile, there is a gravel drainage layer, 50 cm, thick, which serves as a filter layer for leachate and in addition has a role to protect drains and covering waterproofing of heavy equipment that is necessary for the performance of tech sanitary deposit. Through the gravel layer is disposed waste by filling out the plan.

Both layers of insulation, geotextiles must satisfy the following properties: tensile strength, resistance to dielectric effects, resistance to mechanical damage, chemical resistance.

For some locations of landfills in Serbia, geotextiles can be used with the following specifications:

-specific gravity: 1.200g/m^2,
-thickness: 7.5 mm
-resistant longitudinal strain: 21.5 kN/m

-transversal resistance stretching: 40KN/m
-licensed elongation of 130% and 95% longitudinal transversal,
-puncture resistance CDR 5.500N.

Impermeable layer of film is to be deposited on the surface of the geotextile immediately after its installation, since the effect of geotextiles unstable in UV radiation (durability of geotextiles, which are manufactured for this purpose, the UV radiation ranges from 3 weeks to 6 months). It is recommended that heavy equipment is not moving directly over geotextile.

To reduce the penetration of rainfall into the landfill body, and thereby reduce the amount of procednog leachate and landfill gas diffusion prevented through inert covers, provides a multi-layered and final landfill covers along, by reaching the final elevation of disposal. For the final coating layer of a landfill is anticipated multilayer insulation consisting of the following components:

1. Layer of gravel (or similar porous material) to drain gas 30 cm thickness applied over everyday drapes layer of inert material.
2. Layer of geotextile (γ=800g/m^2), as a buffer gas between drainage layer and clay, the clay layer, thickness of 30cm and kf$\geq$1x10^{-5}, which is placed over a layer of gas drainage. Waterproofinglayer HDPE foil 2.0 mm thick
3. Geotextile, (γ=800g/m^2), which has the function of protection against damage gravelly foil material.
4. Layer of gravel for drainage of precipitation, 40 cm thick, which is placed on the foil.
5.Layer of earth for technical reclamation thickness of 50 cm, which is placed over a layer of geotextile.

6.1. Description of activities in alignment multiaxial fabric, as a new product

During the development and implementation of winning multiaxial fabrics, it is necessary to carry out the following activities:

1. Making first detailed plan of activities for all participants in the project
2.Development of second technical documentation required to adapt existing production lines for the production of new types of materials multiaxial.
3.Technology development new types chips multiaxial materials.
4. Establishment of technology for their production lines.
5.Production of a preliminary study on the assessment of the impact of new technological processes on the environment.
6.Preparatory activities for the production of new fabrics.
7. Analysis of quality raw materials for the production of textiles multiaxial.
8. Creating an entirely new range of products multiaxial "sandwich" geotextile, nonwoven geotextile resulting combination (felt, thermoviles) and multiaxial deposited layers of different types of yarn.
9.Test the properties of the obtained materials in national and international accredited laboratories.
10.Verification product to a specific location and landfill.
11. SWOT analysis for new fabrics.
12. Analysis of markets for products.

7. CONCLUSION

Conformity assessment shows the fulfillment of specific requirements related to the product, the test procedures, calibration, inspection and certification. Such products are marked with the CE mark which certifies that the product has met the requirements regarding health, safety and environmental aspects that are contained in the relevant directives

Compliance with European and international principles when prescribingtechnical requirements for products, in order to ensure, a sufficient level of safety of consumers and other users need necessarily, but at the same time, it must take account of the willingness of producers to comply with the requirements.

Production and adopting technical regulations for products is very extensive and demanding job, knowingmany rules with European and global level, and it is necessary that each Ministry or other regulatory authority responsible for the preparation and adoption of technical regulations, the people who will decide perform these tasks and who will have a permanent training.

Regarding compliance multiaxial fabric, as a new product, made by combining various types of yarn (polyethylene, polypropylene, polyester, glass, etc..), we can conclude satisfactory quality that meets the requirements regarding health, safety and environmental directives contained within the set to obtain the CE mark.

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ANALYSIS OF RESPONDENTS ATTITUDES ABOUT CLOTHING SUPPLY AND PURCHASING CAPACITY

I. Skoko, V. Kovačev, M. Gašović, V. Petrović, J. Danikov, V. Kerleta

Abstract: *Given that consumers are a key element of the market and represent the starting point for all marketing plans, it is necessary to examine their attitudes, needs, desires and experiences as consumers. Using statistics, this paper presents analysis of respondent attitudes about clothing supply, their buying decision and choice. The study included 50 people aged 25 to 55 who live in Vojvodina. The research was conducted via an online questionnaire. The testing results and statistical analysis showed that consumers purchase clothes occasionally, that there is a very little knowledge about material properties of the garment so they select mainly on the basis of looks and prices. Beside that, it was concluded that consumers are increasingly supplying in second hand shops and in shopping malls, and branded goods to them is not financially feasible. The research results are expressed through percentages which are shown through graphically participation.*

Keywords: *consumers behaviour, purchasing capacity, fashion marketing, brand*

1. INTRODUCTION

The clothing is an important aspect of human physical appearance. It send a message that differs depending on social class, income, attitude, marital status, etc. Fashion has always been a strong reflection of social and cultural identity and membership in social circles[1]. Therefore, individual membership in a particular social classes define their behaviour as consumer. Fashion consciousness is a convenient consumer attribute for apparel marketers, in that this pre-existing interest in clothing can increase consumer receptivity to apparel product promotions[2]. In the early papers on the subject of consumer behaviour has already been discussed so that the attitudes of certain types of consumers have already analysed and presented. After these studies, collecting of consumer opinion from the Vojvodina, where in recent years there is a current trade of second hand and Chinese goods were carried out. For this reason, there is a need to look at the attitudes of respondents about where they most buy apparel, about their purchasing capacity as well as their pre-knowledge about the quality of garments. From these issues rise the following objectives of this paper:

- define the level of consumers knowledge when they choose the clothes (knowledge about materials and their characteristics),
- determine the degree of brands relevance, fashion trends acceptance and crucial elements in garments choosing,
- purchases term (frequency of purchase of new products, monthly purchasing capacity, the impact of an individual or group on the purchase decision, method of supply) and
- post-purchase analysis (problems after purchase)

2. CONSUMERS BAHAVIOUR

Consumer behaviour refers to the mental and emotional processes during the search and purchase. It includes the study on how people buy, what they buy, when they buy and why they buy. Society is interdependent where every individual affects and has been under the influence of other [1]. Many people use contrasts and colours that express feelings according to their state of mind. Thus, the product’s properties, like design, comfort, individuality, have a decisive role on apparel’s buying behaviour, which may vary depending on a set of factors, mainly on sex [3]. The study of consumers behaviour is based on the psychological, cultural, social, physiological and anthropological aspects. The process of making a decision to garments purchase is divided into three phases: pre-purchase, purchase and post-purchase[4].

Pre-purchase stage refers on recognition of awareness needs, difference between the desired state and the real state, i.e. deficit. At this stage, beside the subjective consciousness, the influences of external

factors is possible. This means that an good designed shop, interesting fashion magazine or modern dressed male or female can affect on purchasing decision. After that decision, the consumer performs internal and external research and search for information. Consumer based on its own knowledge, but also seeks additional help from friends, relatives, he use magazine, television and the other sources. In this way, he collects alternatives and possibilities that are offered to him. This includes the selection of the desired products, location of purchase, method of payment, etc. Only when he gets answer to all the questions, he starts with purchasing. Post-purchase phase is vary important because it will affect on future garments purchases [4]. Here we measure the level of satisfaction or dissatisfaction, whether the right decision is made. Considering the consumer approach to product quality, it should be remembered that their expectations, needs and wants are changeable as well as their product quality perception [5]. Figure 1 presents a model of consumer behaviour [6].

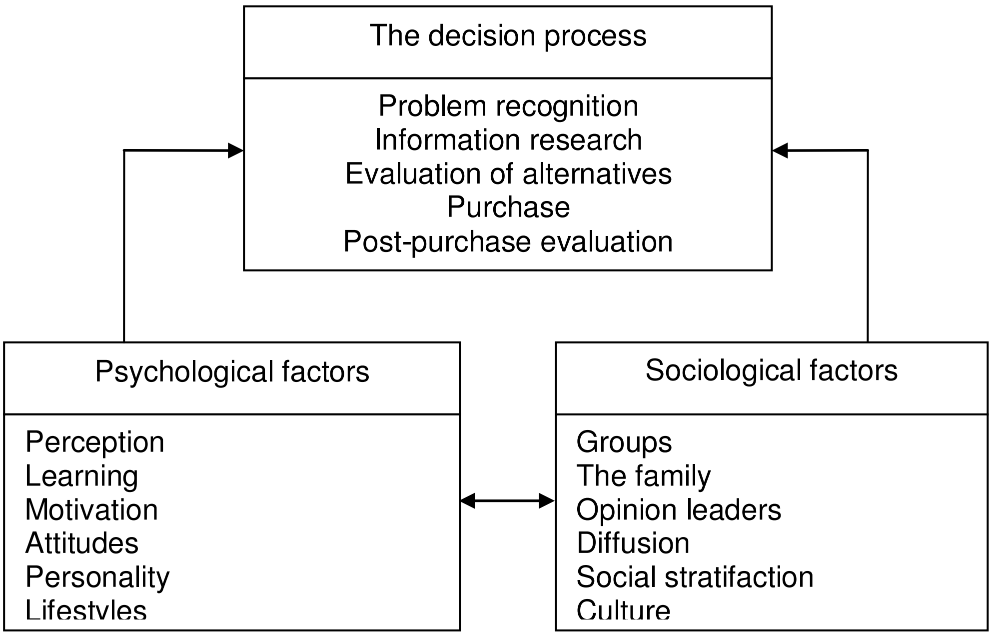

Figure 1:A model of consumer behaviour

Due to various social changes, arise a new forms of purchase. Therefore, except of domestic brand stores, which have manage to survive, today, we find more and more second-hand shops. Figure 2 shows some of the ways of selling the clothes.

a. b. c.

d. e. f.

Figure 2: Different ways of consumers supply: a,b,c – branded boutiques, d –Chinese shop, e – second- hand shop, f - mall

3. METHODOLOGY

The research cover a region of Vojvodina, where the average salary is under the 400 EUR. The study was conducted via an online questionnaire and the respondents were man and women aged 25 to 55 years. The analysis is performed on both sexes, because in terms of consumption of clothes, men behaviour is vary different from the behaviour of women. The common stereotype about men and shopping is that they go into a shop, buy what they need and leave quickly [7]. For this reason, the percentage of women than the men is 80:20, because women are bigger consumers of fashion and clothing products. Besides that, the women were willingly respond to testing while men tried to justify their lack of interest that they are not competent to give answer on these types of questions. The largest proportion of respondents (36%) represents a group of 35 to 40 years old people or those who are employed and have their permanent incomes. Those who participated in this study, were asked to respond on 18 questions relating to their method of choosing of clothes, knowledge of quality and material properties, their clothing style as well as purchasing capacity. Figure 3 presents the structure of respondents.

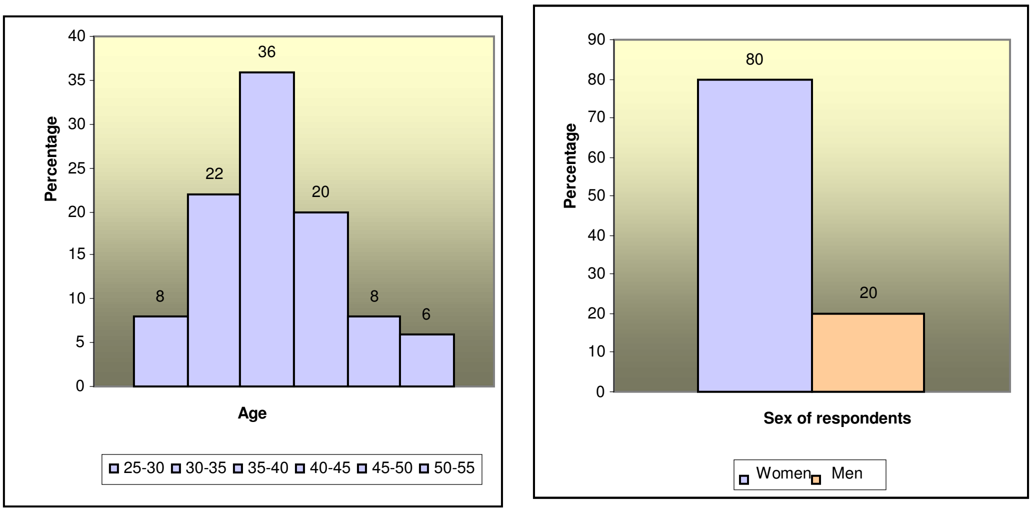

Figure 3. The structure of respondents

4. RESULTS OF RESPONDENTS ATTITUDES

When it comes to knowledge of material types and its composition, the majority of respondents would prefer to choose linen and denim (53% respondents) and elastic material (14,6%). Considering the material composition, 60% of represents have chosen cotton, 25,7% mixtures, 14,3% respondents choose wool, silk and viscose, while none of respondents did not choose polyester and polyamide. The clothes made of polyester has good stability and strength and resistance to stretching[8]. Polyester and polyamide are mostly used for blouses, dresses, trousers, jackets, rain coats, underwear, etc. which shows a lack information of respondents about these material composition.
Answers to questions about the acceptance degree of fashion trend and importance of clothing, are shown in Figures 4 and 5.

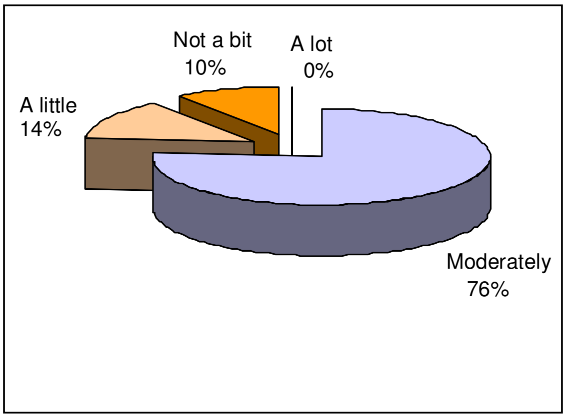

Figure 4: The acceptance degree of fashion trend

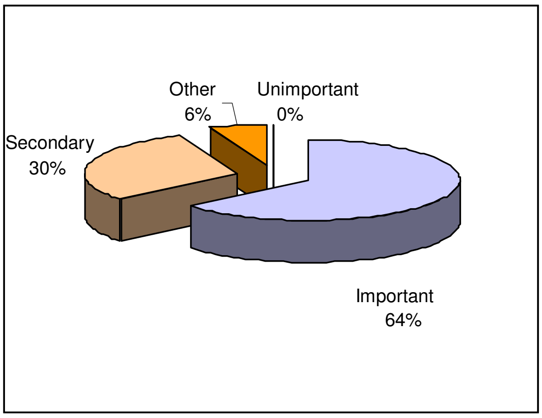

Figure 5: Clothing relevance

The results show that the most respondents accept fashion trends moderately and that clothing is important to them. For respondents, the most important elements of clothing are a cut and the details.
When they buying, they choose clothes by looks, prices and sometimes they pay attention to the composition of the material. What is not crucial for them is brand name and fashion trend. When they responded to the question about the colour that are most represented in their wardrobe, respondents gave different answers, but the choice of black and white (27%) single out the most. This proves that respondents doesn't follow fashion trends, because according to foreign web sites, for 2012 the most popular colours are orange, purple, dark blue, light blue, etc. Figure 6 shows the most preferred colour for respondents.

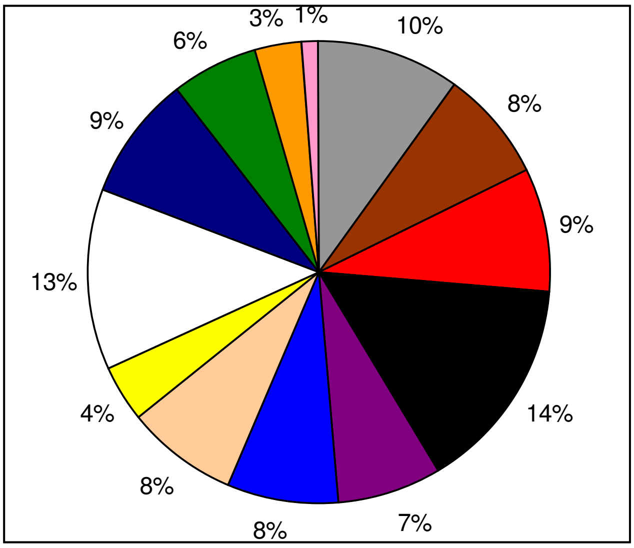

Figure 6: Colour palette represented in the wardrobe of respondents

Answers on group of questions about purchase, i.e. where they buy, their purchase capacity and external influences are presented in Figures 7 and 8.

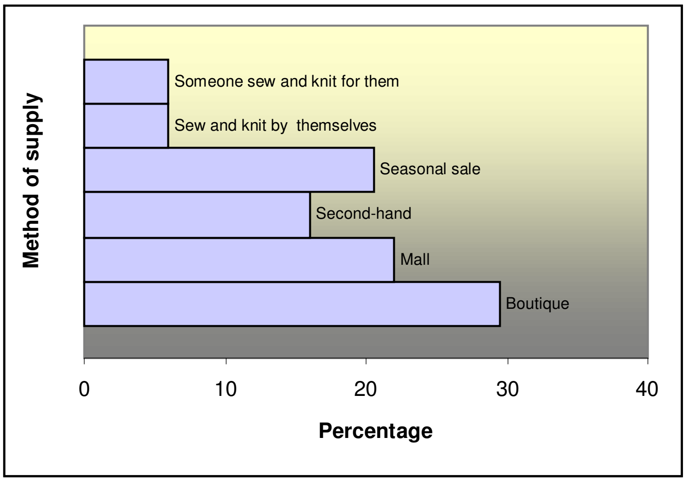

Figure 7. Methods of clothing suplly

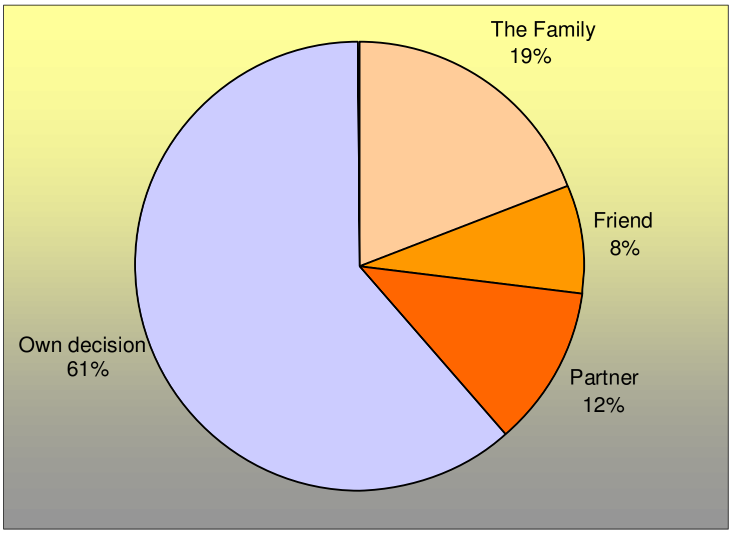

Figure 8. Influence of others on the garments choice

According to the data of Statistical Office of the Republic of Serbia, in 2011 the population in Serbia is expended 4,7% of their salary for buying clothes and shoes [9]. This get along with answers of the respondents that they wouldn't single out more than 10% for the purchase of clothes.

In the questionnaire, respondents were to indicate the problems in the purchase and after wearing selecting clothes. Answers are reflected in a poor choice of quality goods and unrealistic prices. Also, 25% of respondents said that have a problem due to lack of adequate size of garment.

In the post-purchase stage, the problems for the most of respondents are: wash out of the colours, deformation of the shapes as well as breaking the seams.

5. CONCLUSION

There is widespread opinion that the consumer attitude is important factor in fashion marketing. Consumers have different views on fashion and trends that surround them. The opinion of both sexes are investigate, but higher proportion of respondents are women because they are bigger consumer of

clothes. Summarising of all the answers given by the respondents, it can be concluded that fashion and trend are not crucial for them. They are buying products according to look and the prices.
Some of recommendations for further research are in correlation between profession and income of respondents with their method of purchase. Namely, a certain number of respondents said that buy clothes in second-hand shops while their incomes are above the average in the region. Are today's second-hand shops the best choice when it comes to quality and prices, it would be interesting to investigate.

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IMPORTANCE OF CLUSTER ASSOCIATION OF PRIVATE SECTOR AND EDUCATIONAL INSTITUTIONS ON CLUSTER EXAMPLE OF FASHION APPAREL CLUSTER SERBIA- FACTS

Sladjana Milojevic

The Fashion apparel cluster Serbia- FACTS was founded not so ago, September 2010 by the association of companies, scientific-research and educational institutions in order to improve market access and consequently increase the chances of success. The companies in the Cluster Facts are: Ivkovic, Belgrade, Tiffany Production, Cacak, Jasmil, Arilje also the founders of the Cluster, then, Luna, Pozarevac, Eminent, Subotica, Baba kids, Belgrade, PS fashion, Cacak, Passage Pancevo, , Leonardo, Ada, Sanateks, Sjenica, Garman Arilje, AMC Belgrade, Maritni vesto, Leskovac and educational institutions: Technical Faculty “Mihailo Pupin” in Zrenjanin, the Univrtsity of Novi Sad, the Faculty of Applied Arts Belgrade and the College school of Textile Design and Management, Belgrade. The purpose of the Cluster is to provide economic entities faster development and continuous cooperation with educational institutions for mutual interests. It is easier to operate in that way than it would be outside the Cluster, and together affect the strengthening of competitiveness and visibility of the textile industry. The essence of association is exchanging knowledge and experiences between the cluster members, as well as business networking, the strengthening of specialization, the development of joint projects and to increase efficiency and productivity on that basis.

In order to work and act professionally the Fashion apparel cluster Serbia- FACTS established and completed the phase of founding and organizing first: 1) the Cluster Office was established and organized, 2) established organizational and procedural policy, as well as the Cluster structure, 3) a monitoring success program was established, 4) marketing materials and tools were developed and standardized 5) the possible sources of funding were identified.

It is very important for the Cluster that besides basic funding through the cluster membership fees, identify additional sources of funding, in order to be able to implement projects that are extremely important for the Cluster’s development, as well as raising the competitiveness of cluster members and cluster members who cannot finance in full. Right now, the Cluster is in the final phase of implementing the project "Establishing an innovative virtual Facts Cluster Center ", through which member companies and educational institutions are in direct interaction and connection through the Forum. The purpose of the Forum, we built, and through which the professors of educational institutions and designers, working in the member companies have direct and constant communication and knowledge exchange. This project was realized by joint participation of the member companies of the Cluster FACTS, as well as the Ministry of Economy and Regional Development of Serbia.

The Fashion apparel cluster Serbia was founded as an association of the companies and educational and economic institutions from the fashion and clothing industry, as well as the other persons, institutions and educational organizations relevant to this area, in order to achieve the objectives in development, protection, promotion, growth, improvement and harmonization of interests , labor, and business activities of its members, and other business entities, institutions, organizations and persons connected with this area, as well as fashion and clothing industries in general.

Characteristics of the Cluster’s shared vision include:

• To become the leading source in encouraging and supporting innovations in textile companies in Serbia, through partnerships with institutions in public and private sectors;
• National (local and regional) and international presence of textile industry;
• The focal point for increasing competitiveness through increasing awareness of the performance standards, certification (quality) and success, and in return increased the economic (and other) success of the members;

• To serve as a "common voice" of the members to the third persons, both political and economic;
• Constantly generating new marketing opportunities, which would be converted into sales promotion and the potential profitability of the member companies;
• Raising the image of Serbian textile industry as a whole;

The conclusion of the latter is that the vision of the Fashion apparel cluster Serbia is to be the leading organization in supporting and strengthening the overall economic competitiveness of companies in the fashion and clothing industry and textile industry in Serbia.

The mission and role of the Cluster FACTS that contribute to the shared vision achievement include: providing with organizational, logistical, expert, infrastructural, institutional, technical, software and other assistance and support to the continual development and improvement of products' quality and services, innovation and competitiveness of the cluster members, as well as fashion and clothing industry in general.

So far the Cluster FACTS, with the help of GTZ, the German government and the EU SECEP project, has managed to lay the foundations of strategic planning that helped the Cluster to identify strategic objectives and basic principles of the action plan. The identified targets are to be used to measure the success of the organization's activities through its development.

So far, through the planning process the following issues on which we have to work in four key areas have been identified:
- Administrative and Organizational Development
- Marketing and Promotion
- Human Resources
- Joint projects and financial strategy of the Cluster development is focused on:

- Increasing visibility and strengthening of the organization and the entire industry in public and private sectors,
- Human resources
- Commercial development of networking and shared services
- Reaching medium and long term financial sustainability of the Cluster FACTS.

For the Cluster members, the most important activity that contributes to the development of business cooperation and shared services is applying equally to human resources development and encouraging exports.

It is not just the development of the human resources, but professional development is also of great importance for the Cluster members, as well as the education of potential employees, which includes the foundation of active and continuous cooperation with educational institutions and contributing the creation of new or modified vocational education programs. In order to solve the increasing shortage of skilled workers in the companies of its members, and to provide opportunity for students who want to build a career in the clothing industry, the Fakts cluster's members presented a program of practical training for students at VTSS DTM in Belgrade. Four firms, the Cluster members, participate in this program, in which students are to be joint with leading clothing companies based on technical needs of the companies and human resource needs, taking into account the student's commitment and geographical living location in relation to the factory. The benefits of this project for all our cluster members, both schools and firms in the cluster, are obvious. The students have developed and learned new skills during professional practice, while the other companies have developed a new potential workforce that is to be used as competitive advantage in the future. This is a great advantage for the students to have closer practical insight in garment industry and its companies through the cluster's associations. At the same time, the private sector firms of our cluster have a tremendous advantage due to the gain of invaluable insight into the future workers in each of these companies.

In order that cluster properly develops and strengthens its social role as a non-profit organization, designing and creating the organizational structure of the cluster was needed, which aimed to offer a balance of ability to adapt to changing market conditions (both structural and undertaken activities), stability and persistence in meeting goals.
The cluster has the status of legal entity. The bodies of the cluster are:

1) Assembly;
2) The Steering Committee and
3) A Representative (A Cluster Manager).

The Assembly is the supreme organ of the cluster, which make all the most important acts of the cluster (such as the Statute and other regulations), determines attitudes and gives guidelines for the cluster, appoint and dismiss the Steering Committee and a representative (a cluster manager), consider and approve a financial plan and annual financial report, as well as other activities determined by the Statue and the Law.

The Steering Committee is managerial and an executive authority, which manages the cluster and ensure the implementation of its objectives. The Steering Committee implements operational activities and realize planned, implemented, business, professional, technical, and current tasks of the cluster, including all issues related to the conduct of affairs, current affairs and activities of the cluster, except the matters within the competence of the Assembly.

The Steering Committee is consisted of five members, appointed or dismissed by the Assembly and chosen among the members of the Cluster Association.

The Cluster manager or director is also a legal representative of the cluster. He has full executive powers in the legality of the cluster. The cluster manager is responsible for cooperation with the public institutions, associations, business companies, educational, vocational and other subjects. The Cluster Manager's responsibility is connected to the fulfillment of the objectives and management of the cluster work and activities.

The Cluster has an advisory body - the Council, which gives the opinions of major issues related to fashion and clothing industry, as well as the work of the Association. The Council members are not the members of the cluster.

The Cluster may form the professional services, working groups, committees and the other bodies to carry out administrative, technical, professional and other tasks for the cluster.
Depending on a need, the Cluster may form the appropriate working groups (for example a membership Working Group / expansion of the network, a Working Group on Financial and Administrative Affairs, a Working Group for marketing and promotion, a Working Group for project activities. These working groups undertake the activities within its competence conduct appropriate analysis and submit the relevant initiatives and proposals to The Steering Committee. The Working groups have narrow responsibilities focused on the objectives fulfillment, which is the purpose of establishing. Actually, their founding and closing after the achievement of goals gives the cluster dynamism.

In order to strengthen the current position in the domestic market of fashion and clothing industry, it is necessary to improve cooperation with scientific and educational institutions in order to profile workforce efficiently, which would be compensation for the current lack of narrowly-skilled staff. The Cluster members are also planning further development and strengthening the exchange of expertise and know-how, strengthening innovations, improving the quality and productivity. They are interested in interconnections in the field of purchasing raw materials, providing specialized services, and other form of joint appearances, that would give them above-average competitiveness compared to the other companies in this sector.

The Cluster members are interested in entering and business expanding on the Russian market, as well as the markets of neighboring countries, such as Macedonia, Croatia, Slovenia, and markets of the other European countries (the Czech Republic, the Netherlands, Sweden, Denmark, Slovakia and others).The Entry into the international market or business expand abroad is planned through the joint provision of information on market trends, technology trends, business networking, joint participation in international exhibitions, joint exhibition openings and sales rooms, distribution centers and joint marketing promotion through which would be achieved significant cost savings, as well as an offer enrichment with regard to update the production program and the possibility of specialization. The Cluster members are interested in education and training, as well as in the joint research and development, because these are the basic prerequisites for raising their competitiveness especially in the international market. In this regard, by establishing an innovative project Center, the Cluster had a joint activity of 10 member companies and three educational institutions, important for a common approach to an innovative on-line service. This activity amounted to over 10 million dinars. This service is of a great importance for the research, development and exchange of mutual knowledge of the cluster members.

The cluster FACTS participates in the project of the German government ORF through which accomplishes the goal of establishing contacts and cooperation of the Fashion apparel cluster Serbia with the other similar organizations in the region and exchanging and transferring knowledge between producers, as well as scientific and educational institutions from the participating countries in the project (Bulgaria, Macedonia, Bosnia and Herzegovina, Albania and Serbia). It is the project of the German government GIZ / ORF cluster fashion clothing industry that enables international cooperation in researching, developing and exchanging of knowledge. ORF project started in July 2011 and is planned to last up to February 2013.

The Cluster FACTS has also received an invitation to join the SEE EU IPA with a consultancy firm in Germany and Austria as well as holders of the EU project SEE, with the participation of Italy, Greece, Bulgaria, Romania, Albania and Serbia - and our Cluster. A project has been launched with the aim to strengthen the competitiveness of the textile industry in the region and ensure the accurate database of textile manufacturers in the region to facilitate communication and obtain new business and expand cooperation. The project is to include the faculties of Bologna and the other academic institutions in the region, members of the cluster, in order to start the exchange of technological knowledge and expertise of education in the textile sector of teachers and students. Within the project it is also planned to share our experiences and knowledge of the participating countries. The project is to be submitted at the 4th Call in December 2011.

Probably, one of the biggest drivers for associating the textile companies into the cluster is the apparent lack of professional staff which causes the constant struggle of the cluster members in their efforts to maintain and increase productivity. There is a gap between the vocational education programs and staff capacity of graduates from the local universities and vocational schools.

In this sense there are several critical areas identified: designers, modelers, managers, manufacturing / textile engineers, seamstresses and sales managers.

In cooperation with THE **COLLEGE OF TEXTILE – DESIGN, TECHNOLOGY AND MANAGEMENT - DTM** and DTM German Organization for Technical Cooperation in June 2010 so-called "Summer Camp" was organized, during which the courses of standardization, design, management and the like were held. On this occasion the local experts were trained, who later in September 2010, independently and in cooperation with the cluster members, organized a similar course for the standardization in Arilje. The course has proved to be very effective and necessary for the efficient management of local companies. The previously mentioned joint project has confirmed that there have to be activities that would focus on overcoming the lack of skilled workers in the labor market.

In this sense, the cluster is to focus its activities on identifying opportunities for cooperation and taking the initiative to introduce the projects and activities, which would have as a result overcoming the shortage of profiled labor force.

This program is certainly planned as a long-term initiative, in which the cluster would:

• Examine the member companies of the constraints and needs in the field of the expertise and labor force development;

• Examine and engage in dialogue with the academic institutions and vocational schools of the cluster on their willingness and opportunities for the labor force development;
• Identify funders and technical support that will be obliged to bind the partnership between the public and private sectors in the textile industry;

Currently, several companies have the program which should assist in learning and acquiring trade practices in the production of textiles in Serbia. Such practices should be promoted and also identify problems related to such programs. Also, it is necessary to connect the cluster members, and the National Employment Service, universities and schools in activities relating these issues. Further, the best practices should also be pointed out and shared to maximize the profits of these trainings.

The current project of our cluster "Establishing a virtual design innovative Center of the Cluster FACTS" has a great impact on the labor force development. Through the trainings and consultations, the level of knowledge and competence of professionals, employed in the textile companies in the fields of Visual Merchandising and Product Management, is increased. In these programs, students from modern clothing and textile design, textile and clothing design, clothing technology and management departments will be involved, in order to acquire new knowledge in these areas. Also, the project will conduct seminars for teachers in order to meet the needs of business entities that are not satisfied by existing vocational education and training programs. This project should motivate teachers at faculties to improve the existing vocational education and training programs and adjust to the real needs of companies in the textile industry as much as possible.

The Cluster FACTS is planning to take part in the cross-border cooperation project with the possibility of the equipment procurement, primarily to serve laboratories for testing the quality of fabric development and innovation development in educational institutions. Since the cluster has not officially approved this project yet, I am cannot speak about the details but it is evident that there are plans related to the additional benefit of the member companies and educational institutions, and there are strategies for the cluster development plans based on mutual benefits of the private sector and educational institutions.

MEMBER COMPANIES

- Provide necessary opportunities for student internships.
- Financially support activities central to educational system and aid development of innovative educational programs.
- Exchange among selves information relevant to: supplies, sales, marketing, training, production, expert personnel etc..

EDUCATIONAL INSTITUTIONS

- Provide knowledge from textile field.
- Perform advisory and work tasks within cluster.
- Participate in project development and implementation, propose and present projects to cluster.
- Propose, encourage and develop new educational programs in keeping with industry needs.

SKILLS SHORTAGES / GENDER ISSUES ANALYSIS

1) **There are problems of skills shortages of the staff in the clothing/ textile industry** which managers and owners consider as very important. Representatives of educational institutions are aware of these problems, as well. Both are willing to solve this issue.
2) **Enterprises are lacking the most following operational skills**: pattern making, sewing and machinery maintenance. Regarding management and administration sector, companies need experts mostly in: sales&marketing and production management.
3) **Companies have put a lot of efforts in the present work due to lack of professional human resources**. For many employees (production, sales) trainings have been organised in the enterprise. Employees from finance and administration departments regularly attend seminars organised by

different organisation and institutions. Various trainings have been organised for employees in management and administration departments through donor funded projects, like: general management, financial management, marketing and sales, production management etc.

4) **Enterprises and educational institutions share positive experience concerning participation in donor funded projects and programmes**. In particular they find as very useful projects which were working with more target groups at one place, like: employees in enterprises as well in faculties, students, representatives of public sector. Both are interested in a future participation in programmes and participation in case they recognise and treat appropriately real problems and needs of the industry.

5) **None of surveyed enterprises can be considered as the example of good practice in regard to issue of support for women at workplaces**. Most of enterprises find they have suitable business environment and their working time can be adjusted to needs of employed women.

Recommendations for further work with the industry and educational institutions are as follows:

1) **Assist companies to identify needs for professional improvement of employees in mid-term period**. It is quite possible that enterprises apart of problem of skills shortages have problem in management and organisation as well. Therefore it would be useful to carry out diagnosis of the enterprise current state and based on results that enterprise with assistance prepare plan for HR development harmonised with enterprise goals for mid-term periods.

2) Problems with professional competencies of staff could result of inadequate selection and recruitment of employees. **Enterprises could be assisted in development of better selection and recruitment of candidates system as well as system of introduction of newly employed into a job**.

3) **Services of professional improvement for employees offered at the market could be more available** (provided subvention, organisation of training for more trainings …)

4) One of the main causes of the skills shortages is an incoherence of educational system with industry needs. In the high and secondary educational system there are educational profiles which respond to the industry needs, but not with sufficient and appropriate knowledge and skills which are useful for employment. In order to improve this segment it is necessary **to strengthen cooperation between educational institutions and economy as well as assist them that through joint work improve existing curriculum** (for example: to introduce that practical lessons lasts longer than two weeks etc.)

5) In line with industry needs **faculties should work on introduction of new teaching programmes,** as: ***Skills Shortages /Gender Issues Analysis***

visual merchandising, product management etc. Also, VET schools should be encouraged for an introduction of new educational profiles which will meet industry requirements. It is necessary **to assist faculties to get "open" towards economy and support them in many segments of business especially concerning issues of research and development**.

We come to the conclusion that the certain program initiatives undertaken by the cluster association, not only leads to synergistic effects of educational institutions and the private sector, but also directs the Cluster towards meeting important strategic goal which is the human resources development in the textile industry in Serbia, with an ultimate goal of the education system becoming compliant with the real textile industry needs.

ONE OF THE STRATEGIC OBJECTIVES OF THE CLUSTER FACTS IS: Human Resources Development	SUCCESS INDICATOR: The education system in conformity with the needs of industry, a system of permanent education personnel in the medium term

A good Cluster example of clothing fashion industry is the cluster that works properly and has a constant cooperation with industry and educational institutions and in which all partners and participants are equal.

Prepared by: Sladjana Milojevic, the Director of the FASHION APPAREL CLUSTER SERBIA.

SECTION OF STUDENTS PAPERS

TIME OPTIMIZATION OF MAN'S JACKET FINISHING PROCESS

I. Skoko, V. Petrovic, M. Stankovic, Ž. Branović

Abstract: *The characteristics of today's clothing industry is the increased use of machines that leads to reduced processing time. This paper considers the important topics for the technological process of man's jacket finishing in order to get a better view into the activities and the ways in which this process is carried out. Emphasis is placed on the final ironing of jacket thus the used devices in this phase of garment production were analysed. In order to gain insight into the time required for ironing process, the measuring of time for all parts of jacket is carried out as well as comparison of time which was obtained using the presses for each part separately and use of device that performs ironing of several parts at the same time. During the analysing, the recording method was used. The obtained results show that with use of combined presses the time for ironing reduces for 35,32% and with using of form finisher for 48,94%. This also means reducing the number of machine and device in the finishing section so instead of 7 machines, all operation of jacket's pressing can be done on 4 devices.*

Keywords: *finishing of clothes, pressing machine, man's jacket, form finisher*

1. INTRODUCTION

Development of the industrial production of clothing is associates with machines and devices which are used for the clothing production. In today's sections, mechanical work is represented, which of course leads to increased productivity and reduced of processing time. Modern machines and device, as well as application of automation accelerates garment manufacture and enables its production for a much shorter period of time for all three phases (cutting, sewing and finishing). Nowadays, the time is strategical weapon, the equivalent of money, productivity, quality and innovations and therefore, the companies need to shorten the time of product arrival on the market, reduce production cycle while maintaining the high quality and reduce the cost of investment [1]. Interactions between the worker and machine is a relevant factor for the study and analysis of time. With proper definition of required time of same technological operations, we get the elements relevant to the determination of worker's standards, the planning of production capacities, developing a plan of the technological process, the determination of worker's stress degree, the determination of correct work methods and calculation of prices and costs in garment production [2].

Finishing consists of certain operations that is need to be performed in order to improve the organisation and streamlining operations. This is the last stage in garment production where it gets its final appearance, shape and quality. The activities that are carried out in finishing stage, must be performed on high-quality equipment in order to achieve the high quality finish appearance. Depending upon the type of garment, finishing process consists of several technological operations. One of these activities is final ironing. Its tasks are levelling the surface of garment, stabilisation, better aesthetic appearance and functionality. Such improved appearance, makes clothing much attractive to a potential buyer [3].

2. APPLICTION OF MACHINES AND DEVICES FOR FINISHING PROCESS OF MAN'S JACKET

When we talk about the type of garment, men's jacket is in the group of men's top clothing. Also, speaking of groups, jacket falls in the group of clothes that need to ironing completely, i.e. each part separately. Final ironing of man's clothes, and therefore the jacket, performed on presses and special devices. Given that the garments are differ in shape as well as composition, there are various types of presses and devices. For each technological operation of ironing, appropriate device with appropriate shape of bucks are used [2]. Press consists of two bucks between which is placed garment and using a pressure, steam and temperature, the final shape of garment is formed. For final ironing of man's jacket the following presses are in use:

- front finish pressing machine,
- back finish pressing machine,
- collar finish pressing machine,
- shoulder finish pressing machine,
- lapel finish pressing machine,
- sleeves finish pressing machine,
- armhole finish pressing machine.

Ironing of front and back parts can be done on several ways. Depending on what kind of press is used, and which technical characteristics the press has, the daily capacity of pressing parts can be different. For finishing of these parts of jacket, the press with a mounted plate that has a single frame, or double frame can be used. Beside of that, front and back sides of the jacket can be final pressed on circular presses with 120° or 180°. There is, also, the vertically arranged buck shapes for these parts of man's jacket (Figures 2 and 3).

When it comes to ironing of shoulders, it is also possible to use a different types of presses. Thus we have: pressing of left and right shoulder at the same time, i.e. 2 head bucks and 2 lower bucks (Figure 5), pressing of each shoulder separately and using of presses for left shoulder and left sleeve and right shoulder with right sleeve. As we have a presses for shoulders and front and buck parts, there are also the presses for other parts of man's jacket (Figures 4, 6, 7 and 8). Beside of that, it is possible to do pressing of several parts at the same time, for example, lapels and collar or shoulders, armhole and sleeves.

3. METHODOLOGY

For the determination of optimal method in ironing process, the classic model of man's jacket was chosen (Figure 1).

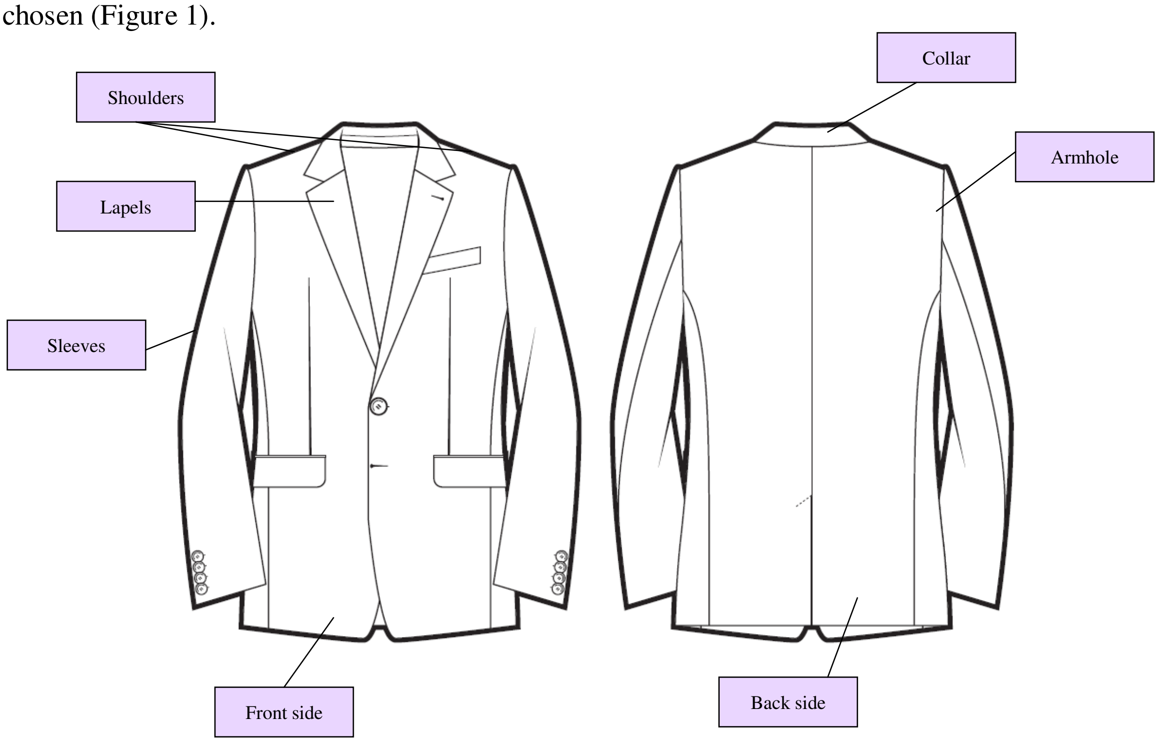

Figure 1: Model of man's jacket

During of determination of the production time, the method of recording was used. It that occasion, three measurement was carried out for each operation of pressing work. The technological time, i.e. the time of machine work and worker's time as well as auxiliary time (setting, moving and remove of working subject, turn on and turn off the machine using the button, as well as removal and disposal of working subject [4]. The measuring of time was carried out on pressing machine of German company Veit and Italian Macpi that are shown on Figure 2-8 [5,6].

Measuring the time required for ironing of front parts of the jacket was done on device with vertically arranged buck shapes. This machine has the separately bucks for left and right side where one worker performs the pressing for both parts alternately.

Figure 2: Front finish pressing machine

The time measuring of ironing of back side was performed on the device where one worker manages with two vertical established bucks at the same time. In this way, the required time for back finishing process is reduced.

Figure 3:Back finish pressing machine

The time measurement of collar pressing was carried out on German pressing machine where obtained average time for three measure is 30 second.

Figure 4: Collar finish pressing machine

At time measuring of shoulders pressing, the machine that presses both shoulders at the same time is selected. In this way, the obtained time of ironing is 20 seconds which is considerably less than pressing of each shoulder separately.

Figure 5:Shoulder finish pressing machine

The measuring of time for ironing of labels was done on the machine with a special formed lower bucks where the average time of pressing is 30 seconds. The ironing is performed simultaneously for both lapels.

Figure 6: Lapel finish pressing machine

The time measuring required for pressing the sleeves was done on machine with bucks on which the sleeves are put so the ironing performed for both sleeve at the same time.

Figure 7: Sleeve finish pressing machine

The necessary time for pressing the armhole was measured on machine with one lower buck where the worker alternately set left and right sleeves.

Figure 8: Armhole finish pressing machine

In order to determine the optimal time of men's jacket ironing, the measuring of time on machine which pressing collar and lapels at the same time (Figure 9) and measuring the time on machine that simultaneous presses the shoulders, sleeves and armhole were carried out (Figure 10).

Figure 9: Collar and lapels pressing machine

Figure 10: Shoulder, sleeves and armhole pressing device

Besides of these devices that have pressing bucks, for ironing of man's jacket the blowing dummy are very useful. The working principle of these devices consists of putting the jacket on a special shaped doll and leaking the strong current of water vapour under the pressure and after that, the current of compressed air. In this way, under the action of heat, moisture and internal pressure, all wrinkles and roughness on the jacket become smooth. Than the permanent form finishing in the shape of doll is performed [7]. These devices are very easy and practical to use because they occupy less space in the finishing sector. Figure 12 presents the work principle of this device.

Figure 11: Form finisher for man’s jacket

Figure 12: The work principle of form finisher device

Figure 12 shows that the time of ironing of man’s jacket using the doll is 120 seconds.

4. RESULTS AND DISCUSSION

Tables 1 and 2 present the obtained time of ironing when using all presses and when are used presses for several operations simultaneously.

Table 1: Measured time of man's jacket ironing with using of presses for each part separetely

Product name: **MAN'S JACKET**			Sector: Finishing	
No.	Operation name	Designatio n	Time (sec)	Note
1	Front pressing		35	
2	Back pressing		17	
3	Collar pressing		30	
4	Shoulder pressing		20	
5	Lapel pressing		30	
6	Sleeves pressing		33	
7	Armhole pressing		70	
TOTAL TIME OF PRESSING			**235 sec / 60 = 3,55 min**	

Table 2: Measured time of man's jacket ironing with using of combined presses

Product name: **MAN'S JACKET**			Sector: Finishing	
No.	Operation name	Designatio n	Time (sec)	Note
1	Front pressing		35	
2	Back pressing		17	
3	Collar and lapel pressing		40	
4	Shoulders, sleeves and armhole		60	
TOTAL TIME OF PRESSING			**152 sec / 60 = 2,53 min**	

Histograms of measured time of ironing with using of different methods and devices are shown in Figure 13.

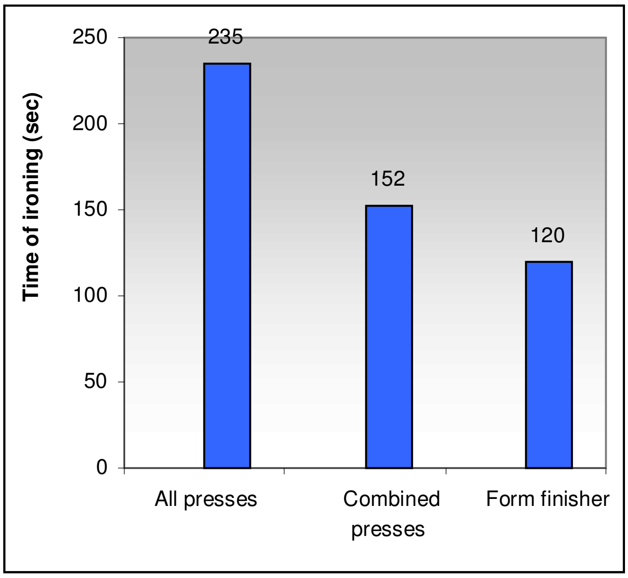

Figure 13: Graph review of time differences with using of different device and methods

Comparing the time of pressing from Tables 1 and 2 and from Histogram 13, it can be concluded:

- Using the presses that will press each part of the jacket separately, requires the maximum time, total 235 seconds.
- Using machine that press several parts at the same time, such as shoulders, sleeves and armhole, lapels and collars, the process time is 152 seconds.
- The whole principle of man's jacket pressing using form finisher is 2 minutes or 120 seconds.
- Using the combined presses as a replace for individual presses, the process time is reduce for 35,32%, while using the form finisher device the time is reduce for 48,94%.
- In the first case, 7 devices is used, in the second, 4 devices and in the third case, only one.

5. CONCLUSION

Garment gets its final and permanent appearance in the finishing stage of production. At this stage, the remove of all possible side effects created in the previous phases is performed. Garments thus reaches its full aesthetic appearance and quality. Nowadays, in the finishing sectors, the devices that performed several operation at the same time are used. Because of that, the time of pressing is considerably shortened, which of course leads to increased capacity, today very important in the production process. Therefore, the aim of this paper was to make an analysis of time that spend using the different devices and methods in the finishing process of man's jacket. The conclusion is that the time of ironing considerably drops when using devices with the working ability of several parts at the same time.

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SHADE NETS FOR PLANT DEVELOPMENT PROVIDING PROTECTION AGAINST SOLAR RADIATION

A. Zdravkovic, Dušan Trajkovic, Vasilije Petrovic, Marija Stankovic, Dragana Goševski

***Apstract**: The aim of this paper is to present the possibilities of changing the natural vegetation of plants by using shade nets in order to improve the quality of plant and crop yield. Nets with different optical properties are in use: green, red, blue, grey, black and aluminet. Furthermore, this paper also deals with the importance of the density of shade nets and their design that are adapted to the photosynthetic active radiation (PAR) [1]. Beside this, we can assume the role of photo-selective nets and their effect on fruit quality; namely, the grey nets tend to produce higher rates of photosynthesis but less leaf variegation [2], in contrast to the blue nets while aluminets reflect and transmit diffused light. Energy nets are energy-saving either in terms of heating or cooling costs and they are placed outside or inside the greenhouse or as a separate and the only net.*

***Key words**: shade nets, energy nets, technical textile, agro-textile*

1. INTRODUCTION

Nowadays, with all modern achievements, the development and progress is also evident in the field of textile industry, especially when it comes to the progress of technical textile. The technical textile is mostly produced for non-esthetic purposes and its function plays the main role. It is a fast-developing sector and as such can interact with other industries. Some of them are: electro, agriculture, mining, water industry, chemical sectors, sports, defense department, car industry and etc. The technical textile, used in agriculture is called agro-textile. In the era of modern agriculture including mass production, the adequate progress will not be possible without agro-textile. When climate conditions are not convenient for the plant growth people try to change those conditions with the new environment appropriate for the vegetation. The most common technique for this purpose is the construction of greenhouses or tunnels covered with plastic or some other material. In this way we can change the environment, this helping plants grow more efficiently. As a result, the new environment not only does it have appropriate soil, better supplies of water, but also favorable climate conditions. It is important to emphasize that the temperature, light, air humidity and gas concentration are in this way controllable. Today, there are many different kinds and structures of materials that can be used for covering these objects, but only those that prevent the contact between the material (plastic, screens etc) and plants are convenient although they are the most expensive ones as well [4].

2. DEVELOPMENT AND USE

Shade nets are used to protect both fields and greenhouses from excessive solar irradiation in order to enhance healthy and fast growing of plants as well as good crops. These protective nets are made with holes and they are primarily used for controlling the transmission of sunlight with their shading effect. They can reduce the damages on plants and crops caused by excessive heat and high temperatures [4]. There are a series of shade nets that have been developed so far. These products enable free air circulation inside the net this preventing the creation of the excessive heat beneath the surface of the structure.

The shade ratio is variable and depends on the knitting density of the shade material. Areas of different climates and crops also require different shade nets [4]. One of the benefits of shade nets is that they cannot be easily damaged for they are easy to construct and maintain.

3. SHADE NETS IN AGRO-TEXTILE

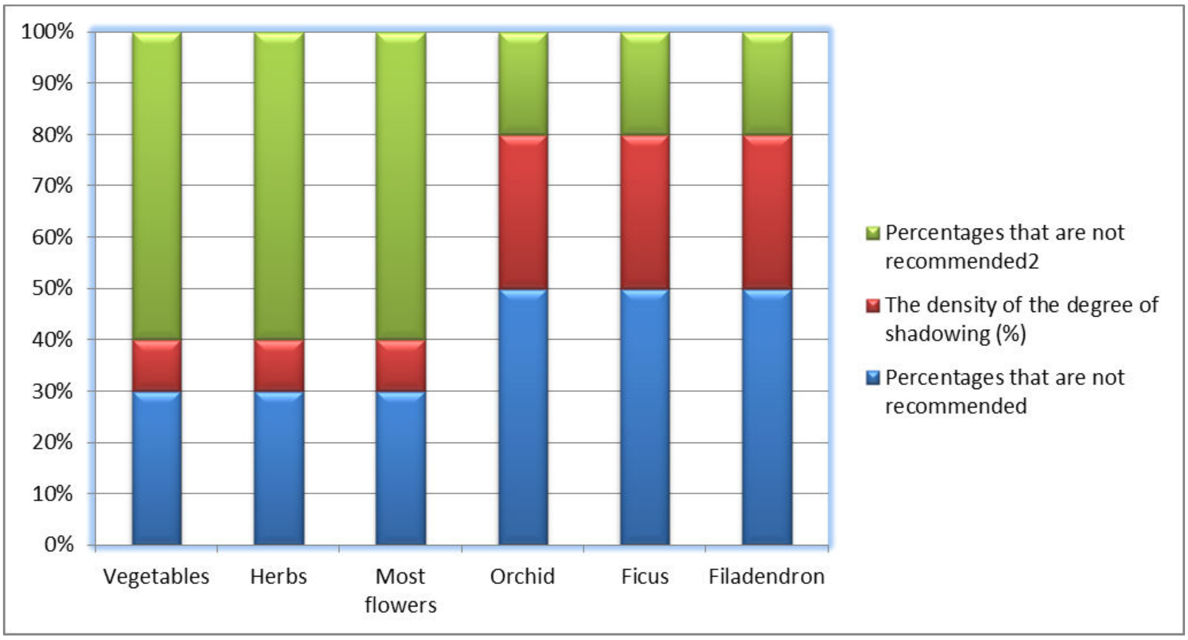
When it comes to modern greenhouses, shade nets are placed like curtains and during its installation they can be moved horizontally depending on how much light penetration is desirable into the canopies. Taking into account that their production includes knitting and weaving, there are numerous techniques of making them. The nets can be of various densities in order to improve the vegetative growth of plants and decorative greens [4]. These nets are made of polyethylene of great density and polypropylene. There are different ways of knitting that depend on the desirable density.

3.1. Colours and the shading rate of protective nets

A series of coloured shade nets have been developed each one specifically modified by the shading rate we need. They can be made as one-colored nets or they can be combined during weaving or knitting thus creating certain nuances of colours. There are: black, white, dark green, green and white, blue and white etc. The commonly used shade net is black because it provides the highest shading and cooling rates.

There are green shade nets that are used for reducing solar radiation and they look like sacks or bags for vegetables. In this way, the intensity of solar light is reduced for 30-60%, again depending on the knitting density of the net.

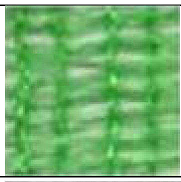
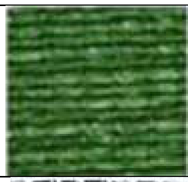
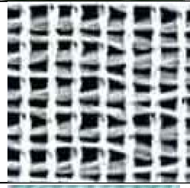
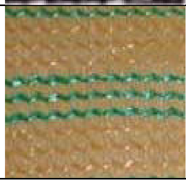
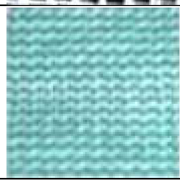
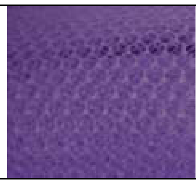
The shading effect can be also made by painting the walls of greenhouses with lime or with special easily erasable colours. Every year the nets and colours are removed and placed when necessary in the periods of high temperatures. This means that this solution is not long-lasting. The shading rate made by these nets is variable, going from 25-90%. In the figure 1. There are examples of different plants and the net densities recommendable for them. The net density percentage that is used is presented in red.



Fiureg.1. Examples of using different rates of net density with certain plants [4]

There are standard colours of shade nets and thy all depend on the place of using. In the table 1, there are different colours and their use.

Table 1, Different colours and their use [3], [4] and [5]

Use	***Colours***
For nursery gardens and decorative greens	 
For greenhouses (some plants need white nets that absorb UV radiation and reflect sunlight)	 
For decorating sport fields, swimming pools, balconies etc.	  

3.2. Coloured photo- selective shade netting

Photo selective shade netting is a new and emerging approach in protected cultivation. The photo selective net products are based on the introduction of various chromatic additives (color additives) during manufacturing, light dispersive and reflective elements into the netting materials. They are designed to selectively screen various spectral components of solar radiation thus protecting plants from direct sunlight. The spectral manipulation is aimed to gain desired physiological responses as well as the light quality necessary for the vegetative growth of plants [4].

Photo selective nets have positive ecological and economical effects on the production, this especially relates to multicoloured nets. The use of this kind of nets does not imply chemical pesticides and significantly reduce plant cutting [4]. The spectral manipulation is a way of controlling several things [4]:

1. The vegetative growth and plant height
2. Branching and dwarfing
3. The timing and quality of flowering
4. Crop growth and colouring
5. The sugar and acid content of fruit
6. Decreases plant dirtiness
7. Reduces watering costs

The coloring effect on plant growth and the absorption rate along with the transmission and reflection of sunlight can be seen in the following table 2.

Table 2, the changing of sunlight quality by using coloured nets [4]

Net colour	***effect***	***Apsorb radiation***	***Transmit radiation***	***Reflect radiation***
Blue	Enhances dwarfing	UV, yellow,red IC	Blue and green	++
red	Stimulates the vegetation growth	UV, blue and green	red-IC	++
yellow	Stimulates the vegetation growth	UV and blue	Green- IC	++
white	Used in greenhouses and increases diffused light	UV	-	+++
Blsck (gray)	Enhances branching, yielding bushy plants with small leaves	The highest rate of light	-	0

Plants growing under the **green** and **red** nets are significantly larger than those under the **grey** and **black** nets. The grey net affects not only the size of the leaves, but also their variegation. The **blue** net induces the most significant variegation (Figure 2).

The chlorophyll content of the green parts of the leaves does not vary significantly under the different nets. Leaf photosynthesis rates do not show significant differences.

The **grey** net leaves give higher apparent rates in some of the measurements, while those measured under the **blue** net are consistently lower than all other nets. The photosynthesis rates, which are measured in micromole uptake per unit time per unit leaf area, might partly depend on the level of leaf variegation, as more variegation means less green area. Thus, the grey net causes less variegation and higher photosynthesis rates, while more variegation and lower rates occur under the blue [1].

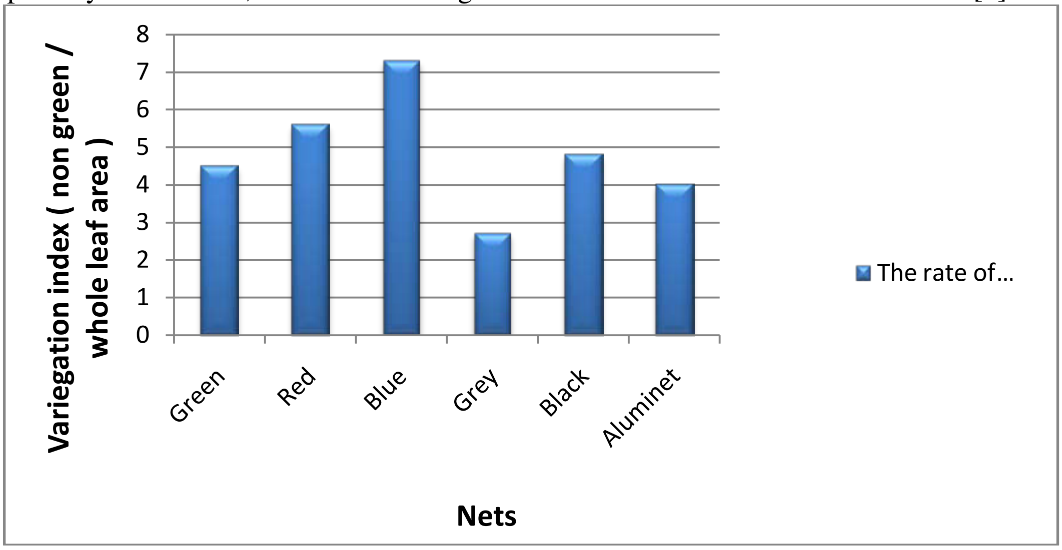


Figure.2. The effect of coloured nets on plant variegation. The index of variegation is based on the ratio of non-green leaf area and the whole leaf area, for all leaves from ten branches. Vertical lines represent standard errors from the means of each branch (n=10)[1]

Plants can sense the quantity and direction of light and use it as a signal to optimize their growth and development in a given environment. In addition to its role in photosynthesis, light is involved in the natural regulation of how and where the photosynthetic products are used within the developing plant, and in photomorphogenetic, photoperiodic and phototropic responses. Light-dependent development of plants is complex, involving the combined action of several photoreceptor systems. These include: the phytochromes, which are responsible for the detection of far-red (FR) and red (R) light, but also sense blue and UV light: the blue-UV-A light-absorbing cyrptochromes. The intensity and spectral properties of sunlight vary during the day, season and year. Additional properties of natural sunlight, namely direct versus scattered, diffused, or reflected light, are also not constant, and depend on cloud formation, dust, air pollution, etc [1].

These factors will determine light penetration into dense canopies, and thus contribute to the overall response of the plant to light. Shade nets may differ in their efficiency in transmitting diffused or scattered light, and also in their ability to scatter the direct light passing through them, according to their physical properties. The complexity and variability of natural irradiation, on the one hand, and the multiple-response reaction of the plant, on the other hand, make it hard to predict how a given manipulation of natural light will affect particular vegetative responses. In the **black** net, only the light going through the holes of the net is transmitted, since the black plastic threads are essentially opaque. In the **aluminet**, part of the light is reflected and scattered [1]. However, in the coloured nets, which are knitted more densely to achieve the same shading effect, a major fraction of the sunlight actually passes through the plastic threads and selectively filtered. Therefore, while the ratio of UV-A/PAR in

the light transmitted by the neutral nets did not differ from that in the natural irradiation, the **red**, **green** and **blue** nets all transmitted light of a significantly lower UV-A/PAR ratio (figure 3).
On the other hand, the R/FR ratios of the light transmitted through both the **blue** and **neutral** nets were the same as the natural light, that of the Red was slightly lower, while that of the Green net was significantly lower than that of the natural irradiation (Figure 3). Light scattering is an important factor determining how much of the light essentially penetrates into the inner canopy [1].

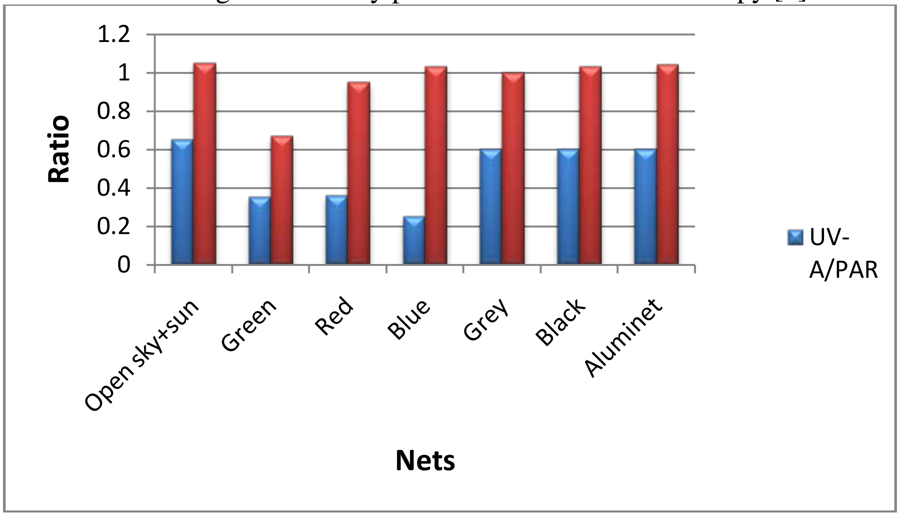


Figure.3, UV-A/PAR and R/FR ratios of the coloured shade nets [1]

An example of coloured photo selective net can be seen in the next figure 4:

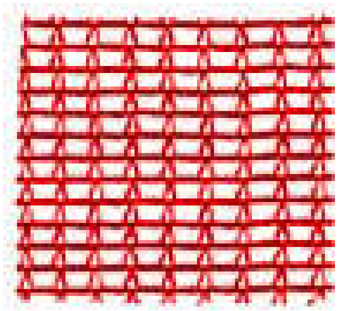


Figure.4, Coloured photo-selective net [4]

3.3. *Energy nets*

The term ‘energy’ comes from its energy-saving role during plant growing, either in terms of heating or cooling costs. Beside their shading effect, these nets provide term isolation both in summer and winter [4].

Energy nets are polyethylene ‘silver’ nets covered with aluminum. They represent a modern tool in agriculture, namely, in greenhouses and the plant production inside them. They are very significant because they reflect unwanted IR (infrared) rays thus releasing the heat load from the greenhouse. During winter they enable the accumulation of the necessary heat, reducing further need to heat the protected area. In the following figure 5, there are examples of different energy nets [3].

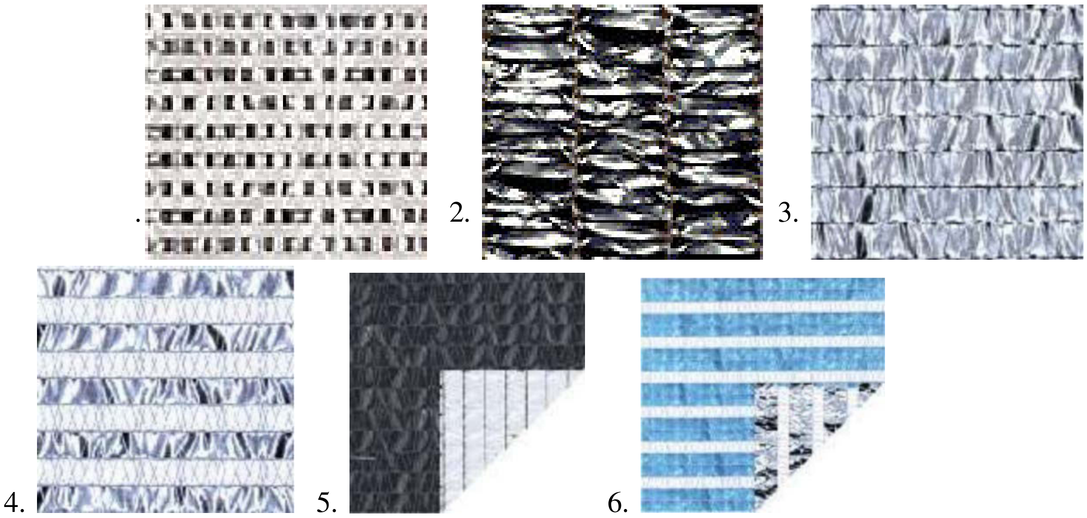


Figure.5 Some energy nets: 1. aluminet; 2. opaque net; 3. the net that preserves heat energy; 4. the net that preserves and reflects heat energy; 5. assimilated: they are placed at nights in order to prolong the day hours by using assimilated lamps; 6.fire protective- the net that prevents the risks of spreading fire but at the same time preserves energy and reflect sunlight [3].

Another helpful way of cooling greenhouses is by opening one side of the greenhouse and letting air and wind come in. Thus, the temperature inside a greenhouse decreases from hot 40 degrees to slightly more comfortable 35 degrees which is the highest temperature recommended for the crops of warm climates. By using additional equipment for cooling greenhouses, the production can be more successful. The least costs of cooling are made by installing micro-sprays that cool with the finest fog and do not have unwanted consequences for the crops (pests, plant diseases and other damages on plants) [3].

4. THE CONSTRUCTION OF SHADE NETS

There are different ways of constructing shade nets depending on the fact whether they are placed from the inner or the outer side of greenhouses. The colours contain the chemically active substance that becomes transparent in the conditions of high humidity and allows light to penetrate into the canopy, which is very important not only in the morning and evening hours but also during cloudy weather and rain.

4.1. Immobile nets

Immobile nets are placed over the covering material providing hail protection. Since they are immobile they constantly reduce the light inside the protected area as well as the intensity of photosynthesis at the morning and evening hours which prolongs the vegetation period of plants. It is one of their disadvantages. An example of immobile nets is presented in the following figure [3].

Figure. 6, the construction of immobile shade nets [3]

4.2. Mobile nets

Mobile nets are energy nets because they are placed on the inner side of greenhouses. These are active systems that enable energy nets to be movable when necessary taking into account the current light intensity. Mobile nets are thus the best solution. They can be moved manually or automatically like an accordion. In the next figure 7. There are examples of these mobile nets [3]. In the figure 7, the knitted energy net can be used as the only covering material for the protected object.

1. 2. 3.

Figure.7 The construction of energy shade nets from the inner side; 1. Like an accordion, 2.rolling on the cross wised shafts; 3. Black net for the protection of sunlight [3].

The construction of some special types of these nets can be done from the outer side. The example of such net is presented in the figure 8. This classic energy net reflects solar radiation and can be rolled. It consists of aluminum tapes between which there are holes to enable the air accumulation. These nets can last for three years when used outside the object, and five years when placed inside the protected area [3].

Figure.8 Energy net that is used from the outside part of a greenhouse and that can be rolled [3].

5. CONCLUSION

It all points to the conclusion that the need for textile materials in agriculture significantly reduced the use of harmful pesticides and herbicides providing healthy crop production. The unique production technique in textile agro-sectors made these products cheaper than chemical pesticides and herbicides.
By using the selective filtration of natural sunlight we control the vegetative growth of decorative greens mainly through the system of greenhouses. Unlike nursery gardens, nets have slight effects on the micro-climates of plants. Nevertheless, they are able to modify the quantity and quality of crop yield transmitting sunlight. Besides reducing the solar specter, nets can change the light reflection and its scattering [1].
The use of textile has proved that it can be flexible and as such suitable for specific geographic locations. Taking into account the new technology of crop protection, we should provide better progress in this area, which finally results in better national economic conditions.

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VISUALIZATION OF KNITTED FABRICS

B. Mokan, V. Petrović, D.Trajković, V. Kovačev

Abstract: *This essay presents the elements and types of warp and weft knitted structures, information needed for their visualization and modeling. In the first chapter there are basic information about knitted structures, their classifications and the observation scales. The basic structural elements as main modelling elements at the meso-scale level are explained, followed by the basic problems and required steps during the modelling. At the end, final rendering and the importance of visualization and simulation is explained.*

1. Introduction

The aim of this essay is to explain the methods of generating a geometrical model which would help in predicting the properties of knitted structures. This can be done virtually on a computer, by using production parameters as input data, which minimizes work time on the real machine. Needed input data is: the type of machine and its properties, the pattern, the yarn parameters and the processes after knitting. All of these parameters must be known before the knitting procedure begins. The physical properties of real fabrics are evaluated by testing during and after the production process. In order to produce fabrics with specific properties, we must do the following procedure repeatedly: produce a test-sample which we measure and then change the machine settings. This has to be repeated several times until the required values of the parameters are achieved. If the measured values are incorrect, then changes in machine settings have to be done, in order to produce and test a new sample.Virtual knitting process will speed up the development by giving initial information about the possible properties of the new product, which is important for tehnical composite textiles, medicine textiles, human implants, car seats, special clothes etc.

2. Classification of knitted structures

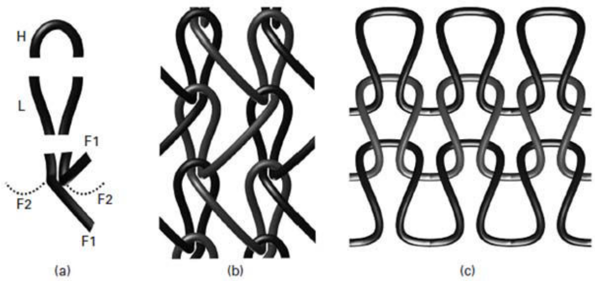

Figure. 1. Loop elements (a), warp (b), weft (c) knitted structures

There are two basic types of knitted structure that depend on the direction of creation of the loops: weft knitted (Fig. .1c) and warp knitted (Fig.1b). Simplest way of recognizing the fabric type is following the way of loop feet (F). If one feet goes up and the other down (F1), we have a warp structure and if feet are going from left to right it's a weft knitted structure (F2). Furthermore, depending on the number of working needle beds, warp and weft structures are divided into two groups:

- single-faced (produced usually on a single-needle bed machine) and
- double-faced (produced on a double-needle bed machine).

In the weft knitting technique there are additional classes of structures:

- purl – where face and reverse stitches are from the same side in the same wale (using double headed needles),
- interlock – which could be classified as a special (sub-)class of doublefaced structures because the loops on both sets are not shifted on a half needle step like those of double face structures..

Single-faced warp knitted structures can be divided into sub-classes depending on the number and arrangement of yarns used during the knitting like:

- single guide bar with full threading,
- multiple guide bars with full threading and
- multiple guide bars with partial threading

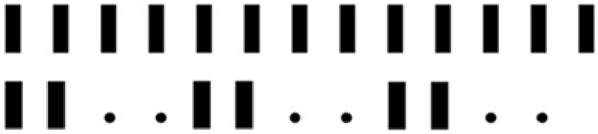

Figure. 2. Diagram of needle threading: first row shows that all sets of needles are threaded, in second row two sets are alternately threaded.

If yarn doesn't pass through every needle bed, but partially, diagram of threading is made. (Fig. 2) Depending on the number of the guide bars and the threading, how many yarns build loops (or other elements) on the same needle during a cycle can be calculated.these informations can be used to calculate general orientation of yarns in loops. In modelling of knitted structures, another classification criterium proved to be very usefull: classification acording to different structural elements in fabrics. Fabrics can be divided into fabrics that have either only plain loops, or loops and one or more of the elements – tucks, platting loops, transferred loops, weft insertions and so on. Each of these elements must be modelled separately.

3. SCALES IN THE STRUCTURE

Knitted structures are made of many structural elements. These elements are made of yarns that are presented as ropes for simplification. In reality the yarns are made of fibres or filaments. There are three levels – structure, structural elements and fibres and they represent macro, meso and micro levels of structural scale.

The macro-scale is important for the applications; it handles the mechanical behaviour of the structure as a continuum membrane or plate with known properties (Fig. 3).

There are different methods of obtaining informations from this scale, and the most used but also most expensive method is mechanical testing of the sample. In order to understand or predict macro scale properties, knowledge of meso scale is necessary. In meso scale, yarns are perceived as continuum with known properties. On this level, geometry and mechanics of the structure unit are considered as known and conclusions about material properties are driven from there. Meso scale models don't consider the effects of micro scale that are result of single fiber interactions. In order to successfully model the complete knitted structure, all these scales must be considered during modelling. There are two sources of information (Fig. 3) that determine most of the fabric properties: the topological basis of the knitting program and the material basis of the fibre properties. With these informations we can predict typical fabric behaviour. The parameters of the knitting process and treating of structure are secundary informations which make the model more precise and give it more detailed mechanical and geometrical profile. Putting all scales from micro to macro in one model hasn't been succesfull yet.

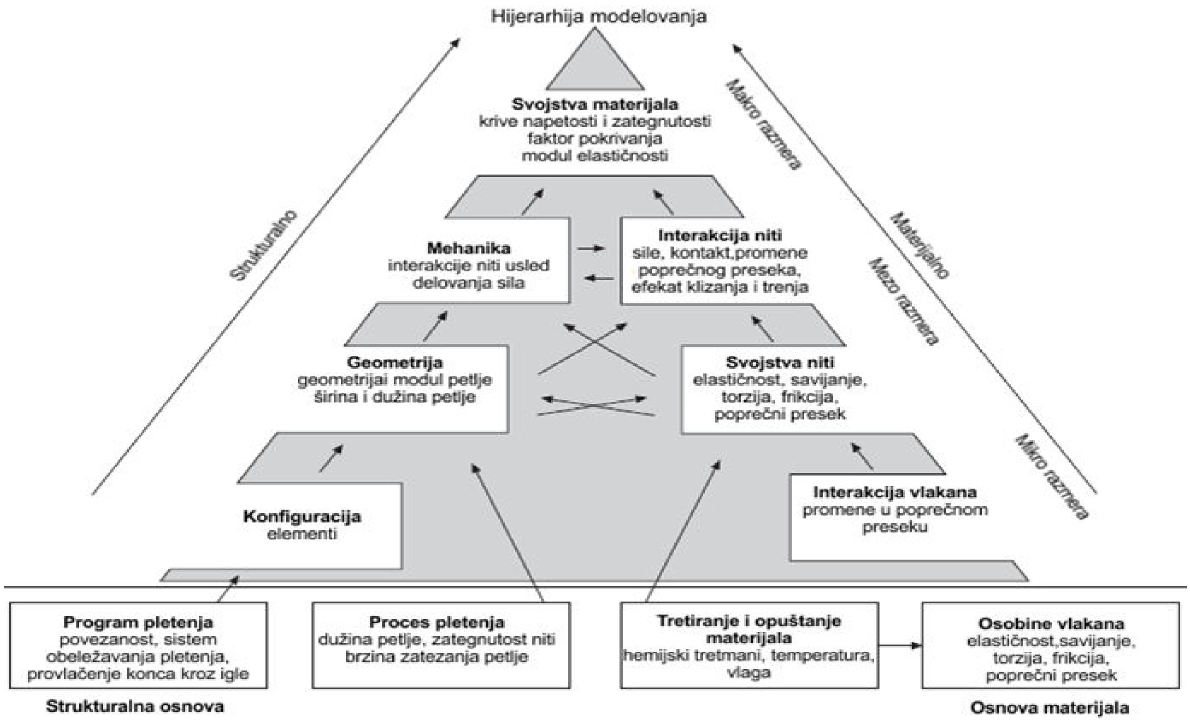

Figure. 3. Hierarchy at the structural and material level of the knitted structures

4. STRUCTURAL ELEMENTS IN MESO SCALE

Woven and braided fabrics can be represented as a set of single structural elements – crossing yarn pieces. Depending on the upper position of weft or warp yarn, these elements can be coded creating a knitting pattern. This aproach is applied also on multilayered structures, where the number of layer is marked instead of marking weft or warp yarns. This approach is implemented in software for weft structures. Most authors use whole loop as a single structural element in modeling. This coding of loops is frequently used in comercial softwares for knitting machines.

4.1 Loops

The interlooping consists of forming yarn(s) into loops, each of which is typically only released after a succeeding loop has been formed and intermeshed with it so that a secure ground loop structure is achieved. The loops are also held together by the yarn passing from one to the next. Loop consists of a head (H) (Fig. 1a), two limbs (L) and at each base is a foot (F). The foot meshes through the head of the loop formed during the previous knitting, cycle, usually by the same needle. The yarn passes from the foot of one loop into the foot and leg of the next loop formed by it. In weft knitting the yarn passes (normally) to the left or right in the same row, while in warp knitting one foot passes to the preceding and the other to the following row.

4.2 Platting loops

Platting means making aloop that consists of more than one yarn. For weft knitted structures it serves as a special technique for pattern making, where one yarn usually covers the other. For warp knitted structures this is a normal process. Most of the warp knitted structures are made with at least two guide bars working in opposite directions to improve stability.

4.3 Held loops

Held loops are typical for weft knitted structures. The needle retains a previous loop. It is not released and knocked over until the next ora later yarn feed. Depending on the technique, the length of the loop differs in material and in symbolic presentation. Held loops have the same lenght as all the other loops in a row. But because of the tension they borrow some of the length from the neighbour loops so they become shorter.

4.4 The float loops

These loops are parts of yarn that float freely between other loops. Limiting the position of these yarns between other loops is very important for modelling because it means that in structure these parts will have a special gemetry. Float loops made by weft insertions must be must be treated specially in order to get the specific configurational diferentiation during the coding of structures. Float loops in weft structures are special elements that require special programming.

4.5 Tuck loops

Tuck loops are overlapped pieces of yarn that haven't formed a loop. They can be formed on a Raschel machine with a fall plate or on a tricot machine with bearded needles and a change presser. With weft knitting machines, tucks are formed by switching off the highest cam, so that the new yarn overlaps the needle with the old loop without knitting the old loop. As yarns are moving vertically for warp structures and horizontally for weft structures, the geometry and effect of tuck loops differs on these structures.

4.6 Transferred loops

Transferred loops are typical for weft knitting machines and is rarely used in modern knitting of warp structures. Transfer loops are created on one needle and then transferred on second needle. The new loop on the needle where the transferred loop before transfering is made, has a different shape. It is similar to tuck loop. This must be taken in to consideration during modelling of geometry. There are advanced structures of bigger complexity for example braids, that require more detailed approach.

4.7 Weft insertion

Weft insertion is a regular element of warp knitting. It is used to stabilize the structure horisontally or to make net structures. It is the most important mechanical part of the structure. It is used in ligtweight nets and also in reinforced composite structures where heavy yarns such as glass or carbon yarns are inserted as weft yarns. In these warp structures the only assignment of loops is to hold these yarns together.

4.8 Inlay and other modified elements

Inlays are yarn (pieces) received from a warp beam, which are normallylocated between the floats, loops and weft insertions. They usually havea greater thickness than the yarns building loops and for this reason they remain almost in a straight form. In some special types of structures modified elements can be found. For instance, pile samples (plush) contain loops with higher lengths. Sometimes they are cut (velvet) and sometimes they build a relief surface.

5. MODELLING STEPS

The process of modeling can be divided in three steps which are used in computational mechanics: pre-processing, solution and post-processing. Pre-processing includes preparations of input data which includes knitting program, (chain links for the warp knitting, knitting notation for the weft knitting), the knitting process parameters and the yarn properties. Checking of accuracy and consistency of these informations is done in this step, because no model can work correctly with the wrong input data.

The solution step can be divided into several sub-steps:

- Topology generation, where the basic structural elements have to be created;

Loop form calculation, where the yarn path in each structural element has to be calculated.
Depending on the accuracy and the models, two sub-modules are required:
– Geometrical: to adjust the geometry so that the generated yarns have the proper thickness and loop density;
– Mechanical: where the yarn equilibrium state and relaxation can be calculated. The contact calculations belong to this part, from which the efficiency of the whole model depends.

- After the calculations are done the post-processing of the data starts. This includes three-dimensional (3D) visualization of the structure, export of the simulated structure for other programs (finite element method, FEM), or calculations of certain parameters of the structure using special algorithms.

6. FINAL RENDERING AND VISUALIZATION

Description and calculations of the axes are the main tasks during modelling of knitted structures. Building a yarn volume or its surface is an easy task which is done by dragging the cross section through the length of yarn axis. When we have a set of key points that define yarn surface, we can use different techniques and software for image production. In order to create a more realistic image, we can put a specific texture on the surface of yarns. The program TexGen (2007) is easy to use for personell that has no programming experience. It is easy to model with this program and also to visualize the structure of textile in meso scale, where different shapes and sizes of cross sections are used on each point.

7. OTHER TYPES OF MODELS

There are other types of models of knitted structures for other purposes. Several researchers use nets of beams which are mechanically equivalent to knitted structures with little elongation. If material parameters are given experimentally , other possible method is using direct 2D membranes as continuum models. Special elements "length" and "contact" can provide more efficient way for mechanical calculations of material behavior. These techniques are still in development.

8. CONCLUSION

In order to simulate materials we must know and be able to visualize the elements of their structure, and types of loops forming them. Simulated materials can be used in many fields. Most important thing for textile technology is the possibility to test the pattern and set the machine virtually, before the machine starts to knit. Modelled materials are an excellent source of information for explaining the complex 3D nature of knitted structures. Modelling software enables using of many learning methods, combining theory with rendered virtual structure, which allows significant increase of information about numbers and types of structures which are learned at specific time.
Designers can change colors and instantly see their effect, and also they can see the effect of combining color with structure. Standard practice for warp structures - using the pattern mapping in software - is now possible for weft knitted structures too. Most important thing for an engineer is 3D modelling. Engineers must predict for example mechanical or thermal reaction of structures, of the reinforced composite based on knitted structure, of medicine artificial vascular braces etc. Simulated structure in picture 4 shows most of these applications at first hand - modeled weft structure at yarn level allows color design with realistic rendering and clean structure on feet surface.

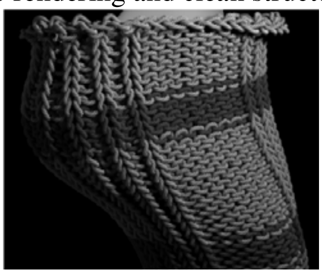

Figure. 4. Simulated weft knitted structure at the yarn level.

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WARP KNITTING OF NETS IN THE AGRO-TEXTILES

Dušan Trajkovic, Aleksandra Zdravkovic, Vasilije Petrovic, dragana Goševski

Abstract *: In this paper we analyzed the making of knitted agro-nets, the so called perforated nets. Accordingly, the paper permeates the basic construction of prick-loop and knitted fabric [1]. As the warp knitting is the only system of knitting these nets, by combining them with some knits we get new hole knits.*

Key words *: agro-textile nets, knitting, warp knitting*

1. INTRODUCTION

A special place in today's development is the development of technical textiles. Technical textiles are produced mainly in the non-Esthetic purposes, but the main part in his exploitation has its function. Technical textiles which are used in agriculture are called ***agro-textile***. When climatic conditions are not favorable for plant growth, we are trying to change the terms and the new environment, so as to be appropriate for the culture. It is the material which is used as a cover to protect plants and soil. It is light, porous, allowing the passage of water and gas, and retains 85% of the radiation at the surface [4]. Warp knitting is the most widespread technique in comparison to the weft knitting.

2. PRODUCTION SYSTEM FOR KNITTING AGRO-NETS

2.1.Knitted loop

The concept of loop represents pulling the two loops through each other, and on that occasion create semiloop, which fibers are touched in 4 places. The loop shown in Figure 1. touches with other loops in the yarn to 8 places, and at the same time creates friction. In order for the knitted fabric to be structurally stable, it must be made from a large number of loops. Each loop has its own size, that is [1]:

- Spacing - the distance between the center of two neighboring loops in the same row of knitted fabric,
- Height - it is the distance of the two curves, that is the two head loop,
- Length - it represents the length that is needed for the formation of a loop, the loop in a flat position.

In addition, each loop is composed of three main parts as shown in Figure 2 [2] :

- Head - rounded loops that arise on the needle or sinker is called the head loop (H)
- Legs - Parts of loops which connect the pinhead with a head of sinker loop (L)
- Footers - Each loop contains two legs - , except the edge loops which have three (S).

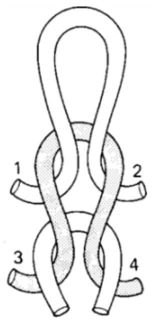


Fig.1. Some point of contact in the loop [2]

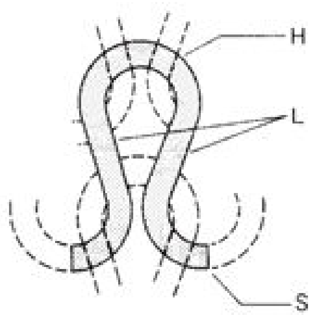


Fig.2. The main parts of the loop [2]

2.1.1. Face of the loop (front side)
The front page shows to the observer the arrival of loop entirely passing over and covering the head of old loop and the other is called the right-hand side. Knits on faces loops have a tendency to show the legs so the needle overlap head of the loops. Figure 3 [1].

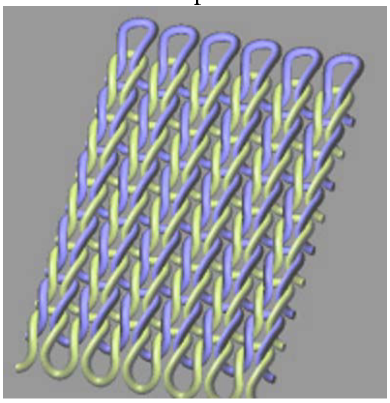
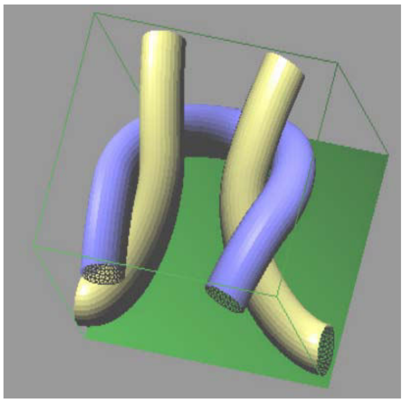
a)  b) 

Fig.3. a) Face of knitwear; b) Overlapping of the head loop [3]

2.1.2. Backface of the loop (back side)
This is the opposite side of the face loop (backface or left side of knitwear) and shows the viewer a new loop passing through under the head of the old loop. You can see the arches of the head of the the loops and the foots, while the hidden between the legs [1]. The reverse loop side is the nearest to the head of the needle because the needle draws the new loop downwards through the old loop. Figure 4.

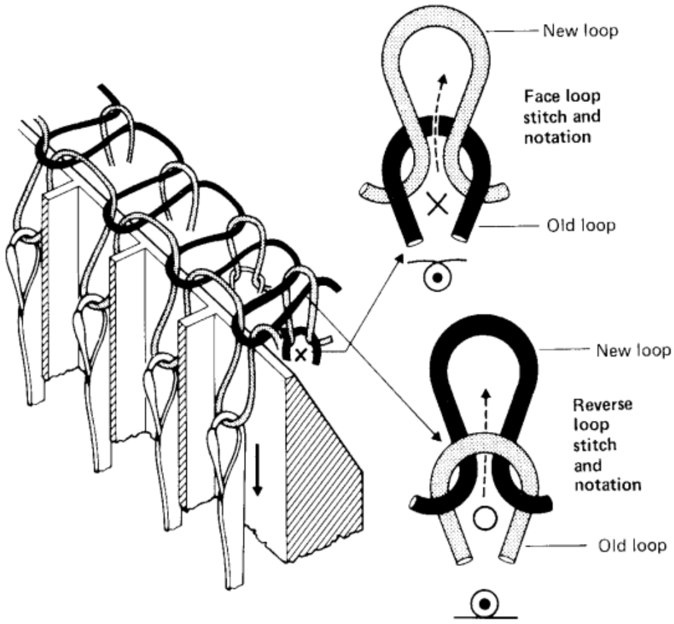


Fig.4. Face- and backface-meshed loops [2]

2.2. Basic warp knitting principles

Knitted fabrics that are warp knitted are done at constant width, although knitting a large number of narrow material within the width of needle reservoir is also possible [1].

2.2.1. Single knit fabric is knitted from a vertical system thread, so-called warp, where each thread leads above and below the needles forming a loop. Part of threads which is taken over needles creates a thing of the loop, whereas part of the threads that lies beneath the needle creates a platinum loop [2].
At warp knitting systems , creating a loops of weft is not done, but with threads passing longitudinally through knitwear with the help of guide bar warp. In the guide bar there are conductive pins that separately take lead and lay needles threads. Single warp knitting are knitting on the one side of

which are visible just right loops and the left on the other side on the second left loop there are layers between them. All warp knitted fabrics can be knitted (Figure 6) with [2]:

- closed-lap loop – which is created with the closed walk of guide bar,
- open-lap loop – that occurs when a guide bar does not make a full quadratic walk during the laying
- or their combination.

With open-lap the loop laying, lower part loop is stretched because guide bar continues laying under the needle in the same direction as when laying over the needles. In Figure 5 is a)
With closed-lap the loop, the the loop is shorter to squeeze the lower part, because guide bar continues laying in the opposite direction of lying over the needles. In Figure 5 a b)

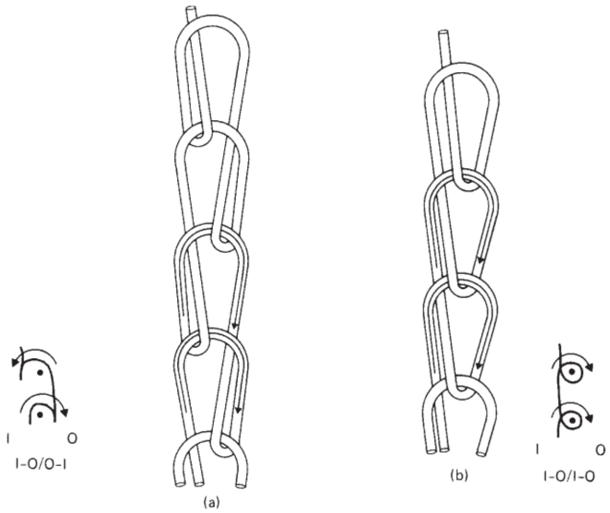


Fig.5. Open and closed the loop circuit singleneedle in the form of chains [2]

a) b)

Fig. 6. a) The open-lap i b) The closed-lap loop at the formation of knitwear [2]

2.2.1.1. The guides

The guides are thin metal plates drilled with a hole their lower end through which warp end may be threaded if required. They are held together at their upper end as a single unit in a metal lead and are spaced to the same gauge as the needles. The leads are attached to a guide bar so that the guides hang down from it, with each one occupying a position, when at rest, midway between two adjacent needles. In this position, the warp thread cannot be received by the needles and it will merely produce a straight vertical float. The needles only receive the warp thread in their hooks if the guide bar overlaps across their hooks, or across their backs when the guide bar underlaps. All guides in a conventional guide bar produce an identical lapping movement at the same time and therefore have identical require-ments of warp tension and rate of feed, although the threads may differ in colour or composition from each other [2]. In Figure 7.

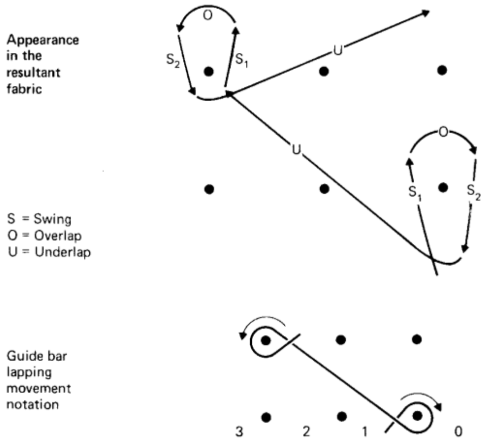


Fig.7. Warp knitting lapping and chain notation [2]

2.2.2.Double knit fabric is made by using guide bar two that perform the same or different laying. These are mostly knits that are produced on a warp machine with a bearded and latch needle (with latches). Guide bar warp can be performed in same direction or opposite laying. In the opposite case, laying is received, due equalization of tension in both layering loops, balanced structure without the appearance of distorted loops, as is the case with single knit fabric. On the reverse of knitwear see the short loop of sinker, platinum bonds that have the same direction when the case is laying the same direction, or they intersect in a case of laying opposite direction. Double knits fabrics are made by using two rectangular guide bar with threads that lead from two warp roller. In this knitwear mutual combinations are possible with other weaves [2].

Next agro-textile networks can be knit in a variety of perforated forms, and they are at a very broad application: marquisette nets, lined warp knitted fabrics, pin net loop structure – cloth (sukno) interlacement, sandfly net - satin (atlas) perforated mesh, structure of a balanced net – rectangular mesh. For example, marquisette networks do not have to be used only for the shading, but by the difference in the density the net itself and its perforated space, it can be the same way of knitting to get to other applications, such as net for gathering the crop at harvest, in the form of fences that protect from the wind, the net for the protection of birds and insects, hail nets, and others.

3. CONCLUSION

The needs of textiles in agriculture has decreased significantly the use of harmful pesticides and herbicides, bringing a healthy crop growth. The unique manufacturing techniques and the properties of these mixture in sector agro-textile, have made these products much cheaper than chemical pesticides and herbicides.
Flexibility especially refers to systems of knitted materials, such as knitted nets, which have a high degree of adaptation to the various needs of agro-textiles. In this way, we can easily adapt to market needs and satisfy the needs of customers in a short of time. We must be careful to shape this new technology and contribute to a better economy of the nation.

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MODELLING AND VISUALIZATION OF KNITTED FABRICS

B. Mokan, V. Petrović, M. Stanković, Ž.Branović

Abstract: *This essay presents the methods of modelling of warp and weft knitted structures. Modeling is explained in three main parts: checking the input data, topology generation and mechanics of the structure. Two types of mechanical model are presented: discrete and continuum. Following are problems connected with the yarn cross-section form, unevenness, etc. At the end, different ways of post-processing are explained, including rendering, visualization, and other calculations.*

1. INTRODUCTION

The aim of this essay is to explain the methods of generating a geometrical model which would help in predicting the properties of knitted structures. This can be done virtually on a computer, by using production parameters as input data, which minimizes work time on the real machine. Needed input data is: the type of machine and its properties, the pattern, the yarn parameters and the processes after knitting. All of these parameters must be known before the knitting procedure begins. The physical properties of real fabrics are evaluated by testing during and after the production process. In order to produce fabrics with specific properties, we must do the following procedure repeatedly: produce a test-sample which we measure and then change the machine settings. This has to be repeated several times until the required values of the parameters are achieved. If the measured values are incorrect, then changes in machine settings have to be done, in order to produce and test a new sample.Virtual knitting process will speed up the development by giving initial information about the possible properties of the new product, which is important for tehnical composite textiles, medicine textiles, human implants, car seats, special clothes etc.

2. MODELLING STEPS

The process of modeling can be divided in three steps which are used in computational mechanics: pre-processing, solution and post-processing. Pre-processing includes preparations of input data which includes knitting program, (chain links for the warp knitting, knitting notation for the weft knitting), the knitting process parameters and the yarn properties. Checking of accuracy and consistency of these informations is done in this step, because no model can work correctly with the wrong input data.

The solution step can be divided into several sub-steps:

- Topology generation, where the basic structural elements have to be created;
- Loop form calculation, where the yarn path in each structural element has to be calculated. Depending on the accuracy and the models, two sub-modules are required:

– Geometrical: to adjust the geometry so that the generated yarns have the proper thickness and loop density;

– Mechanical: where the yarn equilibrium state and relaxation can be calculated. The contact calculations belong to this part, from which the efficiency of the whole model depends.

- After the calculations are done the post-processing of the data starts. This includes three-dimensional (3D) visualization of the structure, export of the simulated structure for other programs (finite element method, FEM), or calculations of certain parameters of the structure using special algorithms.

3. Model building

2.1 Preparation of input data

It is normal to check if the pattern, yarn properties and machine settings are correct before setting it for new pattern and material. These three separate but related tasks are describing the possibility of knitting some pattern with particular yarns on a particular machine. The algorithms of modelling

demand certain tools and rules in order to check the possibility of knitting of input data before the beginning of modeling.
How to check knitability of the input parameters is still an open field for research. There are three main thrends that researchers follow in search of the solution for this problem (1) expert systems with formalized rules, (2) physical process simulation and (3) an engineering approach based on the definition of some limitation rules. Each of these approaches has its own power and its limitations. The best solution could be some combination of the advantages of these three approaches.

Expert systems

The expert system consists of several rules stored in a database. The rules could be defined in a clear and understandable form if the expert system has fuzzy linear systems as an engine (Peeva and Kyosev, 2004) or engine based on neural networks. The neural network requires a large number of samples for learning, the fuzzy linear systems do too, or somebody with experience who could fill in. In both cases, the expert system could produce a reasonable answer only inside the range where it is learned. If completely different input parameters from those are used during the learning process then the error between the proper answer and that computed from the expert system could be quite high. Rule-based systems of the type if A then B built in a logic programming language like Prolog or others have the same problems because they are mathematically equivalent to fuzzy linear systems. The advantage of the expert systems is in their ability to collect and operate with a large number of rules and because of this they are one reasonable tool for building a system for decision making.

Physical simulation

With the growth of power of computers also will grow the importance of simulating of yarn behaviour during knitting and calculating yarn tension in virtuel structure. Simulation of these structures can be based on different mechanical models such as sets of beams springs and masses 3D cylinders etc. Building of the equation system is usually done automatically in the software based on the finite elements model or particle system.More complexed models require more sofisticated numerical algorythms, longer calculation times, and are usually more sensitive to errors in input data. If a set of yarns,machine settings and patterns are used that are not knittable, the process might never finish. Because of this, simulation based on physical properties is not good enough as an independent approach for checking of knittability of input parameters.

The engineer approach

There are simple calculations that can check whether the production of material is possible. Standard checks of knittability begin with checking of compatibility of yarn thickness and available space in the machine and yarn structure. Both for weft and warp structures, yarns must not be thicker than the quarter of distance between the needles. From the well known relationships for loop geometry, developed by Doyle and Munden:

$$c = \frac{k_c}{l}$$

$$w = \frac{k_w}{l}$$

$$\frac{c}{w} = \frac{k_c}{k_w} = 1.3 \qquad [1]$$

and for the tightness factor of the fabric K:

$$K = \frac{\sqrt{tex}}{l} \qquad [2]$$

It can be checked if the planned material is a normal case material or a very special one.

In the above equations, c is the number of courses per unit length, w is the number of wales per unit lengths, kc and kw are constants, tex is the yarn linear density (g km–1), and l is the loop length (cm), the constants in normal cases are in the ranges kc = 5.0–5.5, kw = 3.8–4.1 and K = 13–15.

The next step would be to check if all the loops are interknitted. If this is not the case, the open unstable structure will be built. There are also some special cases during some knitting techniques where particular yarns overlap on the needle but after that they dont knit with the next loop. In this way free length for next loops is reserved which is important for minimising tension of the yarns during knitting.

2.2 Topology generation

The graphical description of the knitting process is a simplified way of notating the configuration of knitted structures. It provides information for understanding the topology of the structure, but it does not present the yarn interconnections exactly. (Fig. 1c and 1b). In cases where the exact 3D geometry of the knitted structure is not needed, but just the appearance of this structure, it is suitable to use the notations as a pattern and to map to the elements pictures of the corresponding elements. For normal engineering applications, where a real 3D representation is required, a set of points of the loops have to be created. A logical way is to start from the 2D models and then add the third dimension.

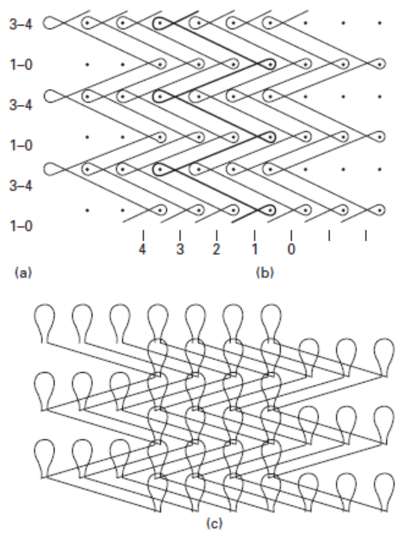

Fig. 1. Notation of the knitting program (chain-links) for warp knitting machines (a), lapping movement and yarn threading (b), and 2D graphical representation of the fabrics (c).

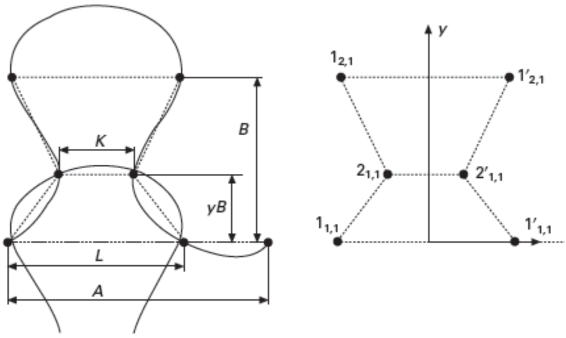

Fig. 2. Loop and the anchor points for building 2D loop topology: (a) main dimensions, used to determine the coordinates of the anchor points, (b) notation of anchor points.

Two-dimensional topology

The 2D topology of loops can be defined using different key points. Most used are the position of the contact points, which can be defined well over the projections of the loop. One of the simplest topological representations is depicted in Fig. 2 The yarn axis of each loop is described as a curve through six points, which are the contact points between the loop at the X–Y plane. The following parameters of the loops must be known for this representation: the loop height B, the loop width L, the course A, the distance between the feet K and the height at this distance yB. With these parameters the points will be defined as follows:

$$P.1 : \left(x = \pm\frac{L}{2}; y \ = 0\right)$$
$$P.2 : (x \ = \pm\frac{K}{2}; y \ = yB) \qquad [3]$$

The coordinates of these points for loops of the wale i and course j then could be defined as:

$$1_{i,j} \ : x \ = \ \pm\frac{L}{2} + A \cdot i \quad y \ = 0 + B \cdot j$$
$$2_{i,j} \ : x \ = \ \pm\frac{K}{2} + A \cdot i \quad y \ = yB + B \cdot j \qquad [4]$$

Using Equation [3], one loop can be defined as a curve, going through the points
$1_{1,1} \ - \ 2_{1,1} \ - \ 1_{2,1} \ - \ 1'_{2,1} - \ 2'_{1,1} - \ 1'_{1,1}$ [5]
The loop height B is defined by the take up speed of the warp knitting machine. For the weft knitting machines, where force driven take up mechanisms are used, B can be defined by the equation [1]. The wale is defined as$A \leq \frac{25.4}{E}$, where E is the machine gauge. If the fabrics have to be modelled in the same dimensions as they are produced on the machine, then A is equal to the space between the needles. In other cases the structure relaxes and A is usually, but not necessary smaller. Factor K and coordinate yB present the minimal distance between the two yarn axes and they depend directly on the yarn radius r:
$K \ \geq 2r$ [6]

$$yB \ \geq 2r$$

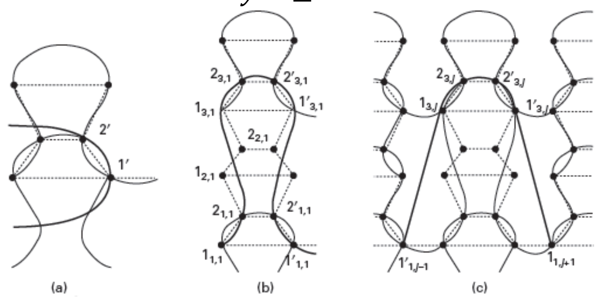

Fig. 3. Key points in the topological representation of the weft insertions (a), hold loops (b) and tuck loops (c).

At the stage of topological representation only the location of the yarn axes is important. The yarn cross-section does not play any role. If the described equations have to be used to build more precise loop geometry, then the changes in the yarn cross-section of staple and multifilament yarns have to be taken into account. The points $1, 2, 2'$, and $1'$ define the position of a loop head. All coordinates of other loops of a plain structure can be calculated by using a simple translation of these points in the X and Y directions. Based on this topology, the key points of all the structural elements can be derived using simple modifications. In Fig. 3. (a) an example of key-point selection for weft insertions at warp knitting structures is demonstrated. To define the position for a weft insertion (of warp knitted fabrics), only the points $1'$ and 2¢ are required, as defined in Equation [4].
The hold loops require the points from more wales. This is why the first subscript of the point number shows to which wale (row) it belongs. A hold loop (Fig. 3.b) then goes through the points

$1_{1,1} \ - \ 2_{1,1} \ - \ 1_{3,1} \ - 2_{3,1} \ - \ 2'_{3,1} - \ 1'_{3,1} - 2'_{1,1} - \ 1'_{1,1}$
$1'_{1,j-1} - 1_{3,j} \ - \ 2_{3,j} \ - \ 2'_{3,j} \ - \ 1'_{3,j} - 2'_{1,1} - \ 1'_{1,j+1}$

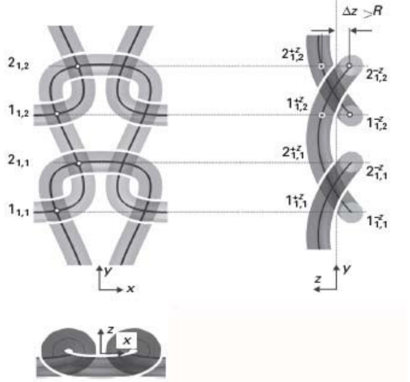

Fig. 4. Key points in the topological representation of loops in 3D space.

3D topology

Three-dimensional approach to structure configuration enables us to make simple but accurate 3D models. They can easily be made out of 2D presentations by adding the z axis (Fig. 4).

To the point $1_{i,j}$ are now associated two points $1^{+z}_{i,j}$ i $1^{-z}_{i,j}$ so that

$$1^{+z}_{i,j}\ (x,y,z) \equiv (1_{i,j}(x), 1_{i,j}(y), +\Delta z)$$

$$1^{-z}_{i,j}\ (x,y,z) \equiv (1_{i,j}(x), 1_{i,j}(y) \quad [7]$$

where $1_{i,j}(x)$ is the x-coordinate of the point $1_{i,j}$. Here $\Delta z > R$, where R is the yarn radius. With this notation, one-half of the plain loop can be defined as a curve going through the points: $1^{-z}_{1,1} - 2^{+z}_{1,1} - 1^{+z}_{1,2} - 2^{-z}_{1,2}$.

There is usually no single best choice for the position of key points. These key points must represent characteristics of the element, have to be defined easily and calculating their coordinates shouldn't be complicated. Loops of a typical pattern of warp knitted structure are made out of more than one yarn, so their key points require multiple positions on the z axis. Examples of structures are shown on pictures 8 and 9 where we can see two loops made out of two yarns and weft insertion.

Fig. 5. Example of modelled warp knitted structure with loops from two yarns.

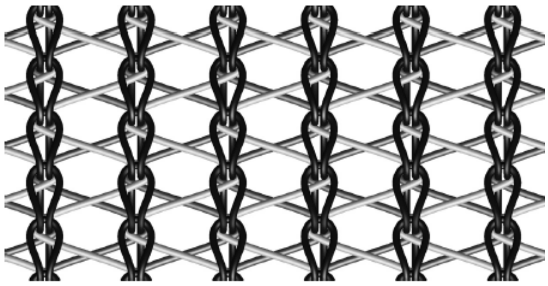

Fig. 6. Example of modelled warp structure with loops and two weft insertions.

Key points of the regular loops that are described are located around local X-Y plain. Structures such as ribbed, interlock and all warp structures made on machines with two sets of needle beds, require two such plains. By using the main key points shown on picture 7, not only plain structures but also structures using other structures can be generated. For example if we are supposed to model piped structure, key points must be set on an arc (picture 10).

2.3 Yarn path representation

During geometrical modeling, two tasks must be done, usually at the same time (1) adjusting the position of the key points according to geometrical parameters of the yarns and (2) calculating the shape of yarn axis..

These tasks have not yet been separated in large research works mainly because only simple structures with same yarn cross sections are used. In reality weft insertions are usually thicker than the other yarns that form loops (in order to keep them in place) (picture 11). In order to model the structure more accurately geometrically speaking, all the spaces between key points must be checked and set according to information about different yarn cross sections.
Key points are set using different strategies. The simplest one is based on fixing the position of the outer element (loop) and translating in desired direction (the single key points) until the distances are equal to yarn diameter. Second task - generating the shape of yarn axis - is one of the most researched subjects in the field of modelling of knitted structures, where the main task is geometrical modelling.

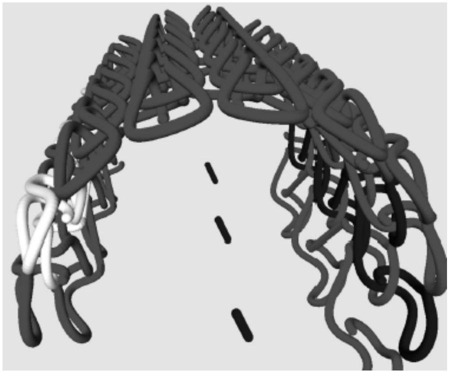

Fig. 7. Part of a warp knitted tubular structure.

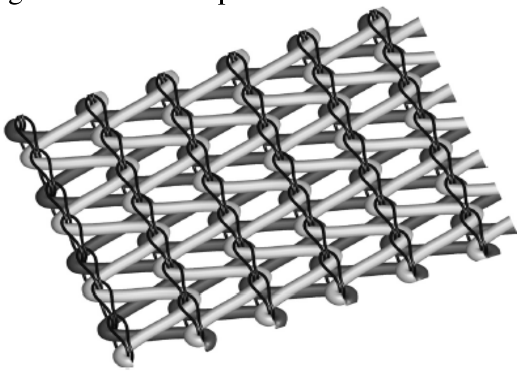

Fig. 8. Warp knitted structure, consisting of yarns with different diameters.

2.4 Mechanical models

Geometrical models mentioned in previous chapters don't take inner and outer forces in to consideration. For that it is necessary to apply all the acting forces in already generated geometry, where the geometry could be presented as a continuum or a discretized medium. the continuum model is usually used for theoretical and analytical investigations of the simple cases. Discrete model can be treated as a discrete continuum model, where main advantage lays in faster and easier programming of their structure..

Continuum model
The mechanical models for textile structures, introduced by Leaf and Glaskin (1955), Konopasek (1980) and Hart (1985), differ in the yarn properties used and the definition of the contact zone (one point, two point, contact line etc). Hart (1985) apply mechanical analysis for warp knitted loops too and demonstrate the influence of the bending rigidity of the yarns over the loop form. The available

models differ in the assumptions made about the yarn properties, such as bending, tension, torsion, compression effects and yarn stiffness. Another point in which the models differ is in the treatment of contact between the yarns, at one, two or more points. The open problem here could be in the rapidly increasing computational complexity if large and more complex structures have to be modelled.

Discrete models

Discrete mechanical models are usually based on reducing the yarns to a mass–spring system. (Fig. 9). The yarn is divided into yarn segments with initial length L_{i0}. All the forces are concentrated upon particles i between segments. Each particle has a mass $m_i = L_{i0\rho}$, where ρ is the linear density of the yarn and the internal and external forces are applied there as a resulting force F_i. The equation of motion of ith particle is given by the second Newton law as:

$$m_i \frac{d^2 r_i}{dt^2} = F_i$$

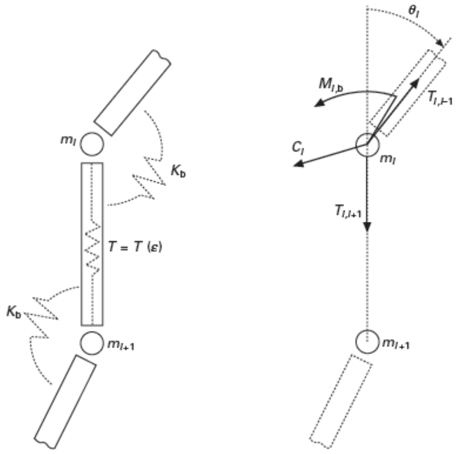

Fig. 9. Model of the yarn as a mass–spring system

where $r_i = (x_i, y_i, z_i)^T$ is the coordinate vector of the current ith particle. The resulting force F_i is calculated as a vector sum of the forces at the particle i :

$$F_i = T_i + B_i + C_i + Q_i$$

where T_i, B_i are the resulting nodal forces from the tension and bending of the yarns, C_i is the resulting force from the contact and lateral compression of the yarn and Q_i is the resulting force for all other external influences like gravity or others.

The bending is modelled using linear beam theory model:

$$M_i = K_b \cdot k \cdot n_{i-1,i,i+1} \qquad [10]$$

where the curvature could be expressed in a simplified linear relation from the bending angle as:

$$k_i = \frac{1}{\rho} = \frac{\theta_i}{L_{i,i-1} + L_{i,i+1}}$$

a $n_{i-1,i,i+1}$ is the normal of the plane, where the links between i , $i-1$ and $i+1$ are located. The bending moment is applied to the nodes through its equivalent forces. The contact forces C_i are calculated according to the model:

$$C_i = k_{kontakt} \cdot f\left(\frac{|x_i - x_j|}{2r}\right) \cdot n_{ij} \qquad [11]$$

Where the function:

$$f(d) = \begin{cases} \frac{1}{d^2} + d^2 - 2 & x < 0 \\ 0 & drugi\ slučaj \end{cases} \qquad \begin{matrix} \text{d<1} \\ \text{drugi slučaj} \end{matrix} \qquad [12]$$

allows better treatment of the contact forces. Equation 12 is an ordinary differential equation system, where the forces from the right hand side are calculated by spatial derivatives. Because of this, the system is and has to be treated as a system of partial differential equations For this scheme, the coordinates at the new time step x^{j+1} are calculated from the coordinates of the previous time steps and the acceleration a^j of the previous time step as follows:

$$x^{j+1} = 2x^j - x^{j-1} + a^j \cdot (\Delta t)^2$$

As an explicit integration method, the stability limit is defined in terms of maximal time step Δt depending on the highest frequency of the system :

$\Delta t_{stabilno} < \frac{L}{c}$

where L is the length of the smallest element in the system and c is the speed of sound in the cu [14]
yarn. In order to avoid oscillations of the mass–spring system, different damping forces ca included. The most simple realization of the damping effect is its implementation into Equation [13] with damping factor *f*D, where

0 □□*f*D << 1

$$x^{j+1} = (2 - f_D)x^j - (1 - f_D)x^{j-1} + a^j \cdot (\Delta t)^2$$

Figure 10 shows the changes in the form of a single loop after several iteration steps. This loop (a) is defined at the beginning as being simplified through eight points, where the first and last points are fixed. After several iteration steps, the edges become more smooth (b) and (c). Finally, the equilibrium state for the internal bending forces is achieved (d).

Finite elements method

The finite elements method (FEM) software enables different strategies for accurate mechanical modelling of the knitted structures. Explicit finite elements method can be used in order to simulate knitting process or large deformations. The implicit FEM is more effective for smaller deformations, for example calculating small portions of the loop. software enables the use of different geometries - fastest method is using beams for calculating with yarn axis. Usually the elements of shell are used when yarns are modelled as complete ropes. The advantage of this approach is in better modelling of yarn cross sections, but also important is to choose surface parameters for shell elements in order to better show material properties.

2.5 Contact between yarns

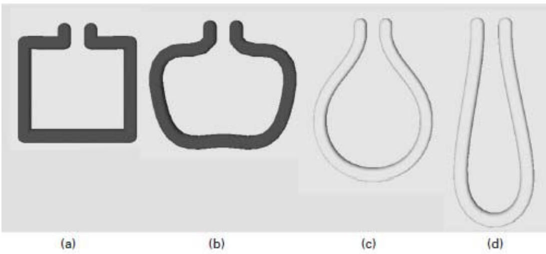

Fig. 10. Simulation of a single yarn under the influence of a pure bending force, from left to right: initial configuration, intermediate states and final state.

The identification and treatment of yarn contacts is one of the most important tasks during the mechanical modelling of knitted structures. There are different approaches to finding those contacts such as to treatment. Which of these approaches should be used depends on the aim, size and complexity of the modelled structure. Large number of research works in this field shows us that desired results are rarely achieved in combining the algorithm stability and calculation time.

2.6 Yarn paths and shape of cross sections

Until recently it was perceived that yarn cross section is constant and round. This perception is close to reality only for structures such as monofilaments, but not multi-filaments. In this case cross section depends on several filament and yarn properties (torsion-friction, yarn shape - relief or smooth etc.) and on yarn bending and contacts with other yarns. By bending, each filament changes its position in space until they reach the most energy efficient spot, and this changes the cross section. (picture 14a). as shown on picture 14, a multifilament yarn can be flat and wide in bending places where forces from other sides are not applied.

5.7 Yarn unevenness

All geometrical and energy models are usually deterministic. They describe the shape of the loop under a presumption that it has constant properties through all its length. In reality all textiles have parameters that succumb significant deviations, for example the cross section plane, shape, elasticity module etc. This means that every calculation of loop shape using constant parameters can be used only as approximate value of yarn bending of the real material. After a few steps in researching the unevenness of yarn parameters, the appearance of the real material is taken into consideration in the control system. Calculated or measured data about cross section is mapped on the picture generated for basic weft structure in order to simulate occasional defects. These researches have only been done for simple structures because for more complex ones it is hard to calculate yarn axis.

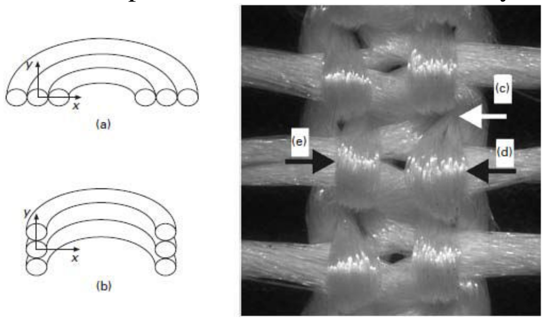

Fig. 11. Yarn cross-section for multifilament yarns. (a) Unstable orientation of three filaments during bending. This configuration is not stable, because (1) the outmost filament has to be elongated and the innermost filaments have to shrink in order to stay in this configuration and (2) more energy is required to bend the joint cross-section around the Y axis, because of the higher moment of inertia. (b) Usual orientation of three filaments during bending. This configuration is stable, because (1) all the filaments have the same length and there is no additional need for some of them to be elongated and (2) less energy is required (less moment of inertia) to bend the cross-section. (c) Configuration of multifilament yarn if compressed laterally from all sides. (d) and (e) Different configurations of the multifilament yarn with an almost similar yarn axis, but with different pressure and orientation at the

3. Final rendering and visualization

Description and calculations of the axes are the main tasks during modelling of knitted structures. Building a yarn volume or its surface is an easy task which is done by dragging the cross section through the length of yarn axis. When we have a set of key points that define yarn surface, we can use different techniques and software for image production. In order to create a more realistic image, we can put a specific texture on the surface of yarns. The program TexGen (2007) is easy to use for personell that has no programming experience. It is easy to model with this program and also to visualize the structure of textile in meso scale, where different shapes and sizes of cross sections are used on each point.

4. Other types of models

There are other types of models of knitted structures for other purposes. Several researchers use nets of beams which are mechanically equivalent to knitted structures with little elongation. If material parameters are given experimentally , other possible method is using direct 2D membranes as continuum models. Special elements "length" and "contact" can provide more efficient way for mechanical calculations of material behavior. These techniques are still in development.

5. Conclusion

During modelling of knitted structures, biggest attention is required in meso scale of modelling. In this scale the connections of different structural elements are described. structural approach to modelling begins with making a simple, configurationally correct description of yarn arrangements. Next step is constructing of yarn axis using sets of key points, considering geometrical yarn parameters and machine parameters.

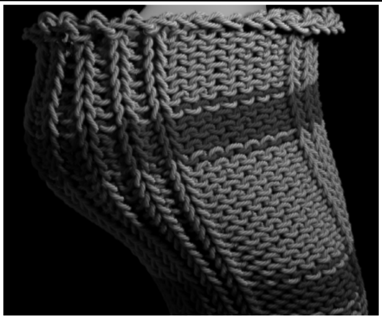

Fig. 12. Simulated weft knitted structure at the yarn level.

This approach is general enough to allow modelling of very complex structures built from different loops, tuck, floats, etc. In cases where geometrical model is not precise enough to simulate yarn axis, we must build mechanical model and calculate static and dynamical system equilibrium. The complete mechanical calculations and realistic rendering of yarn surface are still too time consuming for a textile engineer. But research shows that modelling of knitted structures is possible at loop level and at yarn level. Next expected steps include combination of models at different scales- where micro scale effects will be used in meso scale modelling. These models can be implemented in calculations of behavior in meso scale of the knitted structures.

7. Literature:

[1]http://www.k4i.org.uk/browse/knit_tech/knit_tech/Graphical_warp/Threading_arrangement_of_guide_bars.htm
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[4] Modelling and predicting textile behaviour, Edited by X. Chen, Woodhead Publishing Series in Textiles: Number 94, 2010. str: 225-260
[5] R. Čunko, E. Pezelj: Tekstilni materijali, Tekstilno tehnološki fakultet, Zagreb, 2002.
Pictures taken from : Modelling and predicting textile behaviour, Edited by X. Chen, Woodhead Publishing Series in Textiles: Number 94, 2010; Y. Kyosev, Niederrhein University of Applied Sciences,Germany and W. Renkens, Renkens Consulting,Germany, str: 225-260

KNITTED NETS OF AGRO-TEXTILES

Aleksandra Zdravkovic, Dušan Trajkovic, Vasilije Petrovic, Ivana STAMATOVIĆ, Želimir BRANOVIĆ

***Abstract** : In this paper we analyzed the making of knitted agro-nets, the so called perforated nets. As the warp knitting is the only system of knitting these nets, with Raschel and Tricot machine we get a warp knitted fabric, and since these machines can be used for knitting at different densities of knitting, these nets, in addition to anti-hail functions, are used for shade nets. This paper describes the working process of these machines for knitting perforated shade nets [3].*

***Key words** : agro-textile nets, warp knitting, types of nets, Raschel machine, Tricot machine*

1. INTRODUCTION

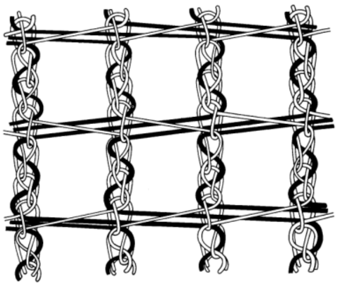
Technical textiles are produced mainly in the non-Esthetic purposes, but the main part in his exploitation has its function. Technical textiles which are used in agriculture are called ***agro-textile***. When climatic conditions are not favorable for plant growth, we are trying to change the terms and the new environment, so as to be appropriate for the culture. It is light, porous, allowing the passage of water and gas, and retains 85% of the radiation at the surface [6]. These nets are made with holes,and we can call them perforated nets. Protective nets which are warp knitted are used in the various sectors and products of mainly to Rashel machines. Agro-networks are manufactured with different weawes and combinations of weawes [6].

2. PRODUCTION SYSTEM FOR KNITTING AGRO-NETS

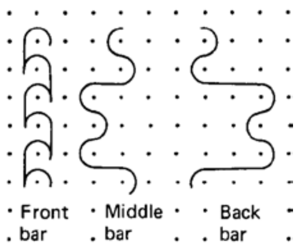
Next agro-textile networks can be knit in a variety of perforated forms, and they are at a very broad application. For example. marquisette networks do not have to be used only for the shading, but by the difference in the density the net itself and its perforated space, it can be the same way of knitting to get to other applications, such as net for gathering the crop at harvest, in the form of fences that protect from the wind, the net for the protection of birds and insects, hail nets, and others. In the next section will be presented a few more types of nets that can be knit on a Raschel machine and Tricot machine [2].

2.1. Marquisette nets

These networks can be made with two or three guide bar guide bar warp, where the guide bar of the two guide bar warp is not stable. First guide bar lie in a chain knit where the other guide bar while tying them together. When creating a the mech with three guide bar warp, first guide bar performed open laying in the chain stitch, and the second and third guide bars tiles performed the opposite laying under two needles. Much better stability and and straighter structure is obtained if a one guide bar laying below two needles andthe other below the three pins where the following products laying like as in Figure 1. [1].



a)



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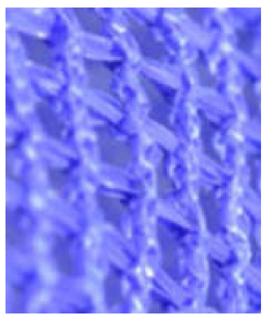


c)

Fig.1.a) Interlacement the Marquisette mech; b) Order of a thread; c) Marquisette mesh [2]

These networks are knitted on Raschel machine, because it is one of two warp knitting machines. This interlacement is used in the agro-telstilu especially in crop protection from the sun, that is.it is used for making shading and shade crops. They have enough openings for light and rain leaks, and yet they are little to protect from the excessive temperature. On the Figure 1. itcan be clearly seen the knit of the marquisette net. This knitwear is one of uniform fabrics.

2.2. Lined warp knitted fabrics

These are double warp knits and are mainly are connected with other loops. The lined knits are created by the interference of liner thread in the basic structure knitwear, and performed only by passing below the needle. In this way, the needle does not create a loop, but the thread is wrapped around the base of platinum loop knit fabric [1].

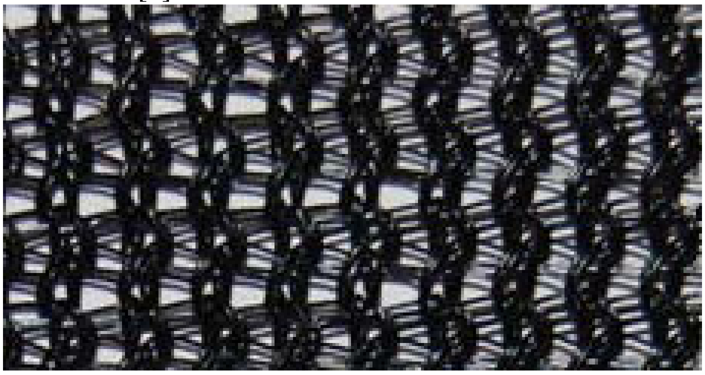
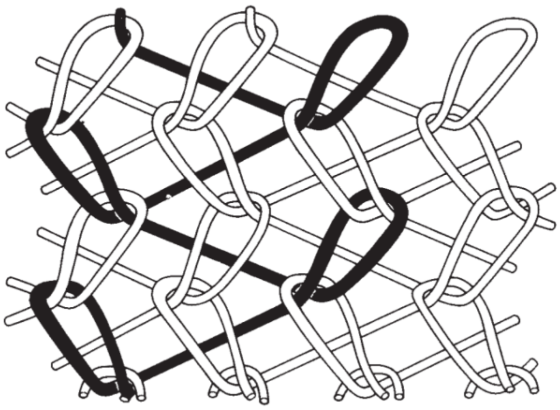


Fig.2. Lined warp knitted fabric [6]

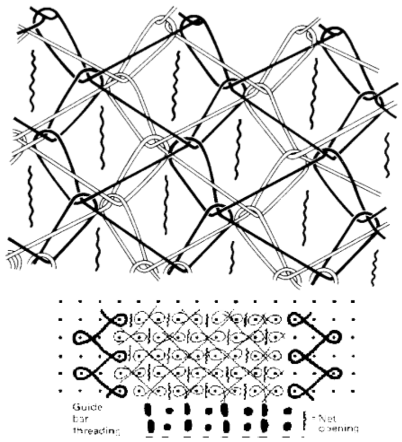
Lined filaments (Figure 2.) can be seen on the left side of the knitted fabric in the form of transverse threads. In order for linead threads to get involved in the structure of knitted fabric, bearing the conductive needles with thread linead must be performed to move aside for deposit under the needle. Laying of both guide bar should be the opposite. The lined knitwear can be combined with a chain stitch, so linking them into a whole, or may be involved with a tricot stitch. It also belongs to the uniform fabric [1].

2.3. Pin net loop structure – cloth (sukno) interlacement

This net is obtained by laying double sukno interlacement, making a small diamond-openings in knitting. Their height is only one row, so this is the least that can be opened to make and they are circular. Because of that they have a very high density. The figure shows that each hole in the knitting lined with 4-leg loop and has 4 sinker connections [1]. The maximum height of these openings is equal to the height of interchange legs. It belongs to the perforated knitted fabrics and knitwear is shown in Figure 3.



a)



b)

Fig.3. a) *Sukno knitwear from which he obtained perforated knitwear; b) Perforated sukno interlacement [2]*

2.4. Sandfly net - Satin (atlas) perforated mesh

This interlacement arises by laying two opposite guide bars in satin interlacment. In Figure 4. satin can be seen hole embroidery knitwear with height Raporte Rv = 4 Dimensions of this net can be modified depending on the report, including its density. Openingsof these nets are in the form of honeycomb. Except the preceding perforated satin knitted fabrics, it is possible with the same introduction thread the performing laying in a distorted satin interlacment [1]. It belongs to the perforated knitted fabrics.

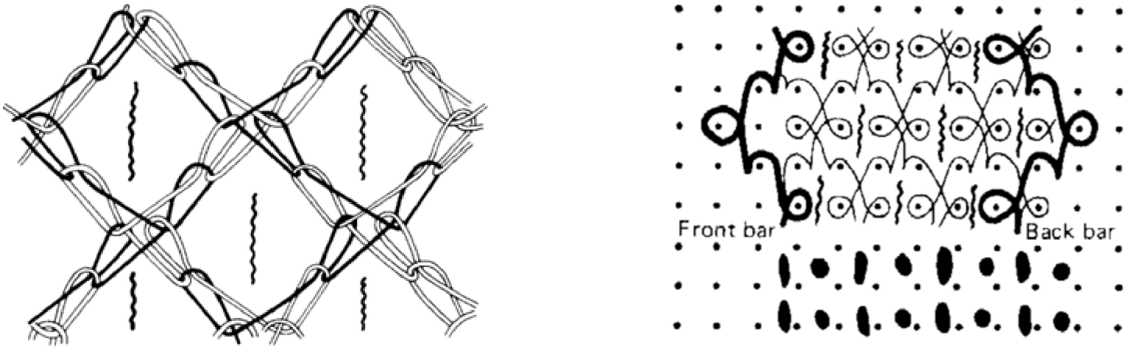


Fig.4. Perforated satin interlacement [2]

2.5. Structure of a balanced net – Rectangular mesh

These nets arise from one or more systems of the warp threads. In combination with perforated and filet stitch, all guide bar have a incomplete introduction thread and every of them laying different carried consecutively for a specific report. In Figure 5. we have an example of combined perforated tights and satin knitted fabrics [1].

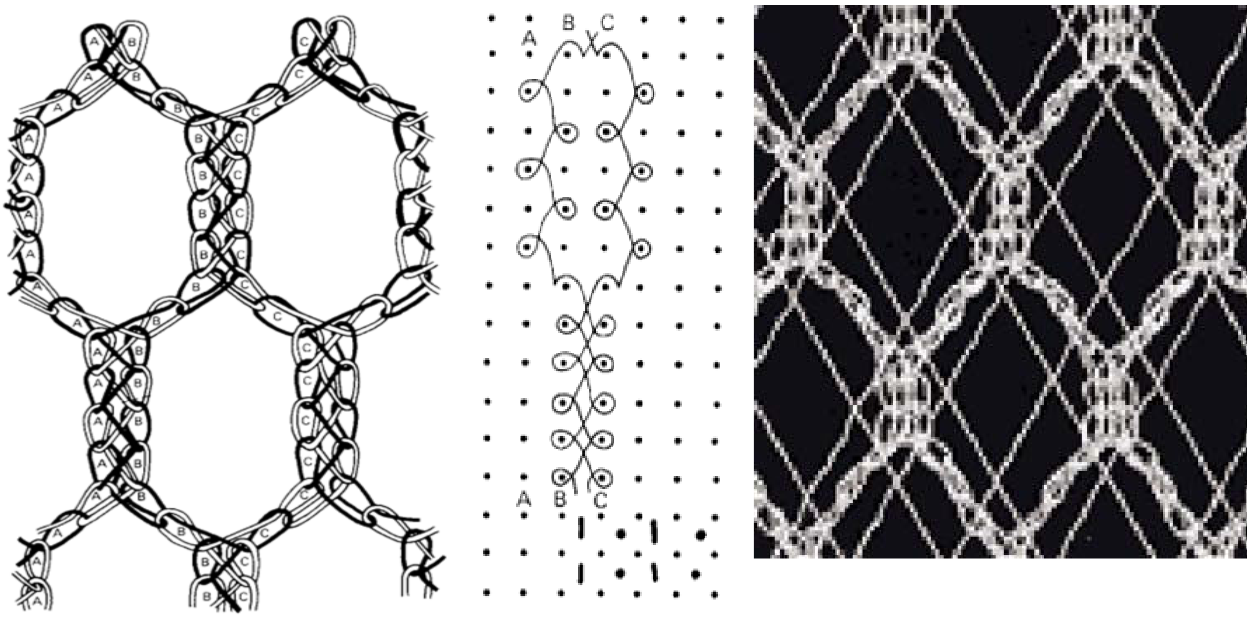


Fig.5. Combined perforated mesh [2]

Typical quadratic hail nets is presented as a lightweight net and high density polyethylene yarn, knitted on Raschel machine. This hail nets is UV stabilized, very strong and resistant to resawing, easy to operate, reducing damage and increasing the yield of crops. It is usually used to protect crops from the hail. It belongs to the perforated knitted fabrics.

3. WARP KNITTING MACHINES

The two major classes of warp knitting machines are Tricots and Raschels [2].

3.1. The Tricot machine

Fabric with tricot machine is drawn-away towards the batching roller almost at right angles to the needle bar. The warp beams are accommodated in an inclined arc towards the back of the machine, with the top beam supplying the front guide bar and the bottom beam supplying the back guide bar. The warp sheets pass over the top of the guide rocker-shaft to their tension rails situated at the front of the machine.

Mechanical attention to the knitting elements is carried out at the front of the machine as the warp beams prevent access to the back. As all the warp sheets are drawn over the rocker-shaft to the front of the machine it is easier to thread up the guide bars commencing with the back bar. The guide bars are therefore numbered from the back towards the front of the machine because of this threading sequence.

The small angle of fabric take-away and the type of knitting action produce a gentle and low tension on the structure being knitted. This is ideal for the high-speed production of simple structures. In Figure 6. is knitting elements in a bearded needle. Figure 7. i 8. Show itself Tricot machine [2].

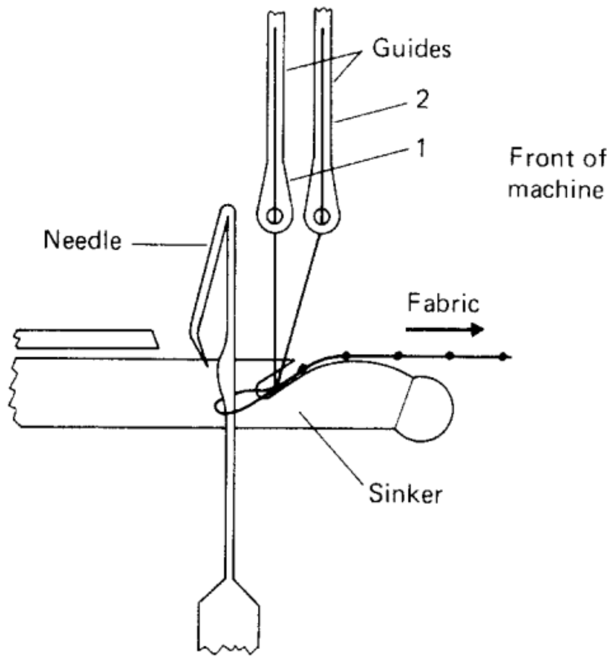


Fig.6. Knitting elements in a bearded needle tricot machine [2]

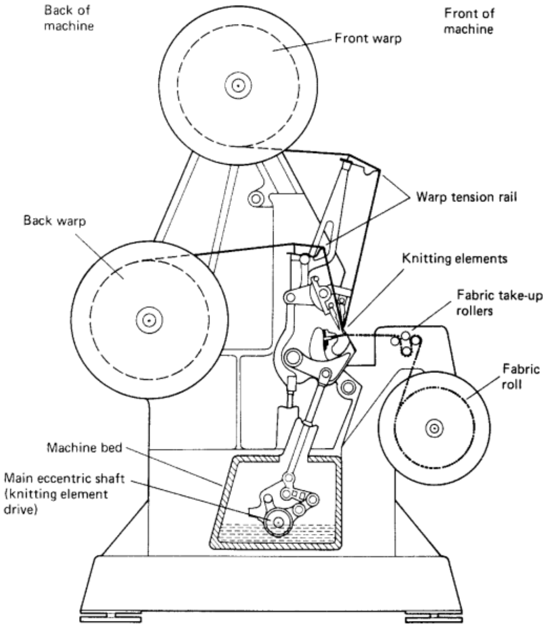


Fig.7. Cross-section of a bearded needle tricot machine [2]

Fig.8. The Tricot machine [4]

The knitting cycle of the bearded needle tricot machine can be displayed through 7 positions needles and guides, Fig.9. :

***1)** The rest position (a).* The needles have risen to 2/3 of their full height from knock-over and have their beards towards the back of the machine. The presser is withdrawn and the guides are at the front of the machine with the sinkers forward, holding the old overlaps in their throats so that they are maintained at the correct height on the needle stems.

***2)** Backward swing and overlap shog* (b, c). After swinging through the needles to the beard side, the guides are overlapped across the beards, usually by one needle space in opposite directions.

***3)** The return swing and second rise (c, d).* As the guides swing to the front, the needles rise to their full height so that the newly-formed overlaps slip off the beards onto the stems above the old overlaps. This arrangement reduces the amount of guide-bar swing necessary and therefore the time required.

***4)** Pressing (e).* The needle bar descends so that the open beards cover the new overlaps. There is a slight pause whilst the presser advances and closes the beards.

***5)** Landing (f).* As the sinkers withdraw, the upward curve of their bellies lands the old overlaps onto the closed beards.

***6)** Knock-over and underlap shog (g).* The presser is withdrawn and the continued descent of the needle bar causes the old overlaps to be knocked-over as the heads of the needles descend below the upper surface of the sinker bellies. The underlap shog which can occur at any time between pressing and knock-over usually occurs in opposite directions on the two guide bars. *7) The sinkers now move forward to* hold down the fabric loops and push them away from the ascending needles, which are rising to the rest position [2].

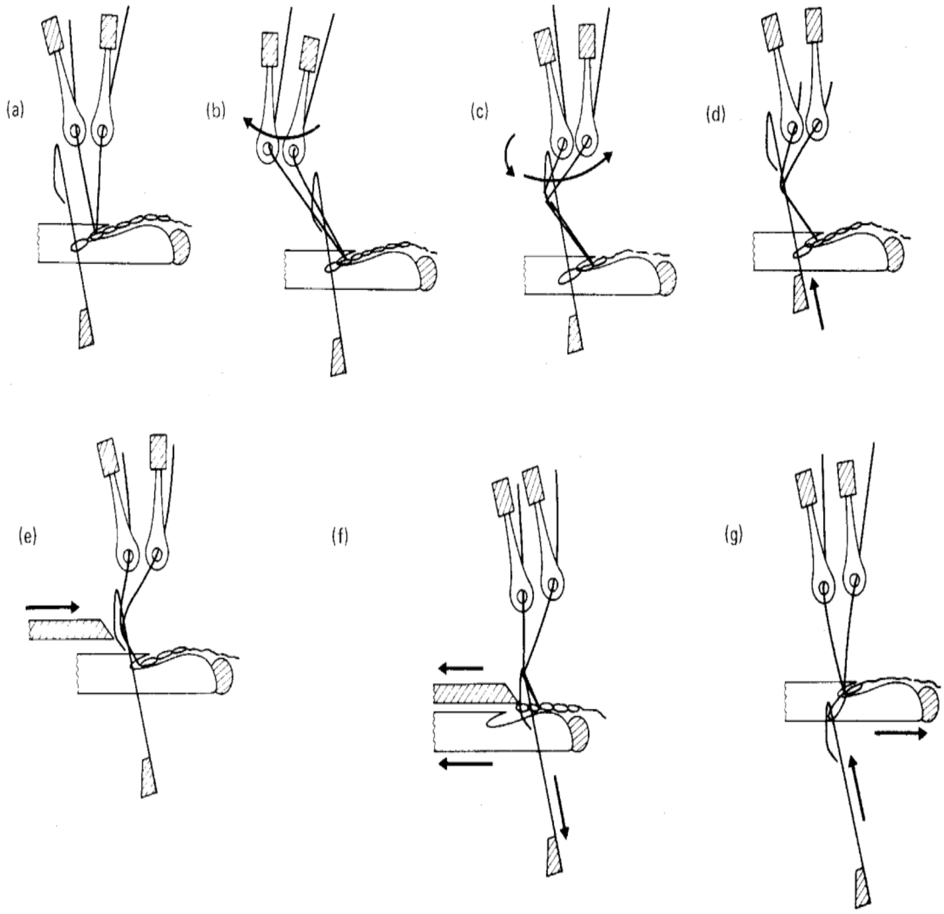


Fig.9. Knitting cycle of a bearded needle tricot machine [2]

3.2. The Raschel machine

Raschel machines are mostly used for knitting hail nets in the agro-textile industry. They are not joined together by a lead across their ends nearest to the needle bar so they can move away clear of the needles, towards the back of the machine, for the rest of the knitting cycle. The needle trick-plate verge acts as a fabric support ledge and knock-over surface.

The fabric is drawn downwards from the needles, almost parallel to the needle bar, at an angle of 120–160 degrees, by a series of take-down rollers.

This creates a high take-up tension, particularly suitable for open fabric structures such as laces and nets. The warp beams are arranged above the needle bar, centred over the rocker-shaft, so that warp sheets pass down to the guide bars on either side of it.

The beams are placed above the machine so that it is accessible at the front for fabric inspec-tion and at the back for mechanical attention to the knitting elements.

The guide bars are threaded, commencing with the middle bars and working outwards from either side of the rocker-shaft. They are numbered from the front of the machine.

With the raschel arrangement, there is accommodation for at least four beams or large numbers of small diameter pattern barsThe accessibility of the raschel machine, its simple knitting action, and its strong and efficient take-down tension make it particularly suitable for the production of coarse gauge open-work structures.

In Figure 10. is knitting elements in a latch needle raschel machine. Figur 11. i 12. show itself Rashel machine [2].

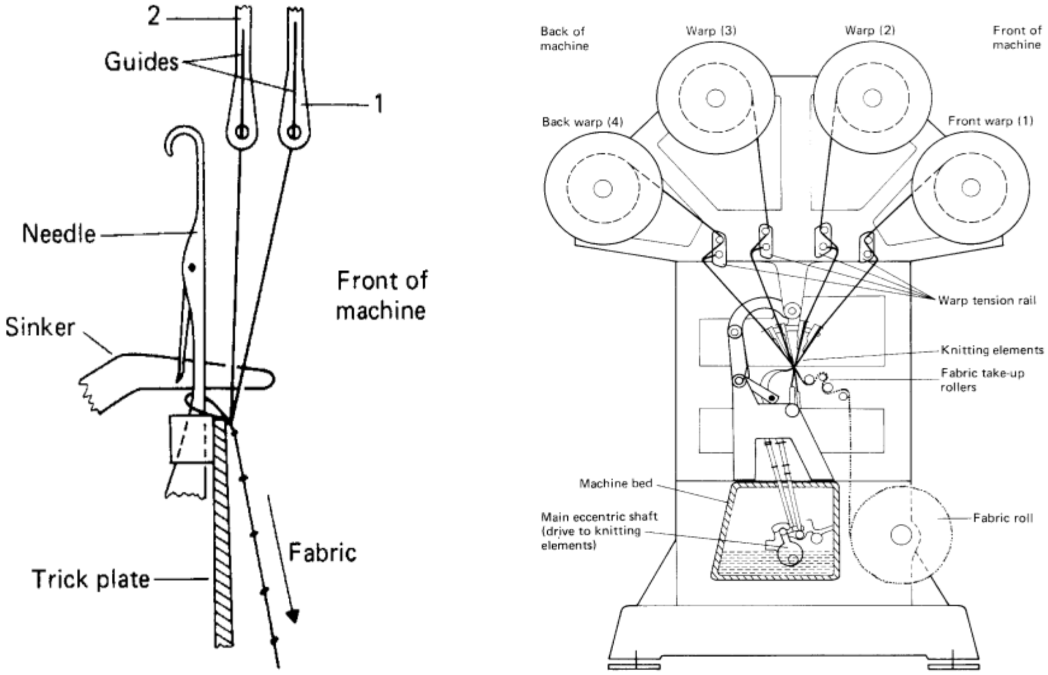


Fig.10. Knitting elements in a latch needle raschel machine

Fig.12. The Raschel machine [5]

The knitting cycle of the bearded needle on Rachel machine :
Raschel needles tend to have longer latches than weft knitting machine needles, to ensure that the wrapped yarns of the overlap goes onto and not below the open latch. This is shown in Figure 13. There is a trick-plate extending the full width of the machine, whose walls preserve the needle spacing and whose verge provides an edge for a clean knock-over. Holding-down sinkers that are thin blades, unleaded at their forward edges, move in a horizontal plain over the top of the trick-plate [2]. Here has a 6 position of the needle:

1) *Holding down (a),* the guide bars are at the front of the machine, completing their underlap shog. The sinker bar moves forward to hold the fabric down whilst the needle bar starts to rise from knock-over.

2) Clearing (b), as the needle bar rises to its full height, the old overlaps slip down onto the stems after opening the latches, which are prevented from flicking closed by latch wires. The sinker bar then starts to withdraw to allow the guide bars to overlap.

***3)** Overlap (c),* the guide bars swing to the back of the machine and then shog for the overlap.
***4)** Return swing (d),* as the guide bars swing to the front, the warp threads wrap into the needle hooks.
***5)** Latch closing (e),* the needle bar descends so that the old overlaps contact and close the latches, trapping the new overlaps inside. The sinker bar now starts to move forward. ***6)** Knocking-over and underlap (f),* as the needle bar continues to descend, its head passes below the surface of the trick-plate, drawing the new overlap through the old overlap which is cast-off and as the sinkers advance over the trick-plate, the underlap shog of the guide bar is commenced [2].

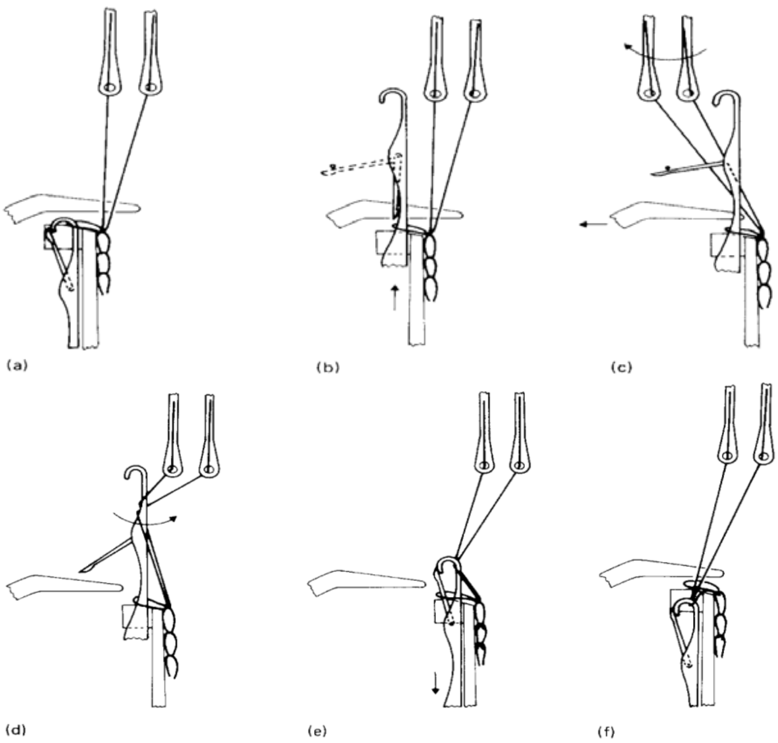


Fig.13. Knitting action of a single needle bar latch needle Raschel machine [2]

4. CONCLUSION

The needs of textiles in agriculture has decreased significantly the use of harmful pesticides and herbicides, bringing a healthy crop growth. The unique manufacturing techniques and the properties of these mixture in sector agro-textile, have made these products much cheaper than chemical pesticides and herbicides.
Flexibility especially refers to systems of knitted materials, such as knitted nets, which have a high degree of adaptation to the various needs of agro-textiles. On the other hand, there is a very simple system of making the transition of a network to another, given the fact that many types of networks can be created on a single machine.

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[5]http://www.liba.de/pages/en/products/raschel-machines.php
[6] http://www.siangmay.com/products/agriculture/agrotextile/

INFLUENCE OF MEN'S SHIRT MODEL COMPLEXITY ON PRODUCTION TIME

Sanja STEFANOVIĆ, Vasilije PETROVIĆ, Marija STANKOVIĆ, Marija SAVIĆ

Abstract: *Manufacturing process time analysis are applying in purpose of relive production time and enlarge productivity. Production time analysis of 3 models mens shirt is used for calculation of daily size produce and number of work resources required for production this garments. Based on results, we can conclude how complicity of model can respond on production time.*

Key words*: men shirt, work operations, production time, sewing*

1. INTRODUCTION

The main feature of garment production technology in the last 150 years is its intensive development in line with the general development of technology and rapid increase of all the achievements which can be applied in garment production process. [1]

Today's textile industry produces clothing items that are attractive, functional, beautiful and pleasant to wear, of a good shape and flexible material. Because of this, the textile industry is placed under increased demands. Clothing line producers must be aware of fashion trends, product design, product variety and quality and market demands on time. At the present time manufacturing processes are accelerated and there is need to respond to the market by the requirements on time. This is why it is necessary to monitor and analyze garment production time and start processes of planning the production right on time. Production time analysis is used with aim of reducing the amount of time that is necessary for production and increasing productivity. [1]

Production time analysis of three men's shirt models, it can be seen how model complexity affects the production time and the amount of work resources needed for their production.

2. MEN'S SHIRT MODEL COMPLEXITY

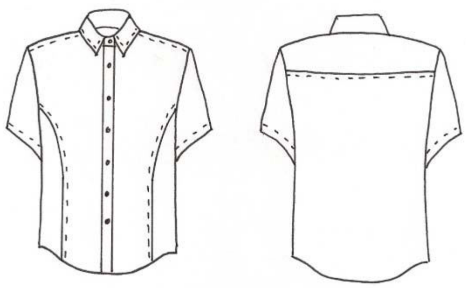

Figure 1. Short sleeve man's shirt sketch of a model – M1 model

Operational sheet of a sewing department for elegant short sleeve man's shirt

1.	2.	3.	4.	5.	6.
1.	Peglanje lajsne , leve i desne	PP	KV	50	23
2.	Našivanje etikete na ledjima	OŠM	KV	50	23
3.	Spajanje gornje i donje ramenjače sa zadnjim delom	OŠM	KV	50	23
4.	Peglanje i rihtanje ramenjače	PP	KV	30	14

5.	Prošivanje lajsne na levom i desnom prenjem delu	OŠM	KV	70	33
6.	Spajanje prednjih talova sa bočnim prednjim delovima	SŠM	KV	60	28
7.	Peglanje šavova na prednjem delu	PP	KV	36	17
8.	Plitak iberštep na sa sastavu bočnih delova i prednjih talova	OŠM	KV	50	23
9.	Rihtanje prednjeg dela	RR	KV	40	19
10.	Spajanje ramenih šavova	OŠM	KV	85	40
11.	Plitak iberštep na ramenim šavovima	OŠM	KV	30	14
12.	Peglanje lajsne rukava	PP	KV	45	21
13.	Nabacivanje rukava	SŠM	KV	75	35
14.	Duboki iberštep na kugli rukava	OŠM	KV	90	42
15.	Peglanje šavova kugle rukava	PP	KV	20	9
16.	Bočno spajanje košulje	SŠM	KV	120	56
17.	Podavijanje rukava (plitak iberštep)	OŠM	KV	125	58
18.	Peglanje i obeležavanje kragne	PP	KV	20	9
19.	Našivanej fišeka za fišbajn na donjoj kragni	OŠM	KV	70	33
20.	Opsecanje gornje kragne	RR	KV	20	9
21.	Štircanje gornje i donje kragne	OŠM	KV	80	37
22.	Opsecanje i cvikovanje kragne	RR	KV	15	7
23.	Raspeglavanje kragne	PP	KV	65	30
24.	Opsicanje gornje lajsne	RR	KV	25	12
25.	Štepanje lajsne	OŠM	KV	20	9
26.	Okretanje lajsne	RR	KV	15	7
27.	Peglanje lajsne	PP	KV	40	19
28.	Štepanje kragne dubokim iberštepom	OŠM	KV	60	28
29.	Nabacivanje kragne na lajsnu	OŠM	KV	85	40
30.	Iberštep na kragni i lajsni	OŠM	KV	45	21
31.	Opsecanje kragne	RR	KV	20	9
32.	Crtanje kragne	RR	KV	30	14
33.	Našivanje kragne na košulju	OŠM	KV	130	61
34.	Zatvaranje kragne i našivanje veličine	OŠM	KV	145	68
35.	Rihtanje košulje i ubacivanje fišbajna	RR	KV	30	14
36.	Izrada rupica	ŠA	KV	55	26
37.	Obeležavanje mesta za dugmeta	RR	KV	20	9
38.	Izrada dugmeta	ŠA	KV	85	40
39.	Podavijanje košulje	OŠM	KV	30	14
40.	Završno peglanje	PP	KV	45	21
41.	Čišćenje od konca	RR	KV	20	9
42.	Pakovanje	RR	KV	50	23
TOTAL PRODACTION TIME				2146"	

Cd = 120
Td = 7,5h → 450\` → 27000"
$t1$ = 2146" ≈ 36\`

Number of workers required

$$R = \frac{Cd \cdot t1}{Td} = \frac{120 \cdot 36}{450} \approx 10$$

Worker's daily capacity

$$Cdr = \frac{Cd}{R} = \frac{120}{10} \approx 12$$

Group tact

$$G = \frac{t1}{R} = \frac{2146}{10} = 214{,}6''$$

Load degree

$$So = \frac{t1}{G} \cdot 100$$

Daily working time fund

$$Tdf = Td \cdot R$$
$$Tdf = 5400$$

$$Ko\check{s}m = \frac{Cd \cdot to\check{s}m}{Td} = \frac{120 \cdot 1040}{27000} \approx 5 \text{ komada običnih šivaćih mašina}$$

$$Ks\check{s}m = \frac{Cd \cdot ts\check{s}m}{Td} = \frac{120 \cdot 60}{27000} \approx 1 \text{ komad specijlnih šivaćih mašina}$$

za opšivanje i spajanje rubova materijala sa 5 konca i dve igle

$$Ks\check{s}m = \frac{Cd \cdot ts\check{s}m}{Td} = \frac{120 \cdot 75}{27000} \approx 1 \text{ komad specijalnih šivačih mašina}$$

za ušivanje rukava

$$Ks\check{s}m = \frac{Cd \cdot ts\check{s}m}{Td} = \frac{120 \cdot 120}{27000} \approx 1 \text{ komad specijalnih dvoiglenih šivaćih}$$

mašina sa lančanim ubodom

$$K\check{s}a = \frac{Cd \cdot t\check{s}a}{Td} = \frac{120 \cdot 85}{27000} \approx 1 \text{ šivaći automat za izradu rupica}$$

$$K\check{s}a = \frac{Cd \cdot t\check{s}a}{Td} = \frac{120 \cdot 55}{27000} \approx 1 \text{ šivaći automat za našivanje dugmeta}$$

$$Kpp = \frac{Cd \cdot tpp}{Td} = \frac{120 \cdot 285}{27000} \approx 2 \text{ radnika za rad na parnoj pegli}$$

$$Krr = \frac{Cd \cdot trr}{Td} = \frac{120 \cdot 265}{27000} \approx 1 \text{ radnik na doradi}$$

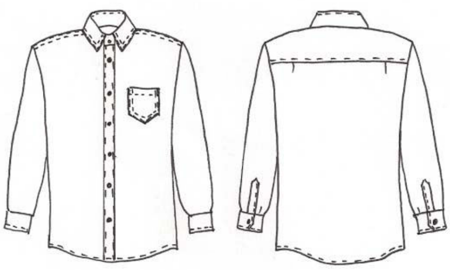

Figure 2. Long sleeve man'shirt sketch of a model – M2 model

Table 2. Operational sheet of a sewing department for M2 model

Operational sheet of a sewing department for sports long sleeve man's shirt					
Redni br.	Naziv operacije	sredstva rada	kategorija rada	vreme izrade	ORO (%)
1.	2.	3.	4.	5.	6.
1.	Peglanje lajsne , leve i desne	PP	KV	40	19
2.	Peglanje dzepa	PP	KV	40	19
3.	Prošivanje lajsne na prednjem delu	OŠM	KV	70	33
4.	Našivanje dzepa	OŠM	KV	130	61
5.	Raspeglavanje lajsni na prednjem delu	PP	KV	15	7
6.	Našivanje etikete	OŠM	KV	80	38
7.	Rihtanje ramenjače	RR	KV	30	14
8.	Spajanje gornje i donje ramenjače sa zadnjim delom	OŠM	KV	90	42
9.	Iberštep na šavu ramenjace i zadnjeg dela	OŠM	KV	50	24
10.	Peglanje i rihtanje ramenjače	PP	KV	15	7
11.	Spajanje ramenih šavova	OŠM	KV	90	42
12.	Iberštep na ramenim šavovima	OŠM	KV	65	31
13.	Peglanje paspula za šlic rukava	PP	KV	15	7
14.	Nabacivnje psapula na šlic rukava	OŠM	KV	65	31
15.	Našivanje kugle rukava	SŠM	KV	70	33
16.	Iberstep na savovima kugle rukava	OŠM	KV	180	85
17.	Spajanje bočnih šavova košulje	SŠM	KV	70	33
18.	Prošivanje manžetne	OŠM	KV	30	14
19.	Spajanje manžetne	OŠM	KV	70	33
20.	Opsecanje manžetne i okretanje	RR	KV	50	24
21.	Iberštep na manžetnama	OŠM	KV	130	61
22.	Peglanje manžetne	PP	KV	15	7
23.	Nabacivanje manžetne na rukavima	OŠM	KV	75	35
24.	Crtanje kragne	RR	KV	17	8
25.	Obrađivanje lajsne	RR	KV	15	7
26.	Štircanje gornje i donje kragne	OŠM	KV	60	28
27.	Preokretanje kragne	RR	KV	15	7
28.	Peglanje kragne sa kalupom	PP	KV	20	9
29.	Iberštepanje lajsne i kragne	OŠM	KV	70	33
30.	Našivanje lajsne na kragnu	OŠM	KV	60	28
31.	Okretanje lajsne	RR	KV	15	7
32.	Zatvaranje lajsne	OŠM	KV	90	42
33.	Našivanje kragne na košulju	OŠM	KV	210	99
34.	Rihtanje košulje	RR	KV	10	5
35.	Podavijanje košulje	OŠM	KV	45	21
36.	Izrada rupica	ŠA	KV	105	49
37.	Našivanje dugmadi	ŠA	KV	110	52

38.	Završno peglanje	PP	KV	150	71
39.	Čišćenje od konca	RR	KV	30	14
40.	Pakovanje	RR	KV	70	33
PRODUCTION TIME				2547"	

Cd = 120
Td = 7,5h → 450` → 27000"
$t1 = 2547'' \approx 43`$

Number of workers required

$$R = \frac{Cd \cdot t1}{Td} = \frac{120 \cdot 43}{450} \approx 12$$

Worker's daily capacity

$$Cdr = \frac{Cd}{R} = \frac{120}{12} \approx 10$$

Group tact

$$G = \frac{t1}{R} = \frac{2547}{12} = 212{,}25''$$

Load degree

$$So = \frac{t1}{G} \cdot 100$$

Daily working time fund

$$Tdf = Td \cdot R$$

$$Tdf = 5400$$

Needed quantity of working resources

$$Ksr = \frac{Cd \cdot tsr}{Td}$$

$$Košm = \frac{Cd \cdot tošm}{Td} = \frac{120 \cdot 1660}{27000} \approx 8 \text{ komada običnih šivaćih mašina}$$

$$Ksšm = \frac{Cd \cdot tsšm}{Td} = \frac{120 \cdot 70}{27000} \approx 1 \quad \text{komad specijalnih dvoiglenih šivaćih mašina sa lančanim ubodom}$$

$$Ksšm = \frac{Cd \cdot tsšm}{Td} = \frac{120 \cdot 70}{27000} \approx 1 \text{ komad specijalnih šivačih mašina za ušivanje rukava}$$

$$Kša = \frac{Cd \cdot tša}{Td} = \frac{120 \cdot 105}{27000} \approx 1 \text{ šivaći automat za izradu rupica}$$

$$Kša = \frac{Cd \cdot tša}{Td} = \frac{120 \cdot 110}{27000} \approx 1 \text{ šivaći automat za našivanje dugmeta}$$

$$Kpp = \frac{Cd \cdot tpp}{Td} = \frac{120 \cdot 295}{27000} \approx 2 \text{ parih pegli}$$

$$Krr = \frac{Cd \cdot trr}{Td} = \frac{120 \cdot 252}{27000} \approx 1 \text{ radnik na doradi}$$

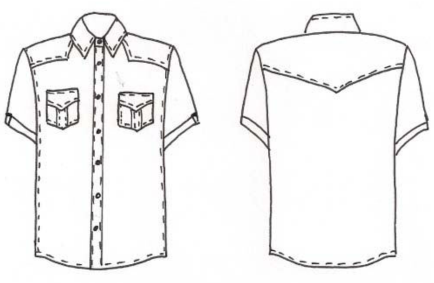

Figure 3. Short sleeve man's shirt sketch of a model – M3 model

OPERACIONI LIST ŠIVARE ZA SPORTSKU MUŠKU KOŠULJU SA KRATKIM RUKAVIMA

Redni br.	Naziv operacije	sredstva rada	kategorija rada	vreme izrade	ORO (%)
1.	2.	3.	4.	5.	6.
1.	Peglanje lajsne , leve i desne	PP	KV	40	18
2.	Peglanje dzepova	PP	KV	70	32
3.	Prošivanje lajsne na prednjem delu	OŠM	KV	70	32
4.	Našivanje dzepova	OŠM	KV	220	100
5.	Spajanje gornjeg i donjeg pokopca	OŠM	KV	60	27
6.	Okretanje poklopaca	RR	KV	30	14
7.	Iberštep na poklopcima za dzepove	OŠM	KV	180	82
8.	Našivanje poklopaca na košulji	OŠM	KV	40	18
9.	Raspeglavanje lajsni na prednjem delu	PP	KV	15	7
10.	Našivanje etikete	OŠM	KV	80	36
11.	Rihtanje ramenjače	RR	KV	30	14
12.	Spajanje gornje i donje ramenjače sa zadnjim delom	OŠM	KV	100	46
13.	Iberštep na šavu ramenjace i zadnjeg dela	OŠM	KV	50	23
14.	Peglanje i rihtanje ramenjače	RR	KV	15	7
15.	Spajanje ramenih šavova i ubacivanje ukrasnog dela	OŠM	KV	110	50
16.	Iberštep na ramenim šavovima i ukrasnom delu	OŠM	KV	155	71
17.	Našivanje kugle rukava	SŠM	KV	70	32
18.	Iberstep na savovima kugle rukava	OŠM	KV	180	82
19.	Spajanje bočnih šavova košulje	SŠM	KV	70	32
20.	Podavijanje rukava	RR	KV	45	21
21.	Izrada ringlica na podvivu rukava	ŠA	KV	30	14
22.	Crtanje kragne	RR	KV	17	8
23.	Obrađivanje lajsne	RR	KV	15	7
24.	Štircanje gornje i donje kragne	OŠM	KV	60	27
25.	Preokretanje kragne	RR	KV	15	7
26.	Peglanje kragne sa kalupom	PP	KV	20	9
27.	Iberštepanje lajsne i kragne	OŠM	KV	90	41
28.	Našivanje lajsne na kragnu	OŠM	KV	85	39
29.	Okretanje lajsne	RR	KV	15	7
30.	Zatvaranje lajsne	OŠM	KV	90	41
31.	Našivanje kragne na košulju	OŠM	KV	235	107
32.	Rihtanje košulje	RR	KV	15	7
33.	Podavijanje košulje	OŠM	KV	55	25
34.	Izrada rupica	ŠA	KV	105	48
35.	Našivanje dugmeta	ŠA	KV	110	50
36.	Stavljanje drihera na košulji	ŠA	KV	45	21

37.	Završno peglanje	PP	KV	150	68
38.	Čišćenje od konca	RR	KV	30	14
38.	Pakovanje	RR	KV	70	32
Time production				2852"	

Cd = 120
Td = 7,5h → 450` → 27000"
$t1 = 2852" \approx 48`$

Number of workers necessary

$$R = \frac{Cd \cdot t1}{Td} = \frac{120 \cdot 48}{450} \approx 13$$

Worker's daily capacity

$$Cdr = \frac{Cd}{R} = \frac{120}{13} \approx 9$$

Group tact

$$G = \frac{t1}{R} = \frac{2852}{13} = 219{,}38"$$

Load degree

$$So = \frac{t1}{G} \cdot 100$$

Daily working time fund

$$Tdf = Td \cdot R$$

$$Tdf = 5400$$

Needed quantity of working resources

$$Ksr = \frac{Cd \cdot tsr}{Td}$$

$$Košm = \frac{Cd \cdot tošm}{Td} = \frac{120 \cdot 1860}{27000} \approx 8 \text{ komada običnih šivaćih mašina}$$

$$Ksšm = \frac{Cd \cdot tsšm}{Td} = \frac{120 \cdot 70}{27000} \approx 1$$ komad specijalnih dvoiglenih šivaćih mašina sa lančanim ubodom

$$Ksšm = \frac{Cd \cdot tsšm}{Td} = \frac{120 \cdot 70}{27000} \approx 1$$ komad specijalnih šivačih mašina za ušivanje rukava

$$Kša = \frac{Cd \cdot tša}{Td} = \frac{120 \cdot 30}{27000} \approx 1 \text{ šivaći automat za izradu zapora}$$

$$Kša = \frac{Cd \cdot tša}{Td} = \frac{120 \cdot 105}{27000} \approx 1 \text{ šivaći automat za izradu rupica}$$

$$Kša = \frac{Cd \cdot tša}{Td} = \frac{120 \cdot 110}{27000} \approx 1 \text{ šivaći automat za našivanje dugmeta}$$

$$Kpp = \frac{Cd \cdot tpp}{Td} = \frac{120 \cdot 295}{27000} \approx 2 \text{ radnika za rad na parnoj pegli}$$

$$Krr = \frac{Cd \cdot trr}{Td} = \frac{120 \cdot 297}{27000} \approx 1 \text{ radnik na doradi}$$

3. Making of assembly plans

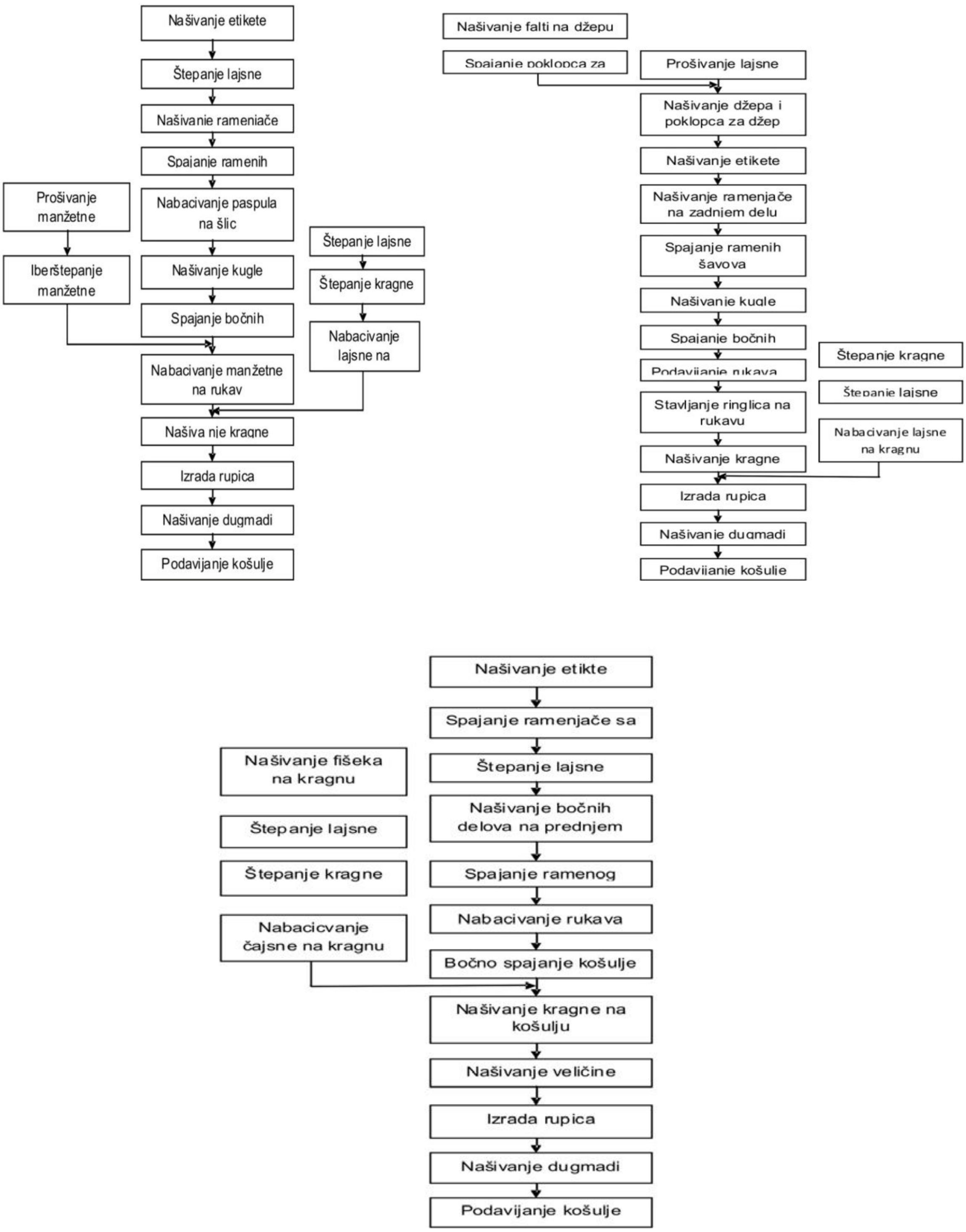

Figure 3.1. Making of assembly plans for M1, M2 and M3

Appearance of sutured men's shirt models


Picture 3.5. Final appearance of elegant short sleeve man's shirt model
Picture 3.6. Final appearance of sports long sleeve man's shirt model

Picture 3.7.Final appearance of sporty short sleeve man's shirt

CONCLUSION

This papers task was to show the diversity of the processing time depending on the severity of the models that are being developed. On operational sheets it can be seen that that the least amount of time was spent during the creation of an elegant men's shirts model, 36 minutes. Men's sports shirt that has long sleeves and one pocket has a build time of 43 minutes, while making sports shirts with short sleeves requires 48 minutes. From these results it can be concluded that the time of man's shirt production depends on the model and the shirt material, ie on whether the shirt is made of sampled material, does the model contain pockets, pleats, decorative parts and etc..

Thus, the model complexity affects the garment production time, and production time has an influence on a number of workers that will be engaged to produce certain clothing item. Production time also affects productivity i.e. production capacity. Greater ammount of time required for production process of man's shirt models increases the number of workers engaged in a production produces, reduces worker's daily capacity and increases the number of machines working in production.

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MODEL COMPLEXITY AND ITS IMPACT ON PRODUCTION TIME

Sanja STEFANOVIĆ, Vasilije PETROVIĆ, Marija STANKOVIĆ, Marija SAVIĆ

Abstract: *The time analysis of production processes is applied in order to reduce processing time and increase productivity. The analysis of time making for the children's jeans trousers and children's jeans bermuda shorts, one can calculate daily production capacities and number of resources that are needed to create these garments. On the basis of the time, it is concluded that the complexity of the model affects the time of their creation.*

Key words: *pants, bermuda shorts, work operations, production time, sewing.*

1. INTRODUCTION

The main feature of garment manufacturing technology in the last 150 years is its rapid development in line with the general development of technology and the rapid increase of all the achievements that can be applied in garment manufacturing processes.

Today, manufacturing processes are accelerated and it is needed to respond to the market demands on accurate time. For this reason it is necessary to monitor and analyze the execution time of clothes and to begin the process of planning production on time. The time analysis of production processes is applied with the aim to reduce processing time and increase productivity.

Well selected technological operations shorten garment making, reduce manufacturing costs per unit of output, allowing the products flow through all stages without experiencing downtime of production, reduce inventories of raw materials, allow rational use of the machinery park, prevent low productivity and the like.

Many technological processing operations can be performed using the different methods and different tools. By technological analysis of making it is necessary to choose the optimal production method that will provide high productivity, maintain the products quality with the time minimum and minimal energy consumption.

2. PLANS MAKING FOR TECHNOLOGICAL OPERATIONS

Technological operations plan is a separate document in which all required technological operations to produce a particular garment are classified according to the order of their performing. Next to the technological operations names in the technological operations plan, the other information related to technological operations will be recorded. [1]
Operating list is made specifically for:

1. Technological process of cutting
2. Technological process of sewing
3. Technological process of finishing

Technological operations plan contains general information section and a list of technological operations. The information part of the of technological operations plan includes:

1. the garment name
2. the model
3. a brief description of the model
4. the model sketch and
5. the other information (customer name, work order number, etc.). [1]

After the operating table drafting is done, the recapitulation of the processing time by type of machinery used for making garment and the time needed for manual labor in order to determine the number of required resources, will be done[1].

Total production time per unit (t1) is obtained by adding the processing time by stages of production:

$$t_1 = t_{kr} + t_{ši} + t_{do}$$

where t_{kr} - processing time for cutting phase
$t_{ši}$ - processing time for the sewing phase
t_{do} - processing time for the finishing phase [1]

3. TECHNOLOGICAL PROCESS OF SEWING

The sewing technological process is a process in which the tailored parts of garment are to be connected through all the phases until a finished garment is made. The organization of the technological sewing process allows quick production flow, reducing inventories of the unfinished production [1].

4. ANALYSIS OF THE SEWING MACHINES OPERATIONS

The sewing process develops through a number of different operations in which the tailored parts of garment are to be connected. These operations are performed by a variety of means from the ordinary sewing machines to the very modern automatic machines. [1]

By analysis of the model M1 and M2 the most important technological operations were selected. Recorded times of the sewing technology operations are shown in Table 5 for model M1 and in Table 7 for the model M2.

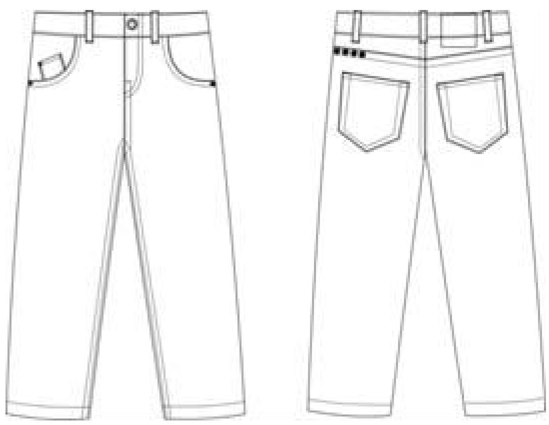

Figure 1. Sketch model M1, children's jeans trousers

Table 1. Technological list of the sewing machines department

Operacioni list šivare za model M1			
Broj radnika u liniji: 15			
Dnevni kapacitet: 174			
redni br.	Naziv tehnološke operacije	sredstvo rada	vreme izrade (min)
1	Proubiti mali džep	OŠM	0,15
2	Obeležiti mesto našivanja malog džepa	RR	0,28
3	Našivanje malog džepa	OŠM	1,3
4	Endlanje podlistaka zaobljenog džepa	SM(ov-4)	0,48
5	Našivanje podlistka na džep kesi zaobljenog džepa	OŠM	1,53
6	Odštircati otvor džep kese	OŠM	0,88
7	Iberštepati džep kesu	SM(2igl)	0,47
8	Zatvoriti džep kesu	SM(ov-4)	0,63
9	Prepeglati otvor zaobljenog džepa	PP	0,51
10	Iberštepati otvor džepa	SM(2igl)	0,81
11	Utvrditi džep kesu na nogavici	OŠM	0,58
12	Prepeglati loštuk šlica	PP	0,15
13	Izendlati loštuk šlica	SM(ov-4)	0,48
14	Spojiti malo sedalo	OŠM	0,87
15	Izendlati malo sedalo	SM(ov-4)	0,5
16	Našiti rasfešlus I loštuk na šlicu	OŠM	2,48
17	Iberštepati malo sedalo	SM(2igl)	0,68
18	Spojiti sredinu gornjeg dela zadnje strane	OŠM	0,33
19	Spojiti veliko sedalo	OŠM	0,88
20	Izendlati veliko sedalo I gornji deo zd.	SM(ov-4)	0,64
21	Spojiti gornji I donji deo zadnjeg dela	OŠM	0,35
22	Iberštepati veliko sedalo I sastav gornjeg I donjeg dela zadnjeg dela pantalona	SM(2igl)	1,3
23	Izraditi ukrasne trake za desnom džepu	SM (po.)	0,95
24	Prepegleti levi I desni džep na zadnjem delu	PP	1,08
25	Proštepati levi I desni džep	OŠM	0,71
26	Obeležiti mesto našivanje džepova na zadnjem delu	RR	0,6
27	Našiti džepove na zadnejm delu	OŠM	4,08
28	Spojiti korak pantalona	OŠM	1,31
29	Izendlati korak pantalona	SM(ov-4)	1,11
30	Iberštepati korak pantalona	SM(2igl)	1,55
31	Spojiti bočne strane nogavica	OŠM	1,91
32	Izendlati bočne strane nogavice	SM(ov-4)	1,21
33	Izraditi gajke	SM(gaj.)	0,75
34	Našiti gajke na pantalonama	OŠM	0,68
35	Spojiti pojas	OŠM	0,33

36	Našiti pojas na pantalone	OŠM	2,7
37	Iberštepati pojas	SM(2igl)	0,76
38	Našiti gajke na pojasu	OŠM	0,7
39	Porubiti nogavice	SM(2igl)	0,79
UKUPNO:			37,50

To calculate the data for the plan making of the technological process of sewing children's jeans trousers models M1, a daily capacity was given (Cd), which is 173 units and daily working time (Tr), which amounts 7.15 hours.

The required number of workers:

$$R = \frac{Cd \cdot T\check{s}i}{Tr} = \frac{174 \cdot 37{,}50}{435} = 15 \text{ the workers in line}$$

Daily capacity per worker:

$$Cd = \frac{Cd}{R} = \frac{174}{15} = 11{,}6 \text{ units}$$

Quantity of ordinary machines (pc) is calculated according to the formula:

$$Kom = \frac{Cd \cdot Tom}{Tr} = \frac{174 \cdot 21{,}07}{435} = 8{,}42 \approx 9 \text{ ordinary sewing machines}$$

The amount of special machines (overlock machines with 4 threads)

$$Ksm = \frac{Cd \cdot Tsm}{Tr} = \frac{174 \cdot 4{,}42}{435} =$$
$$1{,}76 - 2 \text{ special sewing machines} - \text{overlock machines with 4 threads}$$

The amount of special sewing machines - double needle machines:

$$Ksm = \frac{Cd \cdot Tsm}{Tr} = \frac{174 \cdot 6{,}32}{435} = 2{,}52 \approx 2 \text{ 2 special sewing machines- double needle machines}$$

Quantity special sewing machines - beltloop sewing machines:

$$Ksm = \frac{Cd \cdot Tsm}{Tr} = \frac{174 \cdot 0{,}95}{435} = 0{,}38 \approx 1 \text{ 1 special sewing machines- beltloop sewing machines}$$

The amount of special sewing machines - knotting machine

$$Ksm = \frac{Cd \cdot Tsm}{Tr} = \frac{174 \cdot 0{,}75}{435} = 0{,}3 \approx 1 \text{ 2 special sewing machines - knotting machine}$$

The amount of steam iron:

$$Kpp = \frac{Cd \cdot Tpp}{Tr} = \frac{174 \cdot 1{,}74}{435} = 0{,}69 \approx 1 \text{ steam iron}$$

The number of workers for manual labor:

$$Kr = \frac{Cd \cdot Trr}{Tr} = \frac{174 \cdot 0{,}88}{435} = 0{,}40 \approx 1 \text{ worker for inter-phase works}$$

The group tact or the production unit tact is a time interval of retention working subjects in the workplace and in the apparel industry it serves to burden workplaces. It is calculated according to the formula:

$$G = \frac{Tši}{R} = \frac{37{,}50}{15} = 2{,}5\,min$$

Figure 2. Model sketch M2, the children's jeans bermuda shorts

Table 2. Technological list of the sewing machines department

Operacioni list šivare za model M2			
Broj radnika u liniji: 15			
Dnevni kapacitet: 145			
redni br.	Naziv tehnološke operacije	sredstvo rada	vreme izrade (min)
1	Proubiti mali džep	OŠM	0,15
2	Obeležiti mesto našivanja malog džepa	RR	0,28
3	Našivanje malog džepa	OŠM	1,3
4	Endlanje podlistaka zaobljenog džepa	SM(ov-4)	0,48
5	Našivanje podlistka na džep kesi zaobljenog džepa	OŠM	1,53
6	Odštircati otvor džep kese	OŠM	0,88
7	Iberštepati džep kesu	SM(2igl)	0,47
8	Zatvoriti džep kesu	SM(ov-4)	0,63
9	Prepeglati otvor zaobljenog džepa	PP	0,51
10	Iberštepati otvor džepa	SM(2igl)	0,81
11	Utvrditi džep kesu na nogavici	OŠM	0,58
12	Spojiti gornji deo I donji deo nogavica	OŠM	0,76
13	Izendlati spojenu gornju I donju nogavicu	SM(ov-4)	0,49
14	Iberštepati sastav gornje I donje nogavice	SM(2igl)	0,57
15	Prepeglati loštuk šlica	PP	0,15
16	Izendlati loštuk šlica	SM(ov-4)	0,48
17	Spojiti malo sedalo	OŠM	0,87
18	Izendlati malo sedalo	SM(ov-4)	0,5
19	Našiti rasfešlus I loštuk na šlicu	OŠM	2,48
20	Iberštepati malo sedalo	SM(2igl)	0,68
21	Spojiti sredinu gornjeg dela zadnje strane	OŠM	0,33
22	Spojiti veliko sedalo	OŠM	0,88

23	Izendlati veliko sedalo I gornji deo zd.	SM(ov-4)	0,64
24	Spojiti gornji I donji deo zadnjeg dela	OŠM	0,35
25	Iberštepati veliko sedalo I sastav gornjeg I donjeg dela zadnjeg dela pantalona	SM(2igl)	1,3
26	Odštircati patnu levog džepa	OŠM	0,63
27	Prepegleti levi I desni džep na zadnjem delu I patnu	PP	1,08
28	Iberštepati patnu levog džepa	SM(2igl)	0,95
29	Proštepati levi I desni džep	OŠM	0,71
30	Obeležiti mesto našivanje džepova na zadnjem delu	RR	0,6
31	Našiti džepove na zadnejm delu	OŠM	4,08
32	Obeležiti mesto patne	RR	0,19
33	Našiti patnu levog džepa	OŠM	0,38
34	Obeležiti mesto ukrasnog rajsfešlusa	RR	0,35
35	Proseći prorez za našivanje rajsfešlusa iznad desnog džepa	RR	0,41
36	Raspeglati prorez za našivanje ukrasnog rajsfešlusa	PP	0,46
37	Našivanje rajsfešlusa	OŠM	2,64
38	Spojiti korak pantalona	OŠM	1,31
39	Izendlati korak pantalona	SM(ov-4)	1,11
40	Iberštepati korak pantalona	SM(2igl)	1,55
41	Spojiti bočne strane nogavica	OŠM	1,91
42	Izendlati bočne strane nogavice	SM(ov-4)	1,21
43	Izraditi gajke	SM(gaj.)	0,75
44	Našiti gajke na pantalonama	OŠM	0,68
45	Spojiti pojas	OŠM	0,33
46	Našiti pojas na pantalone	OŠM	2,7
47	Iberštepati pojas	SM(2igl)	0,76
48	Našiti gajke na pojasu	OŠM	0,7
49	Izendlati dužinu nogavica	SM(ov-4)	0,89
50	Prepeglati dužinu nogavica	PP	0,52
UKUPNO:			45.00

To calculate the data for the plan making of the technological process of sewing children's jeans trousers models M1, a daily capacity was given (Cd), which is 173 units and daily working time (Tr), which amounts 7.15 hours.

The required number of the workers:

$$R = \frac{Cd \cdot Tši}{Tr} = \frac{145 \cdot 45}{435} = 15 \text{ the workers in line}$$

Daily capacity per worker:

$$Cd = \frac{Cd}{R} = \frac{145}{15} = 9{,}66 \text{ units}$$

Quantity of the ordinary machines (pc) is calculated according to the formula:

$Kom = \frac{Cd \cdot Tom}{Tr} = \frac{145 \cdot 25{,}64}{435} = 8{,}54 \approx 9$ ordinary sewing machines

The amount of special machines (overlock with 4 threads)

$$Ksm = \frac{Cd \cdot Tsm}{Tr} = \frac{145 \cdot 6{,}43}{435} = 2{,}14 \approx 3 \text{ special sewing machines} - overluk\ 4\ treads$$

The amount of special sewing machines - double needle machines:

$$Ksm = \frac{Cd \cdot Tsm}{Tr} = \frac{145 \cdot 7{,}09}{435} = 2{,}36 \approx 2 \text{ special sewing machines} - \text{ double needle machines}$$

The amount of special sewing machines – knotting machine

$$Ksm = \frac{Cd \cdot Tsm}{Tr} = \frac{145 \cdot 0{,}75}{435} = 0{,}25 \approx 1 \text{ special sewing machine} - \text{ knotting machine}$$

The amount of steam iron:

$$Kpp = \frac{Cd \cdot Tpp}{Tr} = \frac{145 \cdot 2{,}72}{435} = 0{,}90 \approx \quad 1 \text{ steam iron}$$

The number of workers for manual labor:

$$Rrr = \frac{Cd \cdot Trr}{Tr} = \frac{145 \cdot 1{,}83}{435} = 0{,}61 \approx 1\ worker$$

The group tact or the production unit tact is a time interval of retention working subjects in the workplace and in the apparel industry it serves to burden workplaces. It is calculated according to the formula:

$$G = \frac{Tši}{R} = \frac{37{,}50}{15} = 2{,}5\ min$$

CONCLUSION

By creating the operational sheets of models M1 and M2 for the children's jeans trousers and children's bermuda shorts, an time analysis of their making has done. Based on the operational sheets, the working tools and resources that are used for each model operation are determined. Further on this basis, the number of machines and workers needed for the daily production capacity of models M1 and M2 is calculated.

In the operational sheets it can be seen that for the development of the model M1 is required 37.50 minutes, while for the model M2 is 45 minutes, which is 7.50 minutes longer. The processing time difference of these two models is caused by the different number of operations that are needed to make them. Thus, for the modeling M1 39 operations are required and for M2 model 50 operations. Model M1 has two operations that model M2 does not have and these are the operation 23 (making ribbons on the pocket) and 39 (trouser legs hem). Model M2 differs from M1 in the operations 12, 13, 14, 26, 28, 33, 34, 35, 36, 37 i.e. the operations that are necessary for the development of the left pocket flap and decorative zipper making.

It can be concluded that a larger number of operations increases the production time of the model and the processing time duration affects the number of pieces that can be sawn in a day, i.e. affects the daily capacity. Thus, 15 people in line can sew 174 pieces of model M1 and 145 pieces of model M2 per day, i.e. 29 model M1 pieces can be sewn more.

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DEVELOPMENT OF TECHNICAL DOCUMENTATION USING INDUSTRIAL DESIGN SOFTWARE KALEDO STYLE ON EXAMPLE OF A FEMALE PANTS

Marija STANKOVIĆ, Vasilije PETROVIĆ, Aleksandra ZDRAVKOVIĆ, Ivana SKOKO, Marija SAVIĆ

Abstract: *This paper presents the development of technical documentation which enabled a solution of a numerous problems that are following production nowadays. These problems are primarily related to the short deadlines of making clothing products with products technical preparation that requires significant time. As a part of this work, industry software KALEDO Style – a program for clothes design is described. Advanced design tools, such as industrial solution software Kaledo Style which is used in this paper, facilitates the creation of new styles and layout patterns. Users of this software can quickly and easily generate their own ideas, combine colors, fabrics and styles, all with the aim of obtaining the optimal solution for the creation of their product range. Use of this software is described in this paper on the example of the preparation of technical documentation for a female pants.*

Key words: *computerized clothes construction, Kaledo Style, technical documentation, female pants*

1. INTRODUCTION

Time in which we live in is characterized by the progressive development of science, engineering and technology, which reflects on the textile industry as well as the designers. Hand made fashion drawings and technical sketches is almost completely replaced with computer drafting. Increasingly, software us used for vector drawings of sketch models which contributes to faster and more efficient development of sketches itself and accompanying technical documentation.

Kaledo Style is French company Lectra software, designed for fashion design. It allows fashion designers easier getting to new trends and themes, makes it easier to design new styles and creating products in different colors and fabrics. The possibility of obtaining high-quality images allows quick and easy communication with the readers of technical specifications.

2. DESCRIPTION AND SKETCH OF A MODEL

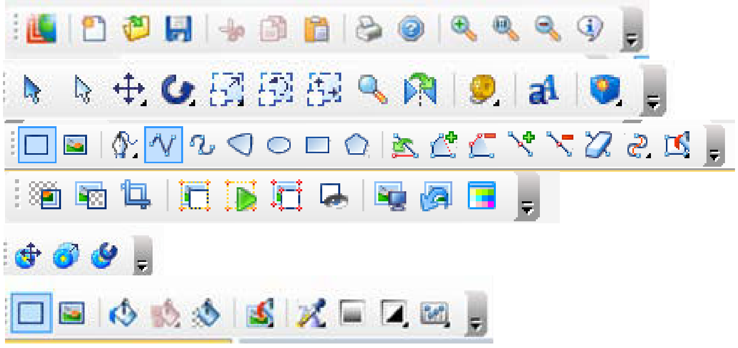
In order to fully define the model, he must be described and sketched. The model is being described for parts of, while the details to be found on the front, the back, the sleeves and collar shall be specified. In addition to descriptions of appearance, it is necessary to describe the ways of making some key details on the model, then what are linings and interlinings. In describing the model, we need to pay attention on the description that should be concise, precise and comprehensible.

During sketching of a model, all the details must be entered i.e. each said gusset, holes, buttons, trim, etc.., because all of them characterize the model and give him the appropriate look. This must be entered because the constructor on the basis of these sketches performs construction and modeling of a given model. Sketch is been colored in colors of materials for better clarity, and samples of all materials included in the model is been submit, for the testing of their physical and chemical features and possible additions of the pattern that could predict the "behavior" of the material on the finished garment. Based on all of these informations constructor starts making of patterns.

3. MAKING OF MODEL SKETCHES IN KALEDO STYLE

For work in this program a group of tools is used, and they are divided on bars depending of the type of tools. On Picture 1. Groups of tools that will be used to create technical sketch models are shown.

a)
b)
c)
d)
e)
f)

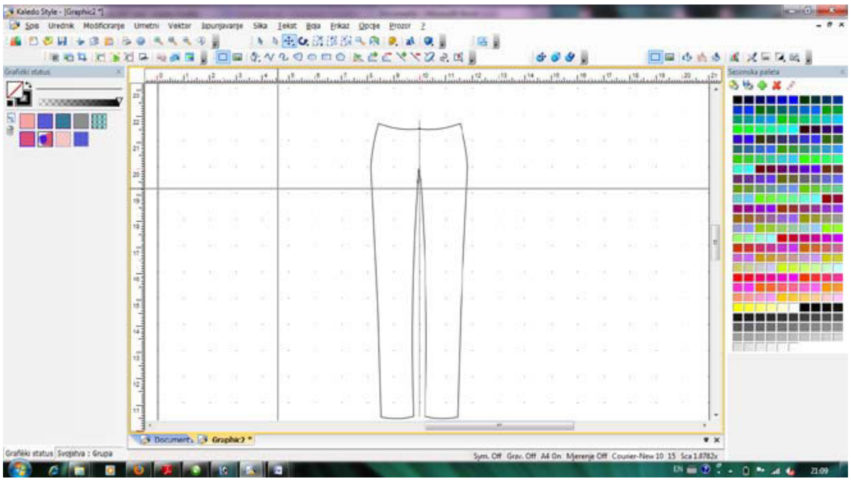


Picture 1. a) basic tools, b) useful tools for manipulation and rotation, c) vectors, d) pictures, e) motives, f) color

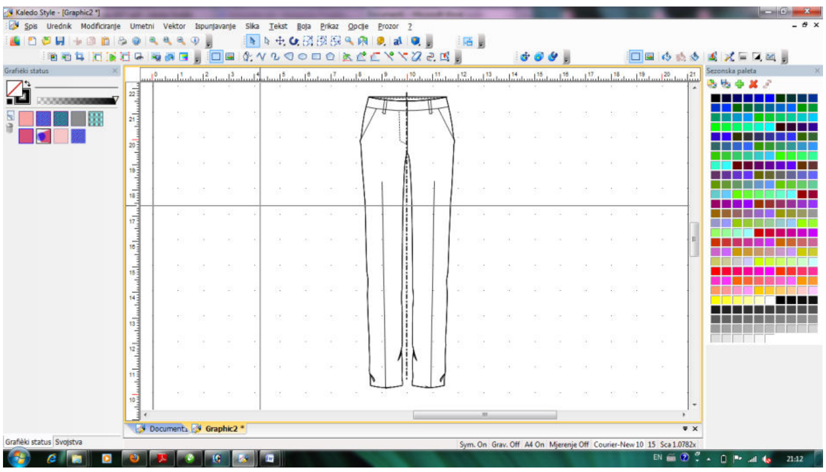
Drawing of a sketch starts by pulling an axis of symmetry, which is located in the toolbar of useful tools. For drawing itself we use tools from the vectors toolbar. The rearrangement of vectors is done by using its component points. Drawing is performed with multi tool line by laying the points. Right click ends the form. QWA and S keys are used to reshape the line segment in the curve. To limit lines horizontally or vertically the Shift key is used. Forcing vector lines or

For easier drawing it is possible to activate a help net inside the working area. Gravity option allows us to draw and position the elements with greater accuracy. Gravity can be set in a way that vector line is attracted to the net in a drawing area or toward other vector objects.

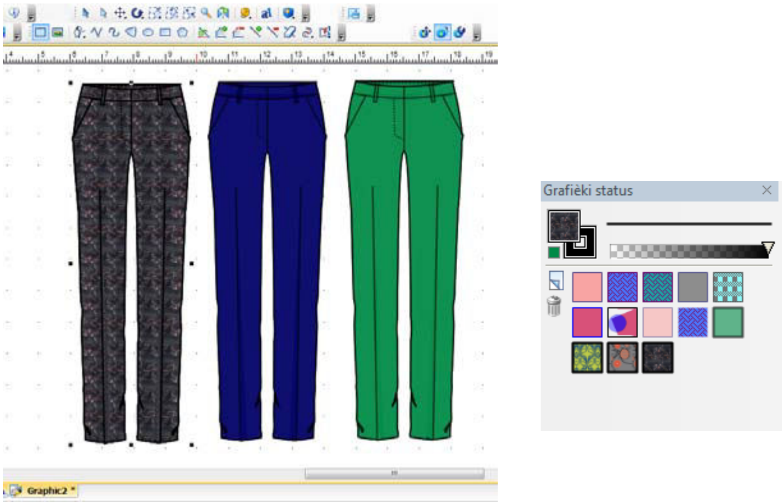
Picture 2. Shows the working area and beginning of making a model sketches, from pulling the axis of symmetry



Picture 2. The basic sketches outline of a female pants model



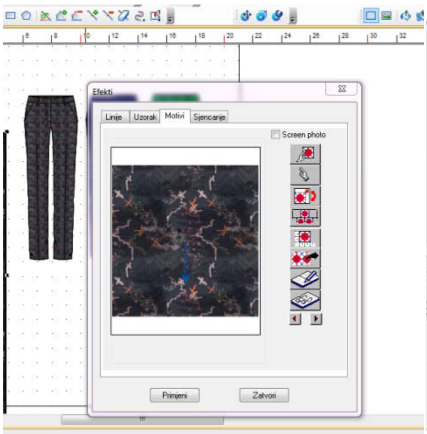
Picture 4. Technical sketch of female pants model

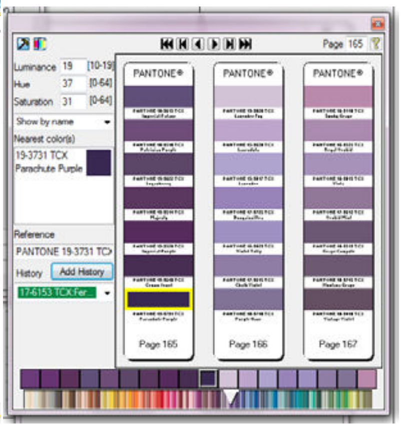


Picture 5. Elaboration of the model by colors. Shows colors and patterns.

After creating of vector drawings for female pants model, development of model by color is approached. The 1st model is made of designed material, while the other two were made from mono colored material. In order to implement the design in a sketch it is necessary to insert a picture of design or scanned picture of the material in the working area of Kaledo. This is accomplished by using a tool for inserting images from the File menu. Double click on a color for filling the form opens a window where on a design card we have options for adding a design. (Picture 6).

If we opt for a mono colored material then the color of the material can be selected from pantone card. (Picture 7)





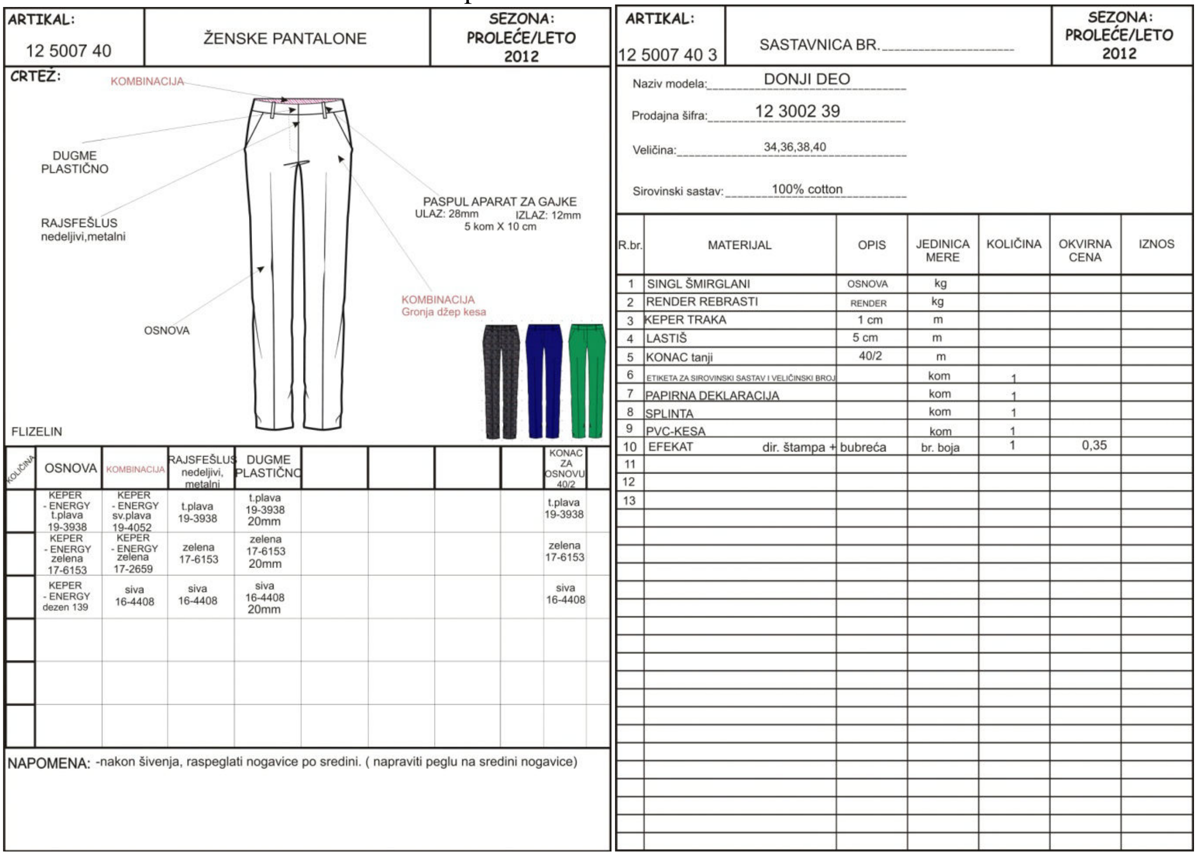
Picture 6. Window for adding the design   Picture 7. Window for selection of panton colors

4. PREPARATION OF TECHNICAL DOCUMENTATION

Components list, is a document that accompanies the product through all its stages. It contains data about the range of sizes, colors and patterns on, details of the base material and material which is going to be incorporated ..
There are different forms, but universally it includes the following information**:**

- The number of components list / current year.
- Production unit
- A description of the model sketches
- Sketch model
- Raw materials that are entering into the composition of materials
- Launch date ...

During the completion of the components list, map patterns (farben map) is made, and it contains data on primary and auxiliary material and materials that are installed (name, code, width, energy use, samples of each color and pattern, thread, fasteners, buttons, etc..). Map designs is made in 3 - 4 copies (for tailors department, department of sewing machines, department of control of intermediate and final quality and sometimes for commercial service). Picture 8. shows the technical documentation for the model of female pants.



ARTIKAL: 12 5007 40	ŽENSKE PANTALONE	SEZONA: PROLEĆE/LETO 2012

CRTEŽ:

KOLIČINA	OSNOVA	KOMBINACIJA	RAJSFEŠLUS nedeljivi, metalni	DUGME PLASTIČNO					KONAC ZA OSNOVU 40/2	
	KEPER - ENERGY t.plava 19-3938	KEPER - ENERGY sv.plava 19-4052	t.plava 19-3938	t.plava 19-3938 20mm					t.plava 19-3938	
	KEPER - ENERGY zelena 17-6153	KEPER - ENERGY zelena 17-2659	zelena 17-6153	zelena 17-6153 20mm					zelena 17-6153	
	KEPER - ENERGY dezen 139	siva 16-4408	siva 16-4408	siva 16-4408 20mm					siva 16-4408	

NAPOMENA: -nakon šivenja, raspeglati nogavice po sredini. (napraviti peglu na sredini nogavice)

ARTIKAL: 12 5007 40 3	SASTAVNICA BR.________________	SEZONA: PROLEĆE/LETO 2012

Naziv modela: DONJI DEO
Prodajna šifra: 12 3002 39
Veličina: 34,36,38,40
Sirovinski sastav: 100% cotton

R.br.	MATERIJAL	OPIS	JEDINICA MERE	KOLIČINA	OKVIRNA CENA	IZNOS
1	SINGL ŠMIRGLANI	OSNOVA	kg			
2	RENDER REBRASTI	RENDER	kg			
3	KEPER TRAKA	1 cm	m			
4	LASTIŠ	5 cm	m			
5	KONAC tanji	40/2	m			
6	ETIKETA ZA SIROVINSKI SASTAV I VELIČINSKI BROJ		kom	1		
7	PAPIRNA DEKLARACIJA		kom	1		
8	SPLINTA		kom	1		
9	PVC-KESA		kom	1		
10	EFEKAT dir. štampa +	bubreća	br. boja	1	0,35	
11						
12						
13						

5. CONCLUSION

Advanced design tools, such as industrial software solution Kaledo Style that has been applied in this paper, facilitates quicker defining of new styles and layout patterns. Users of this software are enabled to quickly and easily generate their own ideas, combine colors, fabrics and styles, all with the aim of obtaining the optimal solution for the creation of their product range.

Kaledo Style offers an unlimited number of variations regarding fabrics, colors, patterns, ornaments as well as numerous details. Because of these Kaledo features course of the development process is facilitated and the introduction of advanced technologies and combining them with the imagination and creativity of a user, presents the perfect solution for creating innovation and trends customization. Kaledo Style usage is a challenge for a single user, because it reduces the pressure of short deadlines for realization of of technical documentation and increases the desire and motivation for creative work. Precisely for this reason, Kaledo is a solution that is gladly accepted among the designers because it represents a way of processing their idea to the final realization in a shorter, more beautiful and much more exciting way to meet the challenges of today.

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THERMOPHYSIOLOGICAL COMFORT – CREATION AND RELEASING OF HEAT FROM THE HUMAN BODY

Aleksandra ZDRAVKOVIĆ, Vasilije PETROVIĆ , Marija STANKOVIĆ, Ivana STAMATOVIĆ, Dragana GOŠEVSKI

Abstract: *This paper represents thermophysiological comfortable clothes starting from the heat creation in the human body, then releasing that heat and also the formation of the microclimate between the skin and clothing [4]. The process of passing moisture through the material with the wick effect is also presented, and air permeability with the formation of the fire effect [4].*

Key words : thermophysiological comfort, creation of heat, releasing of heat, microclimate

1. INTRODUCTION

One of the key components that plays a very important role in human life is dressing. The man's body is predetermined to live in moderate weather conditions and hot climates, which means that when the ambient temperature falls below 20 °C, the body cannot any longer retain its temperature constant. Then clothing insulation becomes necessary [9]. In the beginning clothes were usable only for the protection of the body, now they have other functions that must be followed [1]. After all, there are fashion requirements where every shape is essential along with color, type of material etc. Today clothing reflects the character and lifestyle of a person. Quality clothing also includes, besides the aesthetic and functional requirements, thermophysiological comfort, pleasant feeling when worn, etc [3]. Feeling comfortable while wearing some clothes is one of the crucial quality characteristics of clothing which determines whether the buyer decides if it fits or not.

2. THERMOPHYSIOLOGICAL COMFORT

Physiological characteristics of clothes worn are mostly dependent on the condition of thermal conductivity , heat keeping capabilities and conductivity of moisture. Clothes must fulfil more requirements in order for a person wearing it feel comfortable in any mood. The zone where the **temperature, humidity and air flow** are ideal for the human body is called the "pleasure zone - zone of comfort". These three basic parameters of the physiology of clothes must be adapted to a variety of external and internal influences which include more components in the system of the body, climate, and clothing. These are called physiological comfort characteristics [4].

2.1. Creation of heat in the human body

In order for a man to live, his body must have a continuous exchange of matter with the environment. On that occasion, the matters that are rich of energy must convert into the matters which have a lower potential energy, with the release of energy in the same or a new form [4].

The process of transforming energy is very complex, where, for example, part of the produced energy is converted into mechanical and that energy is then used for performing outside work. But the main part of the energy much as 75 to 80% goes into heat and is used for maintaining a constant body temperature during physical work. If this energy in the human body is not used for the external work, then it is converted into heat (such as when you are sitting or lying). Energy consumption in the terms of minimum activity thermoregulation mechanism is called "basic exchange". It is the minimum energy for maintaining basic life processes.

With aging, both men and a woman appear to come to the decline in basic heat transfer . The basic heat transfer in women is lower than that of men. Heat generation in the human body rather increases along with physical work [4].

2.2. Releasing of heat from the human body

During the activity, releasing of heat from the human body can be done through a variety of ways: radiation, convection, evaporation and breathing.
Radiation and convection lose as 73 to 88% of the total heat generated. In each part of the heated body one part of heat goes into a radiation. The carriers of air power are infrared rays or ***radiation***. Convection is the transfer of energy by particles in the air, by which heat exchange can be [4]:

- free (due to the difference between body temperature and air)
- extorted (under the influence of air movement)

Conduction is a heat transmission from one body to another by touch. By using clothes , the material is in the direct touch with the body. The heat is then transmitted according to Furie's law :

$$Q_{kond.} = \lambda \cdot \frac{t_1 - t_2}{\rho} \cdot S \cdot \tau \text{ [4]}$$

Where is : $Q_{kond.}$ – the amount of heat passing through the area of wall(S) during the time τ
λ – the coefficient of heat transmission
t_1 – the temperature from the inner side of clothes
t_2 – the temperature of the environment
ρ – the thickness of clothes.
At high air temperatures, the releasing of heat can be done by evaporating of the diffused humidity and sweat. The speed of humidity evaporation from the surface of the body depends on:

- the difference between the partial pressures of steams from the surface of the body skin and the air around it
- the speed of air circulation
- clothes permeability of air and steam [4].

While breathing, the releasing of heat comes out of the heated air that a person releases when breathing. If the air from the outside world is colder, the amount of the lost air is bigger.
When the human body does not release enough heat with its coolling mechanism, especially in cases of hard work or in warm weather conditions , the sweating glands are activated which causes the release of water on the skin surface. The water,thus, takes the heat surplus from the skin which then evaporates [2].

The characteristics of the human skin vary depending on different parts of body and they change with time. Nevertheless, the skin has its common structure and in most cases it is similar by its function.The structure of some special skin areas determines the skin function. The human skin consists of three basic layers: the epidermis, the dermis and the hipodermis. Beneath the dermis there is the fat layer called panniculus adiposus (figure 1) [5].

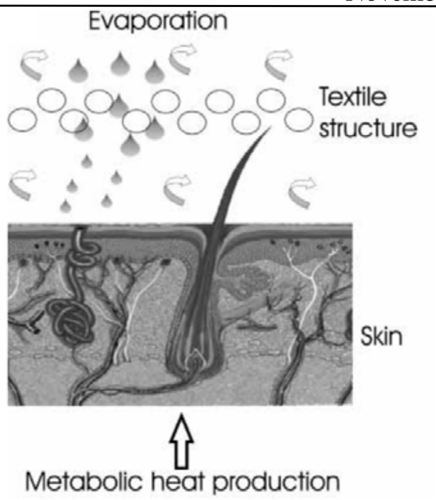


Fig.1.The ttransmission of heat and steam through the skin and fabric [5]

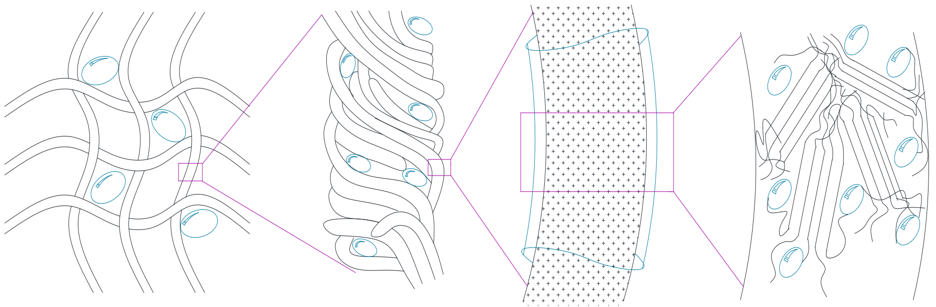
Water steam goes from the skin,through the clothes into the environment, due to the differences between steam pressures on the skin surface $\boldsymbol{p_k}$ and the environmental one $\boldsymbol{p_o}$, according to which the heat of evaporation can be calculated [2]:

$$H_e = \frac{(p_k - p_o) \cdot A}{R_e} \quad [2]$$

Where is : H_e – the heat of evaporation, humid heat passage (W)
p_k – partial water steam pressure on the skin surface. (Pa)
p_o – partial environmental water steam (Pa)
A –the area of heat passage (m^2)
R_e –the clothes resistance to steam passage (Pa m^2 W^{-1})

Humid heat passage consists of the process of convection of heat from the skin surface passing through the **'micro climate'**- the air layer between skin and clothes and the passage of water steam through the fabric layers.(fig. 2. The process consists of [2] :

- *capillary water transport or the condensation of water steam through the fibre capillaries*
- *absorbtion or migration of water steam on the fibre surface*
- *absorbtion of water steam into the fibres , by water passage through the fibres and the disorbtion on the outside part of the material.*
- *the diffusion of water steam through air holes in the material. The diffusion is bigger if the construction of the textile is less dense and if the diffusion path through the textile is shorter*.The diffusion through air holes in the material is the most effective mechanism of evaporated sweat passing through the materialinto the environment.The mechanism is more efficient if the tectile fibres are able to absorb more water steam from from the humid air [2].



Absorbed water (between materials)	*Absorbed water (between fibres in the materials)*	*Absorbed water (on the surface of the fibres)*	*Absorbed water (inside fibres)*

Fig.2. Changing steam position in the material [2]

2.3.The microclimate between clothes and skin

Most of the body is exposed to the micro climate that is created between the skin surface and the layers of clothes. Clothes create the special micro climate between the body and the environment.It acts as a barrier that prevents the heat transmission in the passage of humidity through the skin and environment. This means that clothes prevents sweat to evaporate from the skin surface which can cause that the person feels uncomfortable [2].

Looking from the thermophysiological side , clothes can be considered to be 'pseudophysiological' which affects the process of the body term regulation, and in different climate conditions and activities clothes can affect the feeling of comfortability.The factors that influence the micro climate are presented in the following figure 3 [2].

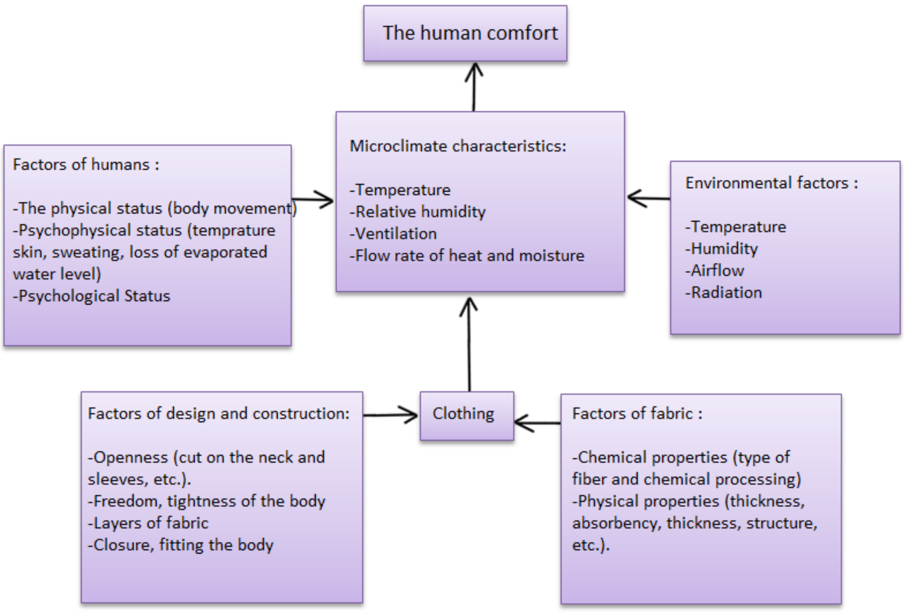


Fig.3. Factors that influence the micro climate between clothes and skin [2]

The degrees of sweating go from 650 do 1000 g h^{-1} . The degree may be 25% higher with **acclimatized people** unlike **non-acclimatized ones**. The maximum degree of sweating can be calculated:

$$S_{w_{max}} = 2{,}6 \cdot (M - 32) \cdot A_{Du} \ [2]$$

Where is : $S_{w_{max}}$ – the maximum degree of sweating (g h^{-1})
M –the metabolism energy (W m^{-2})
A_{Du} – body area according to DuBoisu (m^2)
Since clothes are in the direct contact with the body, they play an important role in providing normal conditions.Clothes absorb sweat and purify skin from sweat and skin fat . For these reasons clothes have to be ***hygroscopic and voluminous*** [4]. Cotton clothes have the best hygienically physiological effects on skin. Clothes must have the next properties(table 1) :

Table 1. [4]

Property of clothes	***winter***	***summer***
thickness, mm	1,3 do 1,5	0,1 do 0,3
Air permeability, dm^2 /m^2s	51 do 100	više od 100

Humid transmission, g/m^2 h	52 do 56	više od 56
Hygroscopicity (at RV = 65%), %	više od 7	više od 7

2.3.1.Humid transmission through the material

The absorption property of materials, as mentioned with hygroscopity, depends on the raw content of the fibres, type of structure and manufacturing. Materials, thus, can absorb more or less humidity from the background in order to acquire some balance. Absorption does not only present the ratio of humidity in the fibres and humidity in the environment, but it is also connected with [2]:

- the phenomena of hysteresis
- heat effects,
- the variability of the content of humidity in the fibres with the temperature,
- the effect of humidity on the physical properties and
- the factors coming from the interaction between humidity and mechanic factors caused by limited swelling of the fibres [2].

The contents of humidity in the fibres , which is defined as part of humidity in the fibre according to the standard atmosphere (20 ± 2 °C and 65 ± 2% relative humidity of air) can be calculated by the formula :

$$W_{sv} = \frac{m_a - m_s}{m_s} \cdot 100 \ [2]$$

Where is : W_{sv} – contents of humidity (%)
m_s – the mass of dry sample exposed to the standard atmosphere (g)
m_a – the mass of absolutely dry sample that is exposed to 105 °C for 4h(g)
The ability of preserving water in the fibre of the fabricW_{zv} can be determined according to the DIN 53 814 standard by using the formula:

$$W_{zv} = \frac{m_c - m_s}{m_s} \cdot 100 \ [2]$$

Where is : W_{zv} –the ability of preserving water (%)
m_s – the mass of dry sample_exposed to the standard atmosphere (g)
m_c – the mass of dry centrifugal sample (g)

The wick effect : is related to the power of absorbtion of humidity and it is one of the most important property of clothes. This method uses the capacititive principle of determining the power of humidity absorbtion and it is done by putting the textile sample between two clamp, the lower part of wich is soaked in the water at the constant level. On the upper part of the apparatus there are two brass plates that are connected with the electricity ,thus, making the electrodes of the condensator. The second electrode is the acquired level of water in the textile sample [4]. The capacity of the condensator is proportional to the plate surface of the condensator and the water levcel in the sample. The measurement represents the change of capacity and the plate surface of the condensator at certain time period. The ratio of the changed capacity and time interval gives the speed of the absorbtion of water. If we use analogous digital systems, then the computer can directly calculate the absorbtion speed of water of the textile material [4].

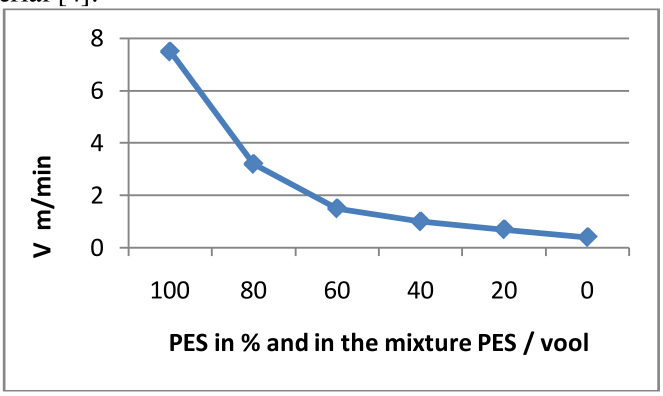


Fig.4. Dijagram brzine upijanja vode tkanine za odela u zavisnosti od odnosa vlakna u mešavini PES/vuna [4]

The textile material for clothes is made of the mixture of wool and polyester fibres at different ratios. The diagram in the figure 4. shows that the speed of water absorbion decreases with the higher amount of wollen fibres in the fabric [4]. The balance between the absorbtion and swelling of the textile fibres depends on the contents of the components in the mixture. The time of balance acquisition is different for different types ogf fibres. (table 2.) [2].

Table 2. [2]

Type of fibre	*Time (h)*
flax	12
flax/PES	12
cotton	24
cotton/PES	24

2.3.2.Air permeability

The fireplace effect : Air is an exellent term isolator.In the system body-climate-clothes, it determines the state of skin, heat transmission, humidity and steam. Air transmits heat radiation as well, for example sunlight.The air circulation between skin, the first layer of clothes and other layers is called the fireplace effect. The tests have shown that smooth textile materials have an irritating effect on skin, because they stick to skin during perspiration, while non-smooth textile is much more comfortable. This effect is based on the air permeability. Smooth materials are easy to get wet unlike rough or uneven materials. With rough materials the space of microclimate between the skin and textile is increased.The air layers between pieces of clothes and the parametres in the system ***body-climate-clothes*** are presented in the next figure 5 [4].

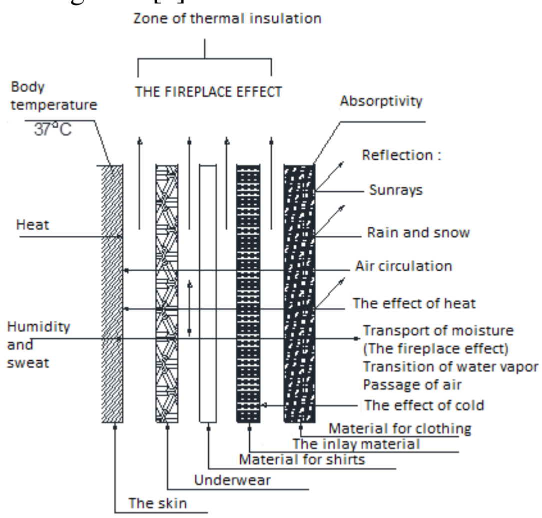


Fig.5. The system "BODY-CLIMATE-CLOTHES" [4]

On conduction air play an important role and the thickness and density of the material. We have the best air permeability of knitted fabrics that are made of textured polyester yarn, while the lowest air permeability have a fabrics who are made from a mixture of polyester and cotton fibers over 65/35% [4].

Textured yarn has revealed to be more voluminous than the spun yarn from staple fiber and of the same composition, because it provides better air permeability. Although the passage of air is dependent on the thickness of material it is increasingly dependent on the structure of the material (Table 3) [4].

Table 3. Impact of construction on the air permeability of textiles [4]

	Thickness,	*Surface*	*Pore*	*Air*

Textile materials	***mm***	***mass , g/m²***	***volume , %***	***permeability dm³/m²s***
Knitwear from the PA filament	0,37	109	74	1685
Knitwear from the PES (textured)	0,76	96	91	2200
Knitwear from the the PES fiber staple	1,05	210	85	1955
The fabric from a mixture of PES / cotton 65/36 %	0,44	115	81	352

4.CONCLUSION

As civilizations developed, so the progress demandedthat the clothes had to change [4]. At the present time, with the help of the tests to determine the quality of a material, we have the opportunity to further develop the area and better comfort and moisture conductivity and temperature of the material. The important function of clothing material is to regulate the transfer of sweat from the skin surface to

the environment. Therefore, the ability of textile material to manage the process of sweat transfer [5]. In the time ahead of us, according to technological developments, it is quite certain that the tests and methods for determining of comfort be further improved. As we live in a relatively "fast" time in our lives, there is no place for any discomfort.

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DEVELOPMENT OF TECHNICAL DOCUMENTATION USING INDUSTRIAL DESIGN SOFTWARE KALEDO STYLE ON EXAMPLE OF A FEMALE SHIRT

Marija STANKOVIĆ, Vasilije PETROVIĆ, Aleksandra ZDRAVKOVIĆ, Ivana SKOKO, Dragana GOĐEVSKI

Abstract: *This paper presents the development of technical documentation which enabled a solution of a numerous problems that are following production nowadays. These problems are primarily related to the short deadlines of making clothing products with products technical preparation that requires significant time. As a part of this work, industry software KALEDO Style – a program for clothes design is described. Advanced design tools, such as industrial solution software Kaledo Style which is used in this paper, facilitates the creation of new styles and layout patterns. Users of this software can quickly and easily generate their own ideas, combine colors, fabrics and styles, all with the aim of obtaining the optimal solution for the creation of their product range. Use of this software is described in this paper on the example of the preparation of technical documentation for a female shirt.*

Key Words: *computerized clothes construction, Kaledo Style, technical documentation, female shirt*

1. INTRODUCTION

Time in which we live in is characterized by the progressive development of science, engineering and technology, which reflects on the textile industry as well as the designers. Hand made fashion drawings and technical sketches is almost completely replaced with computer drafting. Increasingly, software us used for vector drawings of sketch models which contributes to faster and more efficient development of sketches itself and accompanying technical documentation.

Kaledo Style is French company Lectra software, designed for fashion design. It allows fashion designers easier getting to new trends and themes, makes it easier to design new styles and creating products in different colors and fabrics. The possibility of obtaining high-quality images allows quick and easy communication with the readers of technical specifications.

2. DESCRIPTION AND SKETCH OF A MODEL

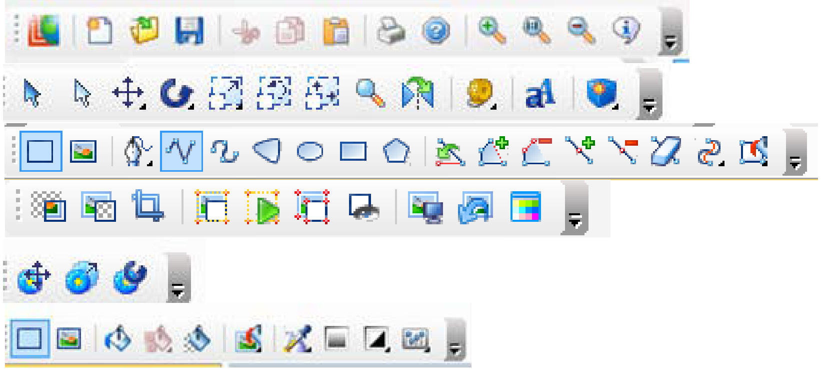
In order to fully define the model, he must be described and sketched. The model is being described for parts of, while the details to be found on the front, the back, the sleeves and collar shall be specified. In addition to descriptions of appearance, it is necessary to describe the ways of making some key details on the model, then what are linings and interlinings. In describing the model, we need to pay attention on the description that should be concise, precise and comprehensible.

During sketching of a model, all the details must be entered i.e. each said gusset, holes, buttons, trim, etc.., because all of them characterize the model and give him the appropriate look. This must be entered because the constructor on the basis of these sketches performs construction and modeling of a given model. Sketch is been colored in colors of materials for better clarity, and samples of all materials included in the model is been submit, for the testing of their physical and chemical features and possible additions of the pattern that could predict the "behavior" of the material on the finished garment. Based on all of these informations constructor starts making of patterns.

3. MAKING OF MODEL SKETCHES IN KALEDO STYLE

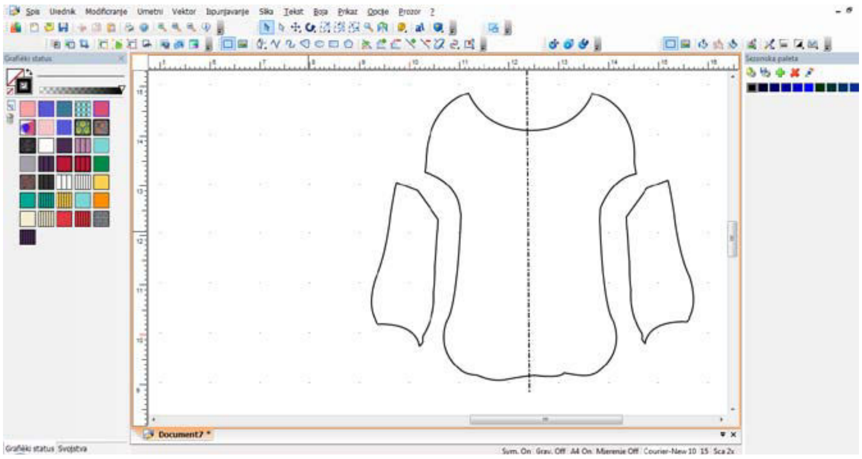
For work in this program a group of tools is used, and they are divided on bars depending of the type of tools. On Picture 1. Groups of tools that will be used to create technical sketch models are shown.

g)
h)
i)
j)
k)
l)

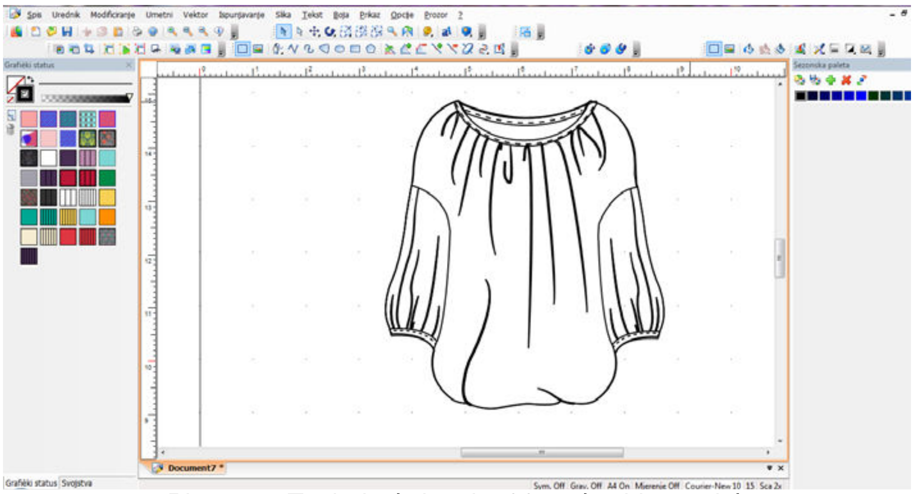


Picture 1. a) basic tools, b) useful tools for manipulation and rotation, c) vectors, d) pictures, e) motives, f) color

Drawing of a sketch starts by pulling an axis of symmetry, which is located in the toolbar of useful tools. For drawing itself we use tools from the vectors toolbar. The rearrangement of vectors is done by using its component points. Drawing is performed with multi tool line by laying the points. Right click ends the form. QWA and S keys are used to reshape the line segment in the curve. To limit lines horizontally or vertically the Shift key is used. Forcing vector lines or
For easier drawing it is possible to activate a help net inside the working area. Gravity option allows us to draw and position the elements with greater accuracy. Gravity can be set in a way that vector line is attracted to the net in a drawing area or toward other vector objects.
Picture 2. Shows the working area and beginning of making a model sketches, from pulling the axis of symmetry



Picture 2. The basic sketches outline of a female shirt model

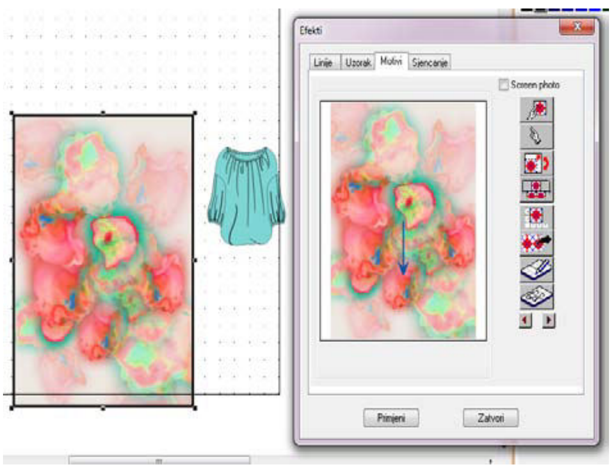


Picture 3. Technical sketch of female shirt model

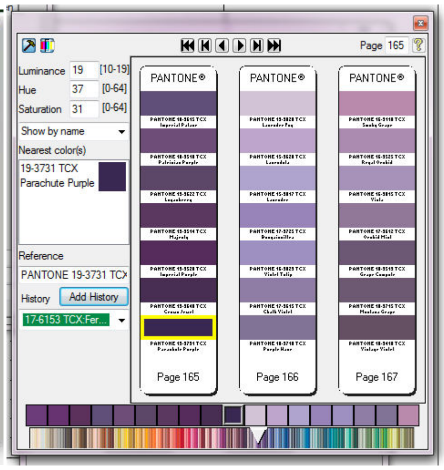
Picture 5. Elaboration of the model by colors. Shows colors and patterns.

After creating of vector drawings for female shirt model, development of model by color is approached. The 1st model is made of designed material, while the other two were made from mono colored material. In order to implement the design in a sketch it is necessary to insert a picture of design or scanned picture of the material in the working area of Kaledo. This is accomplished by using a tool for inserting images from the File menu. Double click on a color for filling the form opens a window where on a design card we have options for adding a design. (Picture 6).

If we opt for a mono colored material then the color of the material can be selected from pantone card. (Picture 7)



Picture 6. Window for adding the design



Picture 7. Window for selection of panton colors

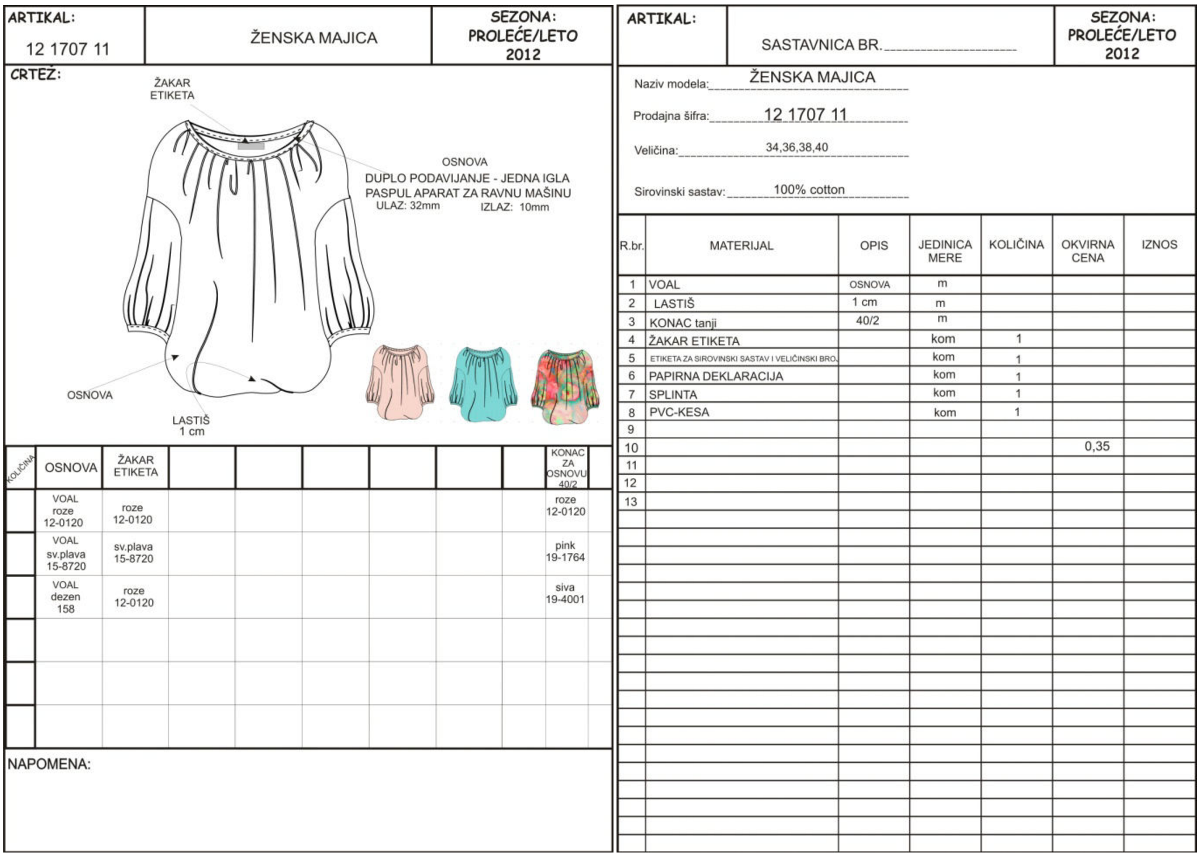
4. PREPARATION OF TECHNICAL DOCUMENTATION

Components list, is a document that accompanies the product through all its stages. It contains data about the range of sizes, colors and patterns on, details of the base material and material which is going to be incorporated ..

There are different forms, but universally it includes the following information**:**

- The number of components list / current year.
- Production unit
- A description of the model sketches
- Sketch model
- Raw materials that are entering into the composition of materials
- Launch date ...

During the completion of the components list, map patterns (farben map) is made, and it contains data on primary and auxiliary material and materials that are installed (name, code, width, energy use, samples of each color and pattern, thread, fasteners, buttons, etc..). Map designs is made in 3 - 4 copies (for tailors department, department of sewing machines, department of control of intermediate and final quality and sometimes for commercial service). Picture 8. shows the technical documentation for the model of female shirt.



ARTIKAL: 12 1707 11 | ŽENSKA MAJICA | SEZONA: PROLEĆE/LETO 2012

CRTEŽ:

KOLIČINA	OSNOVA	ŽAKAR ETIKETA	KONAC ZA OSNOVU 40/2
	VOAL roze 12-0120	roze 12-0120	roze 12-0120
	VOAL sv.plava 15-8720	sv.plava 15-8720	pink 19-1764
	VOAL dezen 158	roze 12-0120	siva 19-4001

NAPOMENA:

ARTIKAL: | SASTAVNICA BR.__________ | SEZONA: PROLEĆE/LETO 2012

Naziv modela: ŽENSKA MAJICA
Prodajna šifra: 12 1707 11
Veličina: 34,36,38,40
Sirovinski sastav: 100% cotton

R.br.	MATERIJAL	OPIS	JEDINICA MERE	KOLIČINA	OKVIRNA CENA	IZNOS
1	VOAL	OSNOVA	m			
2	LASTIŠ	1 cm	m			
3	KONAC tanji	40/2	m			
4	ŽAKAR ETIKETA		kom	1		
5	ETIKETA ZA SIROVINSKI SASTAV I VELIČINSKI BROJ		kom	1		
6	PAPIRNA DEKLARACIJA		kom	1		
7	SPLINTA		kom	1		
8	PVC-KESA		kom	1		
9						
10					0,35	
11						
12						
13						

5. CONCLUSION

Advanced design tools, such as industrial software solution Kaledo Style that has been applied in this paper, facilitates quicker defining of new styles and layout patterns. Users of this software are enabled to quickly and easily generate their own ideas, combine colors, fabrics and styles, all with the aim of obtaining the optimal solution for the creation of their product range.

Kaledo Style offers an unlimited number of variations regarding fabrics, colors, patterns, ornaments as well as numerous details. Because of these Kaledo features course of the development process is facilitated and the introduction of advanced technologies and combining them with the imagination and creativity of a user, presents the perfect solution for creating innovation and trends customization.
Kaledo Style usage is a challenge for a single user, because it reduces the pressure of short deadlines for realization of of technical documentation and increases the desire and motivation for creative work. Precisely for this reason, Kaledo is a solution that is gladly accepted among the designers because it represents a way of processing their idea to the final realization in a shorter, more beautiful and much more exciting way to meet the challenges of today.

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MEASUREMENT SPEED PASSING OF SWEAT

Aleksandra ZDRAVKOVIĆ, Vasilije PETROVIĆ, Marija STANKOVIĆ, Ivana SKOKO, Dragana GOŠEVSKI

Abstract: *This paper represents the heat creation in the human body, with releasing that heat from human body. Only a measure of the speed passing of sweat is covered by objective and subjective methods by using hot plates, puppets and infrared camera [4].*

Key words : speed passage of sweat, hot plate, a puppet, the infrared camera

1. INTRODUCTION

The man's body is predetermined to live in moderate weather conditions and hot climates, which means that when the ambient temperature falls below 20 °C, the body cannot any longer retain its temperature constant. Then clothing insulation becomes necessary [6]. In the beginning clothes were usable only for the protection of the body, now they have other functions that must be followed [1]. After all, there are fashion requirements where every shape is essential along with color, type of material etc. Today clothing reflects the character and lifestyle of a person. Quality clothing also includes, besides the aesthetic and functional requirements, dimensional stability, ease of maintenance, pleasant feeling when worn, the beauty of falling etc [2].

2. MEASUREMENT OF SPEED PASSING SWEAT

2.1. Objective method of measuring the speed passing of sweat

2.1.1. Measuring with the hot plate

For objective measurement of water vapor resistance sweating the famous hot plate is used. It has the ability to simulate the heat and moisture (sweat) transfer processes that occur in human skin. The device is composed of plate which is heated to a constant temperature that corresponds to the human body, with a deviation of ± 0.1 °C, ie a temperature of 36 °C. During the examination resistance to the passage of heat and water vapor. Section for testing is in the center panel and it is surrounded by a guard and transverse heater that prevents heat loss. Sample of fabric is placed on the surface and the flow of heat from the plate to the environment is measured [2].
During the examination resistance to the passage of water vapor, distilled water is supplied from the metering device, heats up and leads to a porous plate through channels in the body heating. Then the top is covered with foil or film which prevents contact of water with the flat material and allows the passage of water vapor, ie the water vapor is permeable and impermeable to liquids. In this way, the skin is simulated and the processes that occur in it[2]. Sweating with the hot plate is shown in Figure 1.

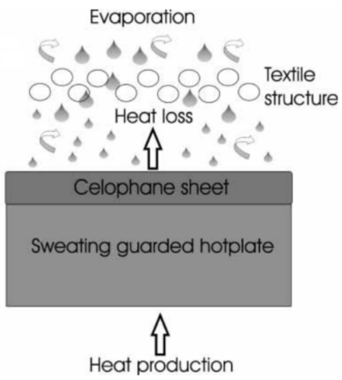

Fig.1. The working principle of the hot plate [4]

In order to get the difference in the masses when sweating, the fabric is measured before and after the experiment.

The resistance of heat flow (Rct) is determined as the difference measuring units and temperature of air, divided by the result of heat flow per unit area. It is determined according to:

$$R_{ct} = \frac{(t_m - t_a) \cdot P}{H} \quad [2]$$

Where is : R_{ct} – resistance to heat transmission, m^2 ℃ W^{-1}
t_m – temperature of measurement unit , ℃
t_a – the air temperature, ℃
P – surface measurement units, m^2
H – power required for heating the unit of measurement, W

The resistance of the passage of water vapor (R_{et}) is a measure of the pressure difference of water vapor on the obverse and reverse of materials and results in passing heat by evaporation, calculated by the following formula:

$$R_{et} = \frac{(p_m - p_a) \cdot P}{H} \quad [2]$$

Where is: R_{et} – resistance to the passage of water vapor, m^2 Pa W^{-1}
p_m – pressure of water vapor on the surface of the measuring unit, Pa
p_a – pressure of water vapor in the air at a temperature T_a , Pa
P – surface measurement units, m^2
H – the power necessary for heating the unit of measurement, W
These methods have their disadvantages, for example; famoushot plate must have samples that are 50 x 50 cm [3].

Thenext Figure 2. presents a method for measuring thermal conductivity of thin (a few millimeters thick) insulation and super-insulating material. The method is based on the temperature measurement in the center of the heater that is inserted between the two samples. Heat capacity of the aluminum block is large enough so that the temperature Tb remains constant throughout the experiment, while the T-temperature of sample. This model is used for the realization of sensitivity analysis of center temperature on various parameters. Consequently, the thermal conductivity can be estimated with good precision for all insulation materials. The method shows that the device with two samples of different thickness improves the accuracy of the estimate thermal capacity [3].

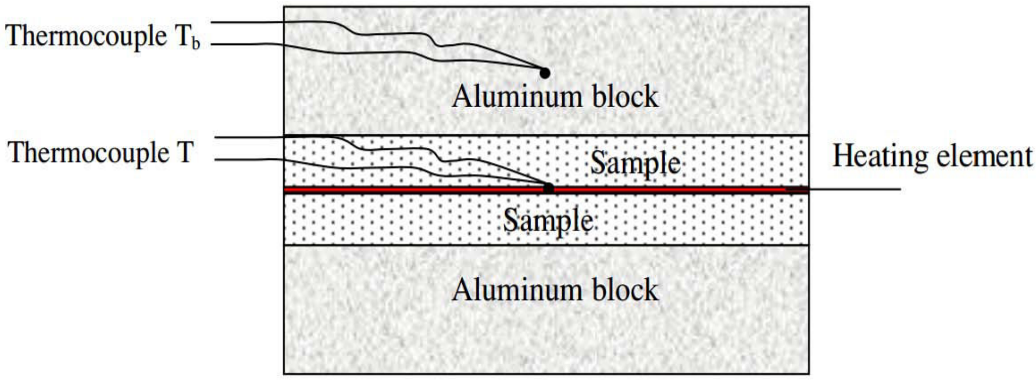

Fig.2. Scheme of the experimental device [3]

This plate is for many researchers, one of the most accurate technique for the determination of thermal properties, but there are still some limitations. Results obtained using the hot plate may not be directly applicable to the clothes, because it ignores the body surface covered by textiles, because the distribution of textile layers on the body is changing the temperature in different parts of the body posture or movement [3].

2.1.2. The measuring with puppet

This is another complex measuring device that is built in the shape of the human body, where it conducts simulations of heat between the human body and the environment. The basic principle that has built this measuring device is the principle of hot plates. Puppets are divided into a number of regulated segments, where the values for the measurement can be followed for the whole body, but specific body parts can also be tracked [2]. The Development of puppets began in the 40-ies. The new phase of the simulation puppets was sweating. In 1996, it developed a puppet that simulates breathing and as such is used to assess the air quality [2].

In different environmental conditions and different activities model predicts the difference in skin temperature and intensity of sweating. Inside the puppet, there are supplies of water to each segment of puppets in order to be able to fully stimulate sweating. The heat losses for each segment of puppets are measured and these data are entered in the model [2].

On the next Figure 3. the IPEMS 1 (Individual Protection Ensemble Mannequin System), a new puppy which is used to test high-resolution content of protective clothing. The puppet is in fact a self-balanced robot that simulates human physiology in realistic tests of protective equipment in a controlled environment. In this puppet a greater complexity is added, as was an additional challenge, in the form of closed articular surface of the skin and, in order to prevent contamination with chemicals [5].

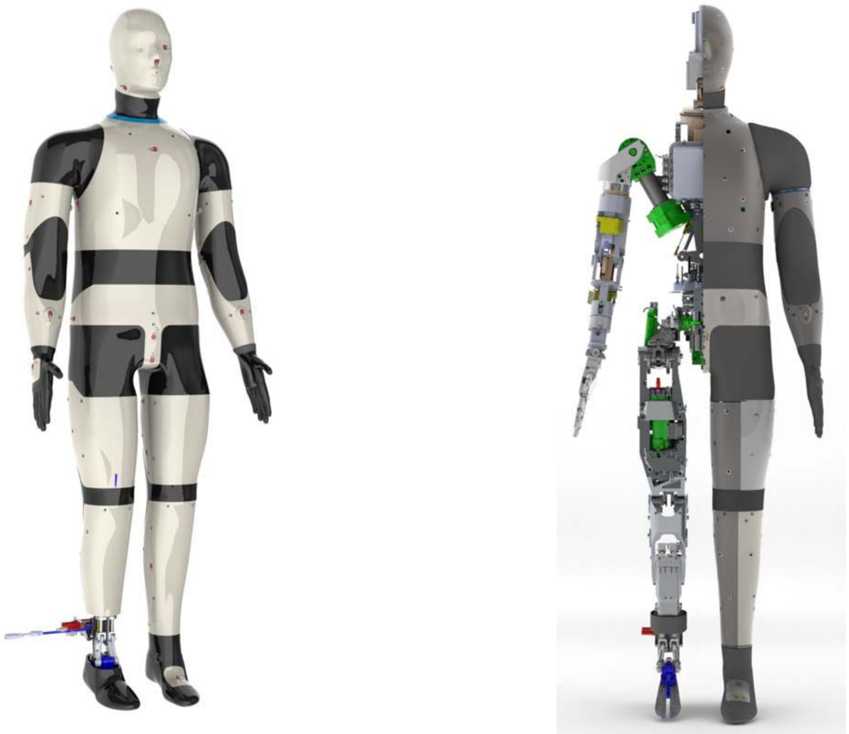

Fig.3. The new „IPEMS“ puppet [5]

2.2. Subjective method of measuring the speed passing of sweat

2.2.1. The measurement with infrared camera

Thermal or infrared (IR) energy is radiation between 1 and 100 microns, at the wave lengths that are longer than the red part of visible light and shorter than micro-waves. It is a non-visible light because its wavelength is too long to be detected by the human eye [4].

Infrared thermography is the method of the use of an infrared imaging and measurement camera to »see« and »measure« thermal energy emitted from an object. The camera is a non-contact device which detects infrared energy (heat) and converts it into an electronic signal, which is processed to produce a thermal image on a video monitor and perform temperature calculations. In this paper an infrared camera was used to measure the temperature differences on the next-to-skin knitted fabric. (Figure 4.) [4].
The summary of the physiologic measurements includes the systolic and diastolic blood pressure (BP) as well as the heart rate. The mentioned physiological pa-rameters were measured both before and after the experiment [4].

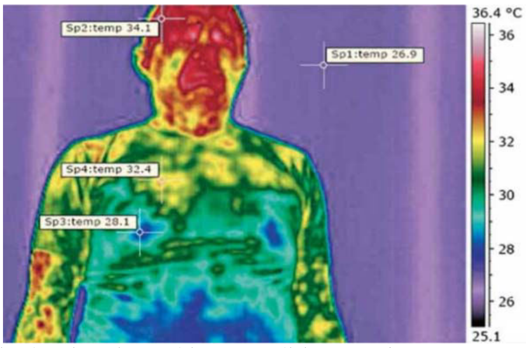

Fig.4. some typical points in ambient condition t=26 ± 1°C, RV=67 ± 3% in infrared light, when wearing polyester shirts [4]

Upon these points, it can be concluded that the highest temperature is in the upper part of the body. Low body temperature is related to the area where the fabric is intensely wet, while the highest point is the temperature, paragraph 4, and refers to the area of dry cloth [4].

Figure 5. shows the comparison of sweating in the am-bient temperature with lowest and highest temperature. It is well seen that the zones of intensive sweating in the lowest ambient temperature are the under arm and chest. In the highest ambient temperature, the sweating zone is spread through the whole upper part of the body except the part of shoulders and upper arm. The sweat absorption on the shirt in the part of the lower front part is not visible because the trousers were under the shirt that absorbed the sweat and enabled its transfer to the upper textile layer [4].

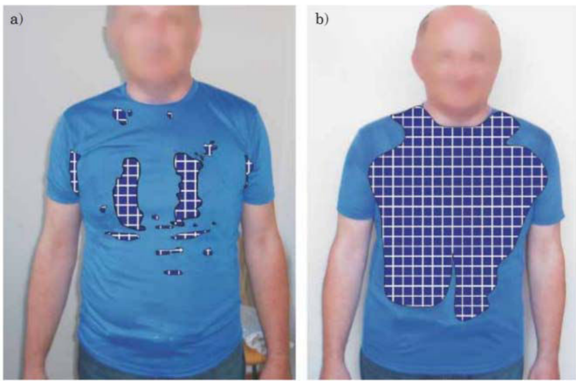

Fig.5. The crosshatched zones of the wet fabrics in visible light: a) ambient condition (t=23 ± 1 °C) b) ambient condition (t=32 ± 1°C) in polyester shirts [4]

3.CONCLUSION

In the past it was only important to protect the body from the weather, and it did not matter what kind of material we put on ourselves. As civilizations developed, so the progress demandedthat the clothes had to change [4]. At the present time, we have the opportunity to further develop the area and better comfort and moisture conductivity and temperature of the material.

In the warm ambient conditions, the body adapts itself by increasing the rate of sweating. Therefore, the ability of textile material to manage the process of sweat transfer is a significant property that affects the subjective feeling of human comfort [4].

In the time ahead of us, according to technological developments, it is quite certain that the tests and methods for determining of comfort be further improved. As we live in a relatively "fast" time in our lives, there is no place for any discomfort.

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MODELLING OF WOWENS AS BARRIER STRUCTURES

Biljana MOKAN, Vasilije PETROVIĆ, Jovan STEPANOVIĆ Želimir BRANOVIĆ

Abstract: *Wowen fabrics that have full systematically arranged structure, that could have the abbility to serve as barriers for fluids, radiation, microparticles and microorganisams, are becoming more and more popullar in terms of research. A structure which has canals between yarns which are specifically shaped and placed is particularly important. Here are presented some procedures of designing shapes of those canals and also sealing tha structure.*

Key words: *barrier fabrics, wowens, canals, yarn configuration, increasing thickness, reinforcing structure*

1. INTRODUCTION

Wowens belong to a group of textiles which have uniform structure, and design of it repeats itself in every element of the fabric. That is why they are used as effective barriers and they can control the flow and permeabillity of:

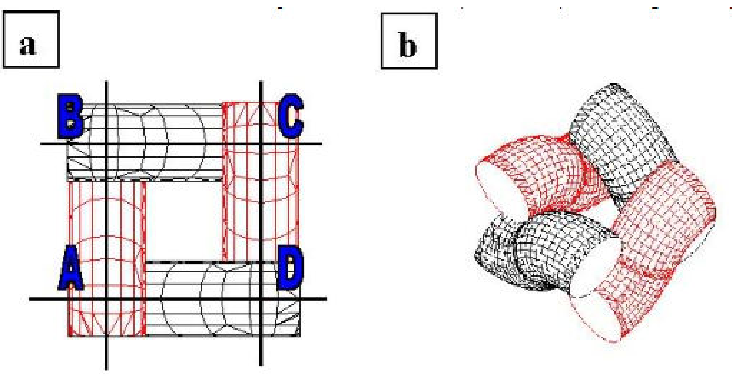
- fluids
- thermal, optical, electromagnetic radiation
- particles of macro and micro dimension

The barrier function of wowens is determined by shape and dimensions of the canals (which are free space between yarns) which go through the fabric. On the other hand, most frequently we look into the surface cover of the fabric by warp (Zo), weft (Zw) or the combination of the yarns (Zow). Surface covering is determined by next equations:

$$Zo = Go\ Do$$
$$Zw = GwDw,$$
$$Zow = Zo + Zw - ZoZw \times 10^{-2},$$

where : Go, Gw – are warp and weft settings
Do, Dw – is the initial circumference of warp and weft yarns
In the past, gauze was made with thread setting of 1000/1dm and sometimes even more. These setting produced 1 000 000 pores pre square decimeter, with pore dimension of less than 0.05x0.05 mm.
Today, these barrier wowens are not used only for separation or particle sifting. That is why next problems must be considered in order to produce more demanding functions of fabrics:

- possibility to tighten the thread structure (density increasing) in order to make smaller canal cross-sections
- choice and identification of chosen spaces between threads (canals) depending on their shape and position.



Picture 1. Model of a wowen fabric with a square structure (equal warp and weft structure) which eans they are of equal diameter and material), double barrier surface, with non deforming threads of circular cross-section

2. SINGLE-LAYERED BARRIER WOVENS

2.1. Selection of weawing process

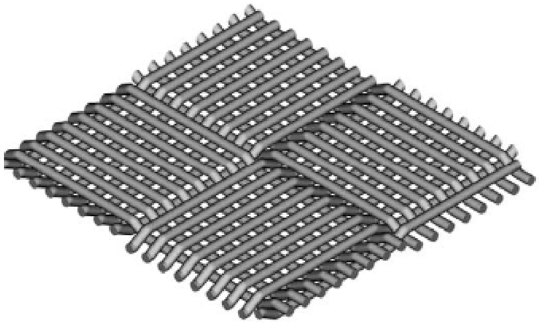
Weawe is chosen based on:

- A way of getting the biggest fabric density by increasing the medium tightness value of the barrier
- Forming the canals between threads

The value of the biggest thread tightness which depends on the way of weawing, is determined in ideal fabrics by warp and weft filling (Eo and Ew) which in this case is 100%. This is determined by these equations:

$$Eo = (doRo + dwpw) / RoAo \times 100\% \text{ , and}$$
$$Ew = (dwRw + dopo) / RwAw \times 100\%$$

where:
Ro,Rw - warp and weft repetittion
Po,Pw - number of inflections of one warp or weft thread
Ao,Aw - warp and weft sets
The greatest tightness of a particular thread system is achieved in weawing with a small number of inflections in relation to the repeat of the other thread system. Such fabrics are for example saten and tweed. Tweed is shown on picture 2.

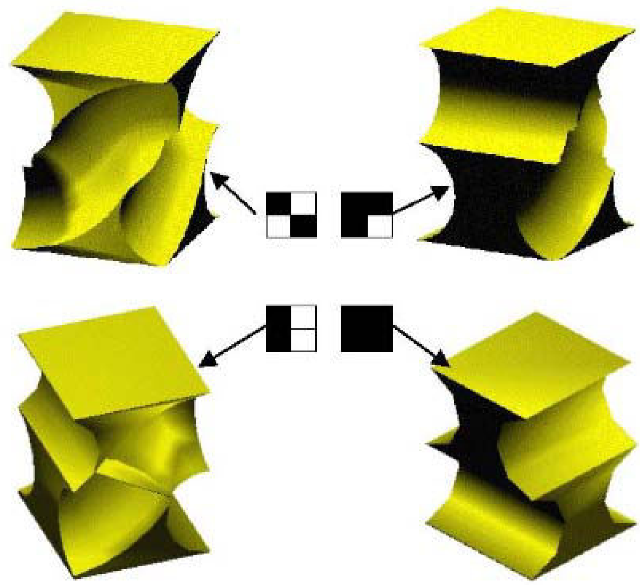


Picture 2. Tweed weawing where Ro = Rw = 16, po= pw =2

If Eo= Ew = 100% ,then:

- the fabric cover of the individual system (Zo=Zw) is 50% and
- the fabric cover of both systems (Zow) is 75% which means the canals take up the quarter of the side which length equals the beginning thread circumferrence, so the amount of pores in the fabric surface is 25%

First step in the canal forming should be choosing one of four canal shapes. On the picture 3, there are four structural models with all threads used, and 3D models show possible canal placements between the threads. Next step would be determining module position in relation to vertical axis.



Picture 3. Structural weawing modul

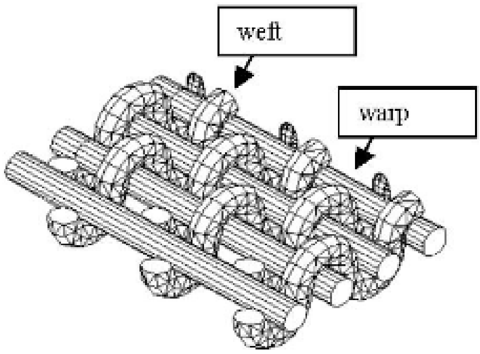
Each of the modules shown on picture 3 has its geometrical characteristics which separate it from the other ones. This way we get fabrics (made from different modules) which have different barrier abbilities. The whole fabric could be made with one weawe type or to be composed from different types of modules. Some modifications are possible:

- different possitions in relation to vertical axis
- changes in structure

3. Methods of increasing middle-tightness

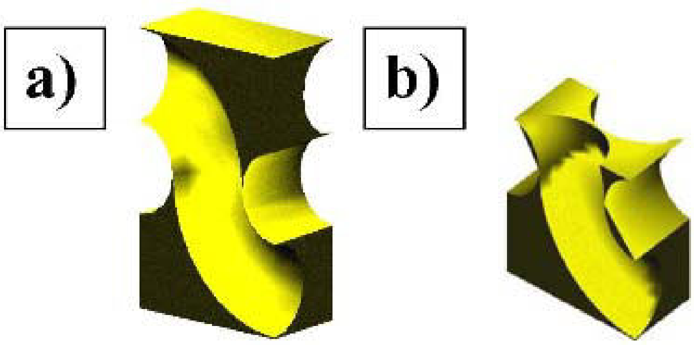
3.1 Changing of the fabric form

Decreasing the dimensions of spaces between threads, which means overfilling the structure with double system barrier surface, is possible after changing the fabric form. Decreasing of tightness of one thread system and increasing the tightness of the other one leads to change of form. The tight thread system is forming a surface with one visible system on the fabric surface. On the picture 4 we can see a model of fabric where double thread barrier surface system is changed to a single thread system.



Picture 4. Fabric model after the change of the beginning form from picture 1 into a form with a weft single-system barrier surface.

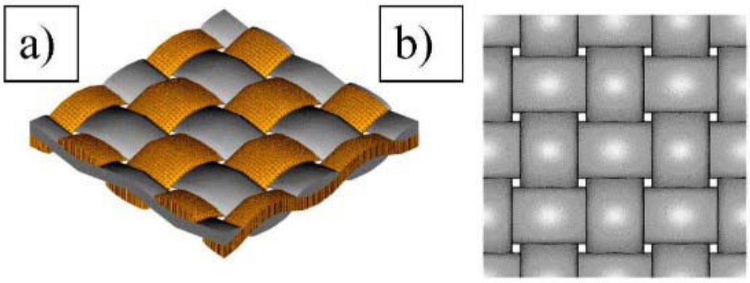
This structure enables tightening of the threads that form impenetrable surface untill they reach 100% cover value and at the same time changing the shapes and dimensions of the canals.



Picture 5. Fabric model after the form change and after the increase in weft settings to the final value of Zw = 100%

4. INFLUENCE OF THE YARN DIAMETER ON FABRIC TIGHTENING ABBILITY

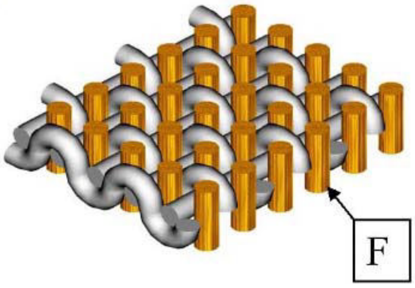
On the picture 6a, we can see a model of the fabric produced from linear textile products with elliptical cross-section. Perpendicular projection on picture 6b shows visible canals that are located on both sides between the threads but are of very small dimensions. Cover value of both thread systems exceeds 90% (Zow>90%).



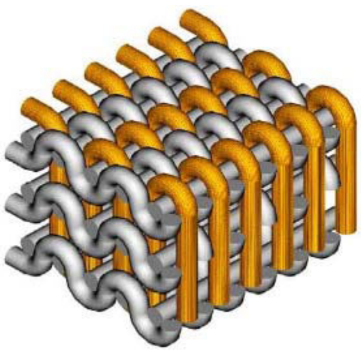
Picture 6. Square model of wowen fabric with double system surface barrier

5. ENCLOSING THE SPACE BETWEEN THREADS

General solution presented here is not based on structure tightening of basic thread systems, but on inserting additional linear textile elements into the spaces between threads. These products can perform additional functions, thanks to choosing a special material; for example they can have individual sorption properties for a specific medium.



Picture 7. Model of wowen material with a filler (F) of the space between the threads



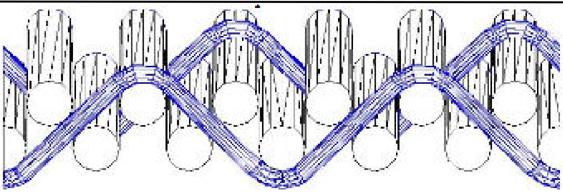
Picture 8. Model of the triple wowen material with layers put together by additional warp thread

Realisation of this kind of structure is achieved by producing triple fabric with layers fused together by additional warp system. If we were to cut this fabric in sections between the layers we would get three fabrics with a basic system of reducing space between threads.

5. MULTILAYERED BARRIER WOVENS

5.1 Layered single thread systems

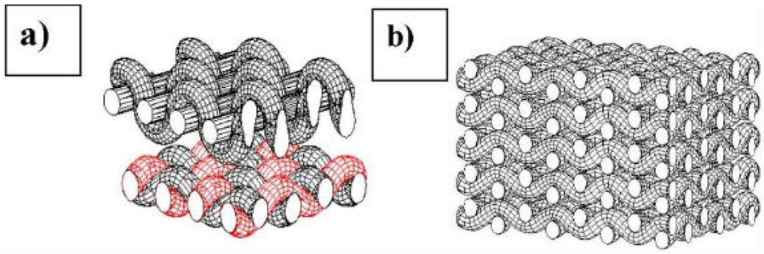
Between singlelayered and multilayered fabrics there are fabrics with only one thread system piled up. On picture 10, we can see a model of the fabric with warp threads placed in two layers, upper and lower with zero deflection, interlaced with wefts placed in one layer. The medium-tightness is secured by the warp threads, which in a real product are pressed together. This task can be accomplished by thickness differentiation of the warp and weft threads.



Picture 9. Model of a fabric with a piled up warp system

6. SIMPLE LAYERING OF THE DOUBLE-THREAD

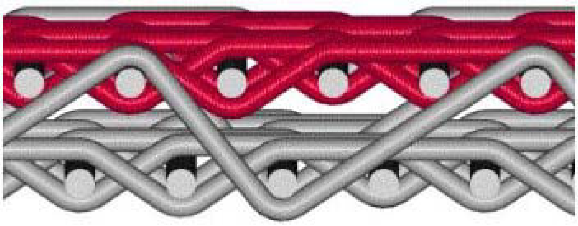
Barrier abbility is achieved with piling up of two or more independent fabrics. Even if their structures are identical, we can see the randomness of canal interplacements between the threads of two opposing layers. In that case many of the advantages of uniform structure of wowens is lost.



Picture 10. Simple layering of two systems
a) two-layered barrier made from fabrics with different weawe models
b) five-layered barrier made from structurally identical wowens

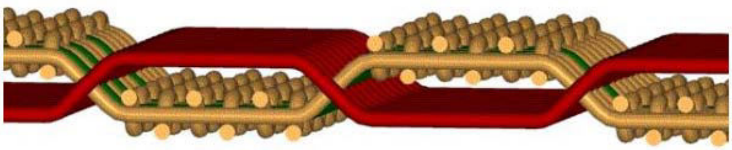
7. COMPLEX LAYERING OF DOUBLE-THREAD SYSTEM

Better controll of the dislocations between inter thread canals in opposing layers is ensuring solutions which are characterised by opposing layers interweawed with specific threads. Only these solutions enable the choices of layers depending on needed penetration efficiency of air, radiation, microorganisams and other abbilities which are achieved by different weawing models or shape structures.
Double weawed fabrics could have an important part in forming of the barrier. The simplest examples are layers sewn together face to back. Thanks to this solution, the mutual positions of the upper and bottom layer channels can be determined and then stabilised.



Picture 11. Double weawed material with layers sewn together back to front with controlled positions of canals in layers.

Fabric layering using a method of opposing layers is a step forward in barrier forming, which at the same time shows how big are the possibilities of this structure. In the first place, upper and bottom layer can be used as subsequent filters and lateral enclosed canals can also be used.



Picture 12. Two-layered structure with layer exchange method

8. CONCLUSION

The possibility of creating fabrics (products of precisely set and stable structure) as barriers for different uses is big, taking into consideration the user demand. In this essay problems are presented that are related to structure aspects that play a big role in forming of the barrier abbility of fabric. The manufacturer of weawes must solve many problems with the specific structure. One of the biggest problems is the possibility to make a structure of any shape from any linear textile product. This means that textile engineers must not forget about the problem of identification of structure for the selected product.

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PARAMETERS FOR ASSESSMENT OF THERMOPHYSIOLOGICAL COMFORT CLOTHING

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Abstract*: The most important feature of functional clothing is to create a stable microclimate next to the skin in order to support body's thermoregulatory system, even if the external environment and physical activity change completely . The thermal comfort of a garment depends on several factors: heat and vapor transport, sweat absorption and drying ability.*

Key words*: thermophysiological comfort, air permeability, thermal conductivity, water vapor transport.*

1. INTRODUCTION

Comfort is a fundamental and universal need of a human being. However, it is very complex and is very difficult to define. According to Fourt and Hollies (1970) comfort involves thermal and non-thermal components and is related to wear situations such as working, non-critical and critical conditions. The physiological responses of the human body to a given combination of clothing and environmental conditions are predictable when the system reaches steady state. According to Slater (1985), comfort is a pleasant state of physiological, psychological, neurophysiological and physical harmony between a human being and the environment.

Thermal comfort is that condition of mind which expresses satisfaction with the thermal environment (ISO 7730). Human thermal comfort depends on the metabolic rate (internal heat production), the heat loss from the body and the climatic conditions. Clothing modifies the heat loss and moisture loss from the skin surface, so it plays a vital role in the maintenance of heat balance. A clothing system which is suitable for one climate may not be suitable for another as clothing insulation is very important for human thermal comfort (Ogulata, 2007). Good thermal insulation properties are needed in clothing and textiles used in cold climates. The thermal insulation depends on different factors like thickness and number of layers, drape, fibre density, flexibility of layers and adequacy of closures. The thermal insulation value of clothing when it is worn is not just dependent on the insulation value of each individual garment but on the whole outfit as the air gaps between the layers of clothing can add considerably to the total thermal insulation value.

Comfort deals with physical processes which generate the stimuli like heat transfer by conduction, convection and radiation, moisture transfer by diffusion and evaporation. It also includes mechanical interactions in the form of pressure, friction and dynamic irregular contact. Comfort is not only comprised of thermal and moisture transmission but also includes air permeability, water repellency and water resistance

The psychometric comfort chart, schematically shown in Fig. 1, correlates the perception of comfort with the various environmental factors known to influence it. The dry bulb temperature is plotted along the horizontal axis. The light side of the chart shows a dew point scale and the left side a wet-bulb temperature scale indicating guide marks for imaginary lines sloping diagonally down from left to right. The lines curving upward from left to right represent RHs. ET* lines are also drawn. These are the sloping dashed lines that cross the RH lines and are labelled in increments of 5 °F. At any point along any one of Improving comfort in clothing

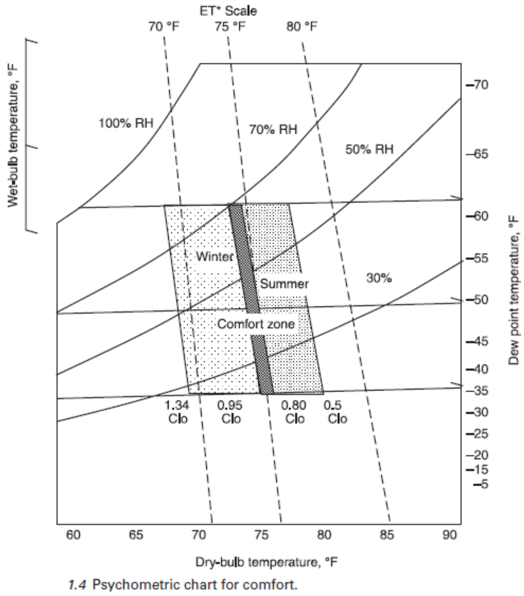

Figure 1. Psychometric chart for comfort

2. AIR PERMEABILITY

Air permeability is described as the rate of air flow passing perpendicularly through a known area, under a prescribed air pressure differential between the two surfaces of a material. Tests were performed according to standard ISO 9237 using a Textest FX-3300 air permeability tester. The air pressure differential between the two surfaces of the material was 100 Pa. Thermal properties were evaluated using the ALAMBETA instrument [12] and tests performed according to standard ISO EN 31092-1994. In all

cases, the measuring head temperature was, approximately, 32°C and the contact pressure 200 Pa. Thermal comfort was characterized by three properties: Thermal conductivity; Thermal resistance and Thermal absorptivity.

Figure 2. Air permeability TEXTEST FX 3300 and ALAMEBTA

In calculating the air permeability of materials at given wind speeds, the method given by Douglas (1975) is often used. The method is analogous to the impact of a fluid on a flat plate using:

$$P = r\ a\ v \quad [5.19]$$

where, P = force exerted on plate (Pa)
r = mass density of air
v = wind velocity in ms^{-1}.
The pressure drop across the plate increases with increasing wind velocity.

Table 5.2 Water vapour transmission comparison

Fabric	Control dish (mm still air)	BS7209 (%)	Gore cup (g m^{-2} day^{-1})	Skin model (m^2 mbar W^{-1})	Permetest (%)
Knitted cotton	0.9	96	19500	0.0415	22.48
Woven cotton	0.9	96	20000	0.0343	17.17
Woven polyester cotton	1	95	18350	0.0386	20.14
Nonwoven insulation	1.4	94	14100	0.0527	16.83
3-ply PTFE hybrid	3.3	85	7300	0.0789	10.46
3-ply Microporous PU	6.4	74	4400	0.1383	8.65
2-ply Impermeable	267	1	250	2.818	5.52

3. THERMAL CONDUCTYVITY

Thermal conductivity is fundamental to determine the heat transfer through fabrics. For textile materials, still air in the fabric structure is the most important factor for conductivity value, as still air has the lowest thermal conductivity value when compared to all fibers (λair = 0.025). Therefore, air transports a low quantity of energy by conduction and thermal conductivity decreases as well [13].

3.1. Thermal Resistance

Thermal resistance expresses the thermal insulation of fabrics and is inversely proportional to thermal conductivity. In a dry fabric or containing very small amounts of water it depends essentially on fabric thickness and, to a lesser extent, on fabric construction and fiber conductivity [2].

The thermal insulation of small fabric specimens can be readily measured in the laboratory by testing dry heat transfer. Hot-plate methods based on two-plate, single plate and guarded plate are the most popular and give results of reasonable accuracy (Fig. 3) (ISO 5085-1 1989 and BS 4745 2005).
1. The two-plate method of test is employed when the fabric to be tested would normally be shielded from the ambient air by an outer layer, for example a shirt when worn beneath a suit. This method utilises the heat flow principle, where measurement of the temperature gradient through the fabric is made using thermocouples.
2. The single-plate method is used when the outer surface of the fabric will be exposed to the ambient air, for example, outerwear clothing. The testing procedure and apparatus are similar to those of the two-plate method, but the cold-plate is now placed adjacent to the apparatus to measure ambient air temperature and the outer surface of the fabric is therefore left uncovered. However, reproducibility is not as good as the two-plate method.

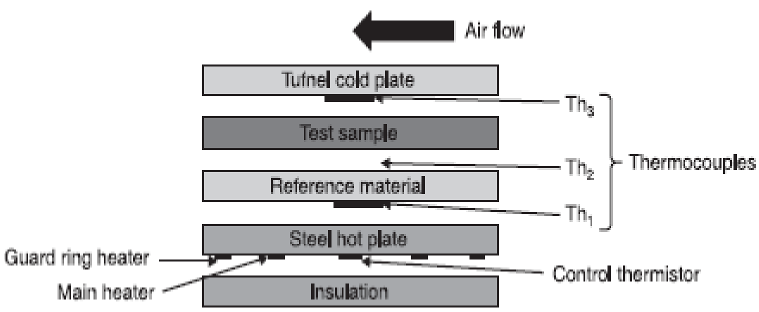

Figure 3. Togmeter – guarded hot plate.

3. The guarded hot-plate method is similar to the single-plate method, but is particularly suited to thicker fabric samples, requiring more sophisticated temperature control but achieving greater accuracy (e.g. ISO 11092). A metal guard plate surrounds all but the upper surface of the test-plate and

is maintained at the same temperature by a separate power supply to eliminate the effect of heat loss from the edges and bottom of the test-plate. There is also a thin layer of insulating material between the guard-plate and the test-plate to keep the temperature control of the two independent of one another. The temperature, humidity and air speed can be controlled when the apparatus is placed in an environmental chamber. Using a guarded hot plate for heat resistance measurement to measure the amount of heat lost through a sample with a temperature gradient between the plate and the environment, the insulation of the fabric can be calculated as:

$$R_{ct} = \frac{\bar{t}_{plate} - \bar{t}_a}{H_{DRY}} - R_0$$

where,
*R*ct = heat resistance of fabric sample (m2 K W–1)
*t*plate = mean hot plate surface temperature (C)
ta = ambient temperature (C)
HDRY = dry heat loss per m2 of plate (wm–2)
*R*0 = heat resistance measured without sample (m2 K W–1)

3.2. Thermal Absorptivity

Thermal absorptivity is the objective measurement of the warm-cool feeling of fabrics and is a surfacerelated characteristic. If the thermal absorptivity is high, it gives a cooler feeling at first contact with the skin. The surface character of the fabric greatly influences this sensation [12, 14].

4. WATER VAPOUR TRANSPORT

The more efficient the fabric is at allowing this water vapour to reach the ambient air the more breathable it is said to be. Breathability as described here is therefore regarded as a measure of the water vapour migration through a textile and not a measure of its air permeability or windproof characteristics. The water vapour transport properties of a textile are commonly expressed in one of three ways:
1. The water vapour flow in unit time through unit area of fabric under specific conditions of temperature and relative humidity, for example g m–2 day–1. This is commonly defined as either water vapour permeability (WVP) or moisture vapour transmission rate (MVTR).
2. The water vapour resistance, a measure of the resistance to water vapour migration expressed as the equivalent thickness of still air which has the same resistance to water vapour diffusion as the textile (mm still air). Resistance data are generally more useful than the permeability data because they are additive for clothing layers in the same way as electrical resistances in series and the thermal resistances of clothing. The overall resistance of a clothing assembly can therefore be estimated by adding together the resistances of the individual textile layers and the resistances of the air gaps between the layers. The resistance of an ensemble bears an inverse relationship to its water vapour permeability.
3. The resistance to evaporative heat flow (Ret) is the quantity which determines the latent or evaporative heat flux of a textile layer under steady state conditions effected by a partial water vapour pressure gradient perpendicular to the fabric. The resistance of a textile to water vapour flow has values for individual materials commonly expressed in units of m2mbar W–1 or m2Pa W–1.

4.1. Water vapour permeability

There are many different methods described in the literature for measuring the water vapour permeability of breathable textiles: some are national standards (CGSB49 BS, 7209, etc.) and others have been independently developed by clothing manufacturers, often to show their own products more favourably. The most common and simplest approach is that of the cup or dish method, of which there are two basic types, both based on weight change as shown in Fig.4
1. *The Desiccant Method*, where a sample is sealed to the open mouth of a dish containing a desiccant, such as calcium chloride or calcium acetate, and the assembly placed in a controlled atmosphere. The

weight gain of the assembly with time as moisture is attracted to the desiccant is used to determine the permeability
2. *The Water Method*, where a sample is sealed to the open mouth of a vessel containing water. This is then placed in a controlled atmosphere, either upright or inverted depending on realism and sample type. A further modification is to interpose a microporous membrane or an air gap between the water and the sample. The weight loss with time is used to determine the rate of water vapour migration.

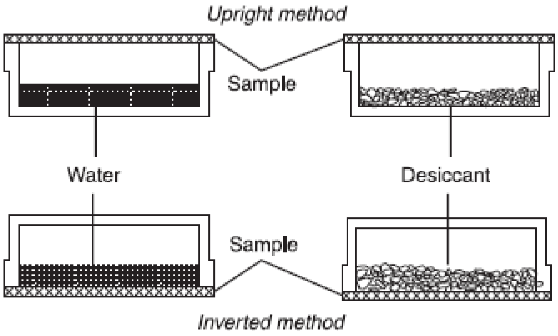

Figure 5. Water vapour permeability – cup method

The main test variables which influence water vapour permeability are the temperature and relative humidity at each surface of the sample. These are also influenced by the still air layers on both sides of the assembly. In general, the
water vapour permeability is given by:

$$WVP(gm^{-2}day^{-1}) = \frac{M_0 - M_1 * 24}{A * t}$$

where,
*M*0 = weight of the test assembly before test (g)
*M*1 = weight of the test assembly after test period t (g)
t = time between successive weighings of the test assembly (hours)
A = area of the exposed test fabric (m2).
The water vapour content of air is usually stated as per cent relative humidity (RH). However as the term suggests, relative humidity is not a measure of the absolute concentration of water molecules, but a percentage of the maximum amount of water vapour the air can hold at that temperature.

The water vapour permeability of textiles can also be assessed in relative units. ‘Relative wvp’ is calculated by comparing the masses of water vapour that are evaporated from either an open dish or a dish covered with a standard fabric with a dish with specimen as in BS 7209 (1990).

$$WVP_R = \left(\frac{m_{op}}{m_{sp}}\right).100$$

where,
WVPR = relative wvp (%)
mop = mass of water vapour evaporated from the open dish or dish with standard fabric (g)
msp = mass of water vapour evaporated from the dish with specimen (g).

4.2. Water vapour resistance

A relationship between water vapour permeability and water vapour resistance is derived from Fick’s first law of diffusion which states that the flux in the x-direction, Fx, is proportional to the concentration gradient Dc/Dx (Glasstone 1960; Fourt and Harris 1947) such that:

$$R = \frac{1}{Q} D(\Delta C) At$$

where,
R = resistance of the system (cm)
Q = weight change of the test assembly during test period t (g)
t = test period (s)
A = area of the exposed test fabric (cm2)
D = the diffusion coefficient (cm2 s–1)
ΔC = difference in water vapour concentration across the test assembly (g cm–3).
(Q/At, the water vapour permeability, can be measured directly.)

4.3. Diffusion Ability

Expresses the rate of water diffusing in the fabric surface and represents fabric's instantaneous water (perspiration) absorbency and transferring ability. The fabric samples were placed flat on a hydrophobic board with the outer surface facing down. The diffusion area (mm2) was measured 30 seconds after dripping 0.2 ml of water, using a precise dropper whose tip was 10 mm above the fabric surface. The measurement was repeated at five different points and the average of the diffusion area (mm2) was taken to indicate the diffusion ability of the fabrics.

5. CONCLUSION

The thermal property of fabric is very important for both its thermal comfort and protection against challenging weather conditions Fabric thermal properties have been of great interest and importance for textile researchers, since they are among the major characteristics that determine wearing comfort. It is observed that the parameters of thermal conductivity, thermal resistance, thermal absorptivity and air permeability are veary importante for wearing.

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DEVELOPMENT OF TECHNICAL DOCUMENTATION USING INDUSTRIAL DESIGN SOFTWARE KALEDO STYLE ON EXAMPLE OF A FEMALE TROUSERS

Marija STANKOVIĆ, Vasilije PETROVIĆ, Aleksandra Zdravković, Ivana Skoko, Željko Branović

Abstrac: *This paper presents the development of technical documentation which enabled a solution of a numerous problems that are following production nowadays. These problems are primarily related to the short deadlines of making clothing products with products technical preparation that requires significant time. As a part of this work, industry software KALEDO Style – a program for clothes design is described. Advanced design tools, such as industrial solution software Kaledo Style which is used in this paper, facilitates the creation of new styles and layout patterns. Users of this software can quickly and easily generate their own ideas, combine colors, fabrics and styles, all with the aim of obtaining the optimal solution for the creation of their product range. Use of this software is described in this paper on the example of the preparation of technical documentation for a female trousers.*

Key words: *computerized clothes construction, Kaledo Style, technical documentation, female trousers*

1. INTRODUCTION

Time in which we live in is characterized by the progressive development of science, engineering and technology, which reflects on the textile industry as well as the designers. Hand made fashion drawings and technical sketches is almost completely replaced with computer drafting. Increasingly, software us used for vector drawings of sketch models which contributes to faster and more efficient development of sketches itself and accompanying technical documentation.

Kaledo Style is French company Lectra software, designed for fashion design. It allows fashion designers easier getting to new trends and themes, makes it easier to design new styles and creating products in different colors and fabrics. The possibility of obtaining high-quality images allows quick and easy communication with the readers of technical specifications.

2. DESCRIPTION AND SKETCH OF MODEL

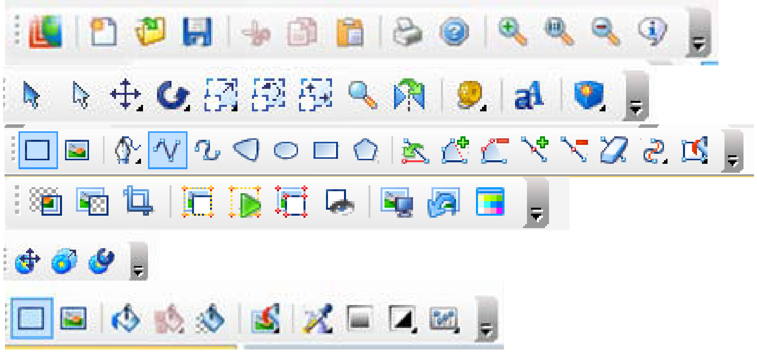
In order to fully define the model, he must be described and sketched. The model is being described for parts of, while the details to be found on the front, the back, the sleeves and collar shall be specified. In addition to descriptions of appearance, it is necessary to describe the ways of making some key details on the model, then what are linings and interlinings. In describing the model, we need to pay attention on the description that should be concise, precise and comprehensible.

During sketching of a model, all the details must be entered i.e. each said gusset, holes, buttons, trim, etc.., because all of them characterize the model and give him the appropriate look. This must be entered because the constructor on the basis of these sketches performs construction and modeling of a given model. Sketch is been colored in colors of materials for better clarity, and samples of all materials included in the model is been submit, for the testing of their physical and chemical features and possible additions of the pattern that could predict the "behavior" of the material on the finished garment. Based on all of these informations constructor starts making of patterns.

3. MAKING OF MODEL SKETCHES IN KALEDO STYLE

For work in this program a group of tools is used, and they are divided on bars depending of the type of tools. On Picture 1. Groups of tools that will be used to create technical sketch models are shown.

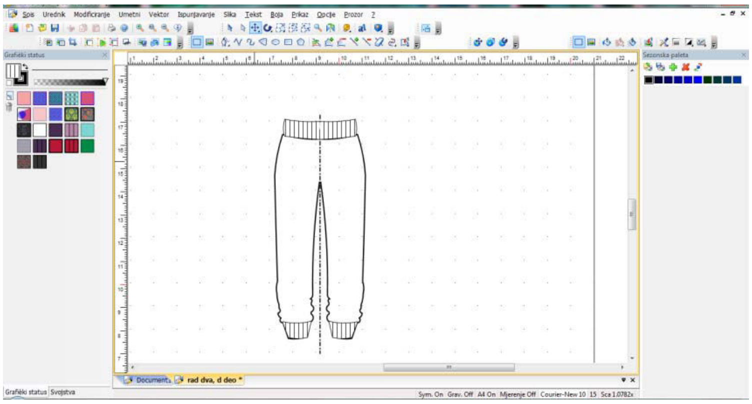
m)
n)
o)
p)
q)
r)



Picture 1. a) basic tools, b) useful tools for manipulation and rotation, c) vectors, d) pictures, e) motives, f) color

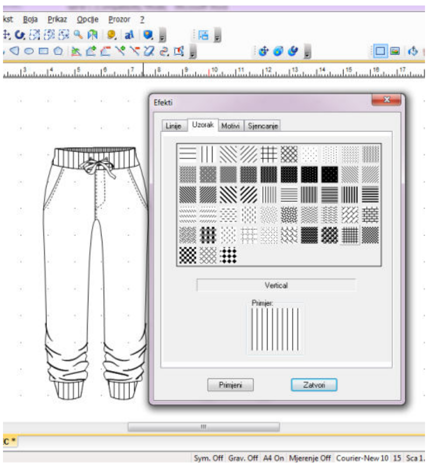
Drawing of a sketch starts by pulling an axis of symmetry, which is located in the toolbar of useful tools. For drawing itself we use tools from the vectors toolbar. The rearrangement of vectors is done by using its component points. Drawing is performed with multi tool line by laying the points. Right click ends the form. QWA and S keys are used to reshape the line segment in the curve. To limit lines horizontally or vertically the Shift key is used.

For easier drawing it is possible to activate a help net inside the working area. Gravity option allows us to draw and position the elements with greater accuracy. Gravity can be set in a way that vector line is attracted to the net in a drawing area or toward other vector objects. Picture 2. Shows the working area and beginning of making a model sketches, from pulling the axis of symmetry

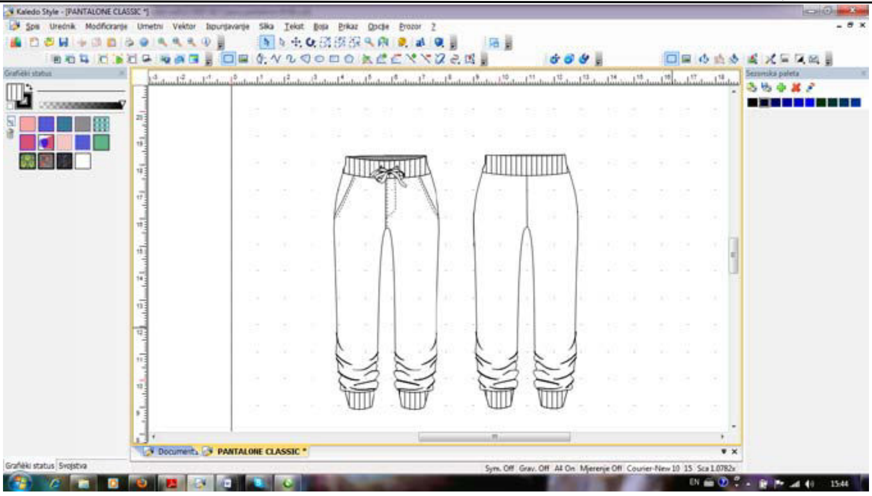


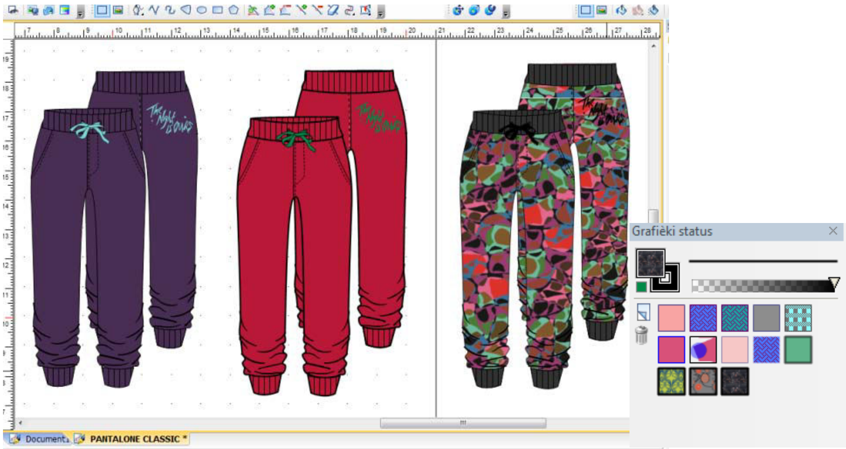
Picture 2. The basic sketches outline of a female trousers model

For filling the gap, i.e. for drawing the render, hatch that is set in the option card effects and samples is used (Picture 3).



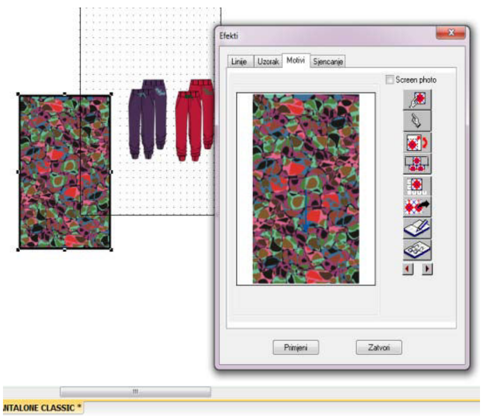
Picture 3. Hatching option, i.e. drawing of the render on the trousers

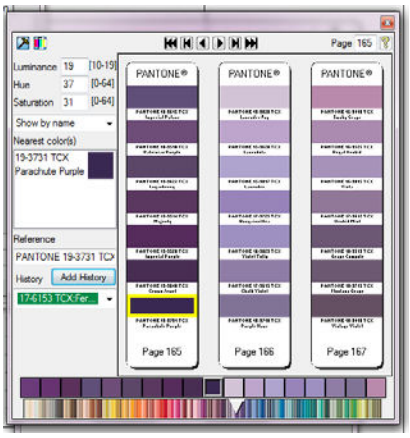

Picture 4. Technical sketch of female trousers model


Picture 5. Elaboration of the model by colors. Shows colors and patterns.

After creating of vector drawings for female pants model, development of model by color is approached. The 1st model is made of designed material, while the other two were made from mono colored material. In order to implement the design in a sketch it is necessary to insert a picture of design or scanned picture of the material in the working area of Kaledo. This is accomplished by using a tool for inserting images from the File menu. Double click on a color for filling the form opens a window where on a design card we have options for adding a design. (Picture 6).

If we opt for a mono colored material then the color of the material can be selected from pantone card. (Picture 7)


Picture 6. Window for adding the design

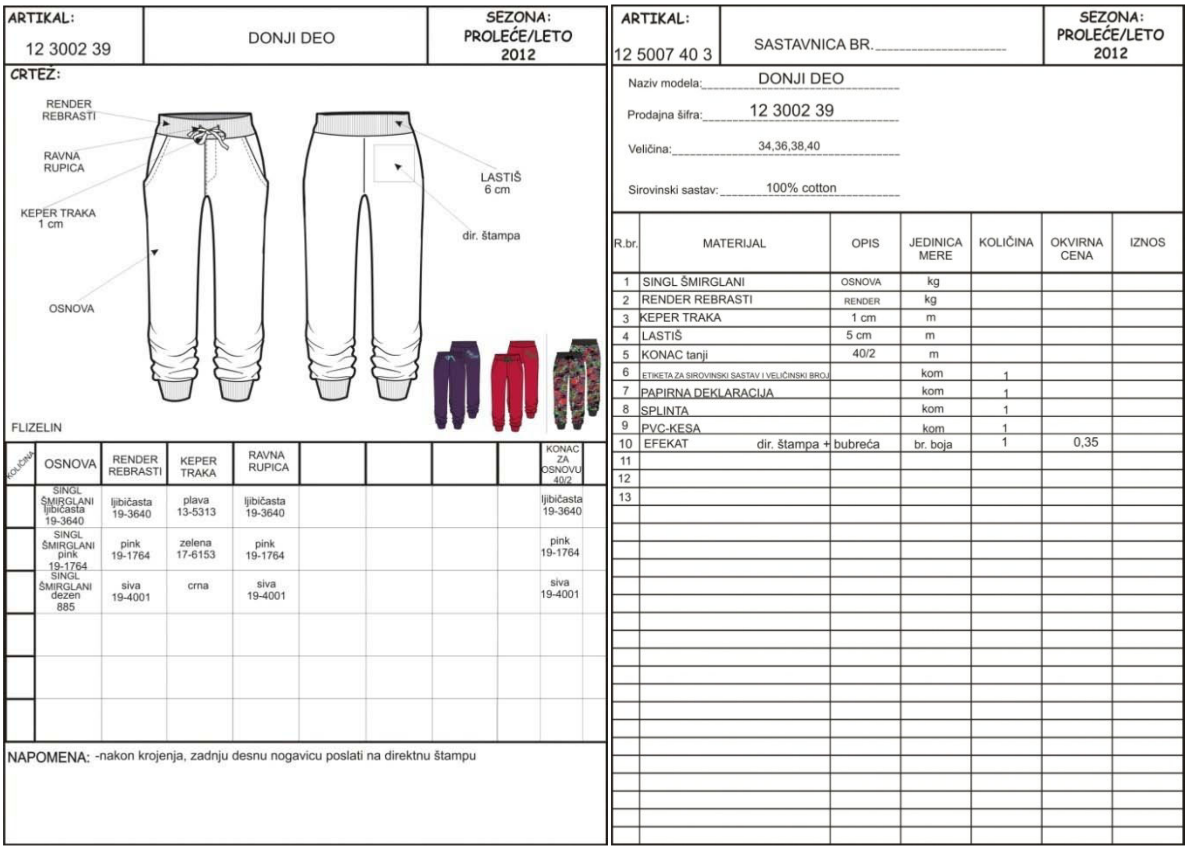

Picture 7. Window for selection of panton colors

4. Preparation of technical documentation

Components list, is a document that accompanies the product through all its stages. It contains data about the range of sizes, colors and patterns on, details of the base material and material which is going to be incorporated ..
There are different forms, but universally it includes the following information**:**

- The number of components list / current year.
- Production unit
- A description of the model sketches
- Sketch model
- Raw materials that are entering into the composition of materials
- Launch date ...

During the completion of the components list, map patterns (farben map) is made, and it contains data on primary and auxiliary material and materials that are installed (name, code, width, energy use, samples of each color and pattern, thread, fasteners, buttons, etc..). Map designs is made in 3 - 4 copies (for tailors department, department of sewing machines, department of control of intermediate and final quality and sometimes for commercial service). Picture 8. shows the technical documentation for the model of female trousers.



ARTIKAL: 12 3002 39 | DONJI DEO | SEZONA: PROLEĆE/LETO 2012

CRTEŽ:

KOLIČINA	OSNOVA	RENDER REBRASTI	KEPER TRAKA	RAVNA RUPICA					KONAC ZA OSNOVU 40/2	
	SINGL ŠMIRGLANI ljibičasta 19-3640	ljibičasta 19-3640	plava 13-5313	ljibičasta 19-3640					ljibičasta 19-3640	
	SINGL ŠMIRGLANI pink 19-1764	pink 19-1764	zelena 17-6153	pink 19-1764					pink 19-1764	
	SINGL ŠMIRGLANI dezen 885	siva 19-4001	crna	siva 19-4001					siva 19-4001	

NAPOMENA: -nakon krojenja, zadnju desnu nogavicu poslati na direktnu štampu

ARTIKAL: 12 5007 40 3 | SASTAVNICA BR.________ | SEZONA: PROLEĆE/LETO 2012

Naziv modela: DONJI DEO
Prodajna šifra: 12 3002 39
Veličina: 34,36,38,40
Sirovinski sastav: 100% cotton

R.br.	MATERIJAL	OPIS	JEDINICA MERE	KOLIČINA	OKVIRNA CENA	IZNOS
1	SINGL ŠMIRGLANI	OSNOVA	kg			
2	RENDER REBRASTI	RENDER	kg			
3	KEPER TRAKA	1 cm	m			
4	LASTIŠ	5 cm	m			
5	KONAC tanji	40/2	m			
6	ETIKETA ZA SIROVINSKI SASTAV I VELIČINSKI BROJ		kom	1		
7	PAPIRNA DEKLARACIJA		kom	1		
8	SPLINTA		kom	1		
9	PVC-KESA		kom	1		
10	EFEKAT dir. štampa	+ bubreća	br. boja	1	0,35	
11						
12						
13						

5. CONCLUSION

Advanced design tools, such as industrial software solution Kaledo Style that has been applied in this paper, facilitates quicker defining of new styles and layout patterns. Users of this software are enabled to quickly and easily generate their own ideas, combine colors, fabrics and styles, all with the aim of obtaining the optimal solution for the creation of their product range. Kaledo Style offers an unlimited number of variations regarding fabrics, colors, patterns, ornaments as well as numerous details. Because of these Kaledo features course of the development process is facilitated and the introduction

of advanced technologies and combining them with the imagination and creativity of a user, presents the perfect solution for creating innovation and trends customization.
Kaledo Style usage is a challenge for a single user, because it reduces the pressure of short deadlines for realization of of technical documentation and increases the desire and motivation for creative work. Precisely for this reason, Kaledo is a solution that is gladly accepted among the designers because it represents a way of processing their idea to the final realization in a shorter, more beautiful and much more exciting way to meet the challenges of today.

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EFFECT OF CUTTING PARTS ORIENTATION IN CUTTING PATTERN ON SPENT MATERIAL

Vasilije Petrovic, Marija Stankovic, Aleksandra Zdravković, Sanja Stefanović

Abstract: The cutting patterns represent composition all cutting parts of garment rationally incorporated in a given width of the material. This work becomes much easier with the appearance of CAD / CAM system. The cutting patterns have better processing punctuality and possibility to control spent material. 5 sizes are obtained by grading children pants. The cutting parts of those sizes are matched into the cutting patterns in one or two directions.

Key words: grading, CAD / CAM system, cutting pattern, cutting parts, spent material, material utilization.

1. INTRODUCTION

Constructing cutting patterns, modeling, tailoring images making and the apparel design were carried out manually until the appearance of computers. Using the computers these tasks were significantly accelerated and the quality and accuracy are greatly increased. Therefore, in today's apparel industry the constructional preparation work is unimaginable without using the computers. [1]

When placing the tailoring parts on the fabric, it is very important that the direction of the cutting parts basis coincides with the material length. The tailoring parts deployment depends on the fabric or knitwear type, as well as on whether the fabrics or knitwear are with or without patterns, plaid, striped, etc. [1].

In this paper, two cutting patterns are analyzed in which cutting parts are incorporated and placed in unidirectional or bidirectional way. By the analysis of these two ways of fitting cutting parts, which of them is more effective and with less the losses can be seen.

2. GRADING, INCREASING AND DECREASING OF PATTERN CUTTINGS

The cuttings grading is the process of making size range required for the mass clothing production. By increasing and decreasing of the cutting parts, they can be made in all sizes, for all types of materials that are needed for making a garment. The pattern cuttings for clothing models are made mainly in medium sizes of a certain age and the body development and the other parameters will be obtained by the grading process, i.e. by increasing and decreasing pattern cuttings. [2]
The garments making in various, as much as possible, sizes that are needed to satisfy the greatest number of potential buyers.
The cutting parts can be increased and decreased in three ways:

- the constructing limit sizes method
- the method of the basis size and measures difference
- the method of generating sizes [2]

The method of limit values construction is consisted of making the smallest and the largest size that is used with the basis size to create all the rest.

The method of grading garment patterns, based on the basis size and measures difference, is consisted of the cutting parts development of the basis size manually or using computer and the other parameters are obtained by measuring the appropriate amount, i.e. the measures difference, which depends on the measures variations between the specified sizes on particular points. This method is now mostly used in the handcrafted work as well as in increasing and decreasing by the computer. [2]

The size generating method is begun to be used in recent times and is related to the computer making of the cutting patterns in so-called CAD system. The cutting patterns making in this manner is based on the fact that computer stores the making procedures of the one size cutting pattern and that computer has certain drawn lengths in a similar way as the construction which is done manually. Based on the cutting patterns made by the base size, the specific tables of measures and appropriate program, the computer automatically generates the cutting parts of all rest sizes. [3]

Basic configuration of the CAD system in apparel industry includes:
1) The device for recording the coordinates of the cutting parts points (digitizer). It contains a rectangular panel, digitizer and connecting devices.
2) The device for connecting the other devices in the network with the database. These devices contain: a graphical display, a keyboard, a mouse and a central computer that connects all the peripheral devices with the digitizer.
3) The automatic cutting patterns drawing (plotter), which is connected to the central computer using the appropriate cable. [3]

The electronic grading procedure according to the system developed by all manufacturers of CAD equipment is carried out in the following stages:
a) Manual or computer construction of the basic or basis cuttings.
b) Determination and the main points marking of the basic cuttings.
c) Grading rules preparation.
d) Recording the coordinates of the major and minor points.
e) Grading cuttings.
f) Data control. [3]

For software packages, the systems of standard clothing sizes with an appropriate way to mark any country are used. All changes are performed quickly and easily which is particularly related to the digitization process with simultaneous display on the screen and the garment model making from a series of garments. In addition, there is the possibility of developing new cutting parts (for example lining, adhesive interlinings, etc…) according to the existing ones. [3]

There is a possibility of application of the options for keeping functions that are often repetitive, which significantly speeds up and simplifies operation. For duplicating cuttings is needed to know the increase values of constructive points by the axes 0x and 0y and the additional information contained in the computer memory. After introducing the necessary information, the multiplied cuttings calculation follows and getting output data. After the test, the operator introduces the multiplied cuttings results and the other information about the cuttings in the computer memory. The operations sequence is performed by automatic process of copying and multiplying cutting patterns using this system.

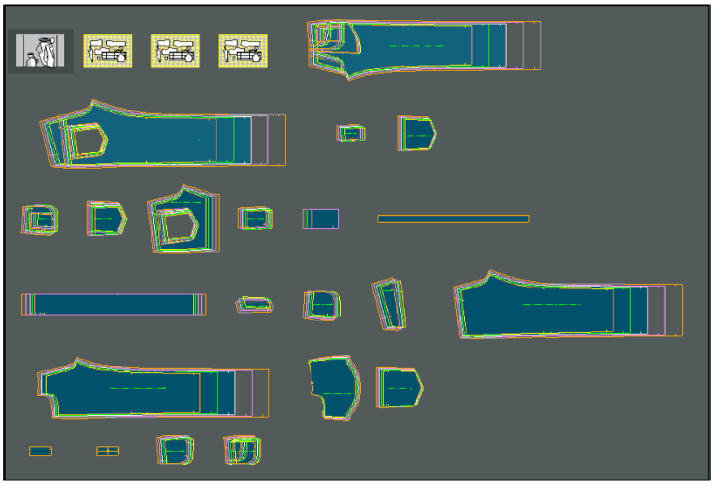


Figure.1 Grading cutting pieces of children's jeans pants in the CAD system

Model M-1 grading was performed on the CAD system "Lectra". [3]
Figure 2.1. The children's trousers grading 1 model in the CAD system is shown. Base size is 10. The sizes derived from base size are 6, 8, 12,14.

3. LABELING AND MARKING CUTTINGS

The basis direction is to be marked on each cutting part, the code, the model size and the important points that are marked by the nicks. The marking direction essentially serves as a guide for the templates fitting of a specific clothing article. If the basis direction is improperly marked or the template is improperly fitted, it may deform the finished garment due to the stretching of its parts. [1]
The nick or fixed points are important work guides and using them in production the workers can orient how to fit two parts of the clothing article. [1]

4. TEMPLATES CREATING

The cutting patterns are copied pattern form on a special paper, cardboard or plastic film that are cut by the drawn lines. This is done because the paper pattern are not suitable for industrial applications.

5. MAKING CUTTING PATTERNS AND THEIR REPRODUCTION

The cutting pattern represents the set of all cutting parts of a garment rationally fitted in a given width of the material.
When placing cutting parts on the fabric is very important that the basis direction of cutting parts coincides with the length of the material. The deployment of cutting parts depends on the type of fabric or knitwear, actually on whether the fabric or knitwear are with or without patterns, plaid, striped, etc. [1].
The cutting parts which are not formed by stitches or gussets are usually tailored of the slanting fabric because it is more flexible in that position. In this tailoring, the cutting parts require more spent material than in straight fabric tailoring. Before tailoring, is necessary to make the following checks:

- are all cutting parts are situated on the fabric, knitwear or paper,
- are all cutting parts on fabric are properly laid according to the fabric decline and are the possible errors on the fabric or knitwear,
- if the fabric has a pattern, check that all the samples lie in one direction,
- with the printed fabrics, make sure that the pattern on some parts of the cutting pattern matches or continues,
- if the cutting part is double, is it laid with the corresponding edge on the fabric or knitwear crease,
- whether the material is properly folded, with the fabric turned inward unless otherwise planned. [1]

With the advantages of CAD / CAM systems, this job becomes much easier. Increased making precision, then greater possibilities of the spent material control...
When starting to create a new cutting pattern, it is needed to determine its following parameters:

- the cutting patter name,
- the type and kind of material,
- the way of laying material
- the material sample,
- the width and edge of material,
- model that fits,
- model sizes and the number of repetitions and so on. [1]

These data are entered in specific applications to be processed, and then they generate a surface on which cutting pattern fits and call tasked models from databases. Only fitting can be performed manually or automatically. The distances can be made around the cutting parts that need to go to a fine tailoring. The design of designed materials can be scanned and entered into the computer and on the cutting parts are placed control points by which part fits exactly where is determined in the cutting pattern. [1]

6. CUTTING PATTERN ANALYSIS

In Figure 2 the cutting pattern of children's jeans pants model M1 is shown. In this cutting pattern, the cutting parts of jeans pants are placed so that the base direction is oriented in both directions. The material width is 1.5 m, while the cutting pattern length is 4, 279 m. The total material utilization is expressed as a percentage and amounts 83.75%.

Figure 2. Cutting pattern of model M1 where the cutting parts are nested into two directions

In Figure3 the second cutting pattern of children's jeans pants of the same model M1 is shown. The cutting parts are placed so that the base direction is focused to one direction. The material width is 1.5 m and the cutting pattern length is 4.478 m. The total material utilization amounts 80.40%.

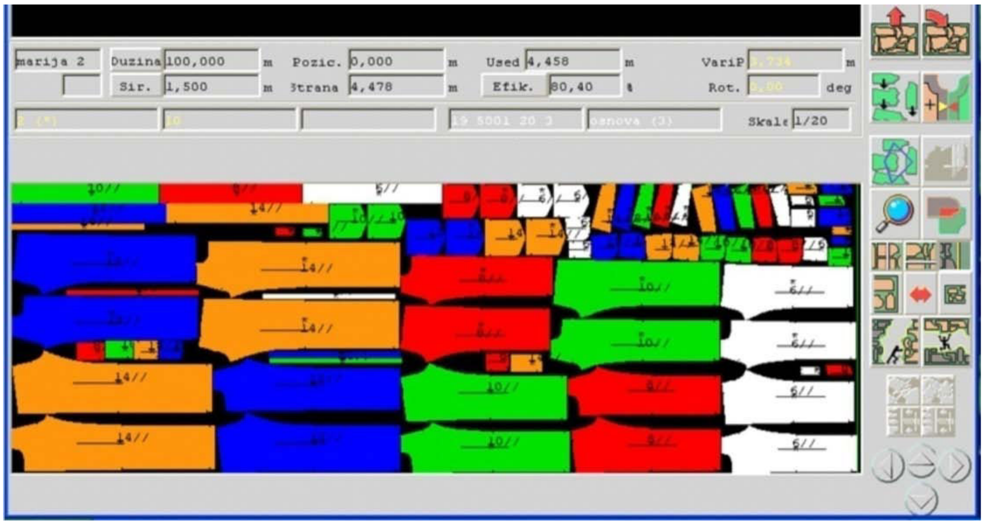
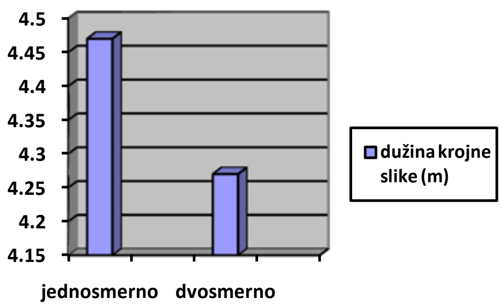


Figure 3. Cutting pattern of model M1 where the cutting parts have unidirectional fitting

It can be concluded that the utilization of materials, and thus saving material, is the greater for the bidirectional fitting of the cutting parts, as opposed to cutting pattern where is shown the unidirectional fitting. In figure 4. the histogram of the cutting pattern length is shown, ie. The length of spent material, where it can be clearly seen that the greater material savings are in the bidirectional fitting of the cutting parts. In figure 5. histogram of the materials utilization is shown, where the obtained values are expressed in percentages and where it can be clearly seen that using the bidirectional fitting of the cutting parts the higher utilization materials becomes. The bidirectional fitting of the cutting parts of jeans clothing is not recommended because there is a different behavior of the jeans fabric base during the final sanding process.



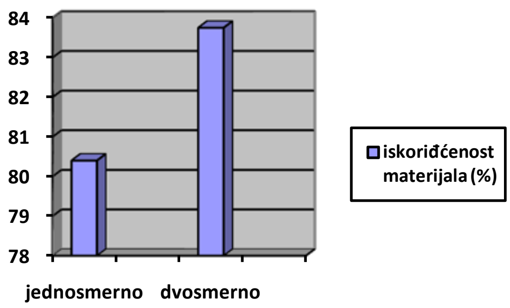


Figure. 4 The material consumption histogram. Figure 5 The material utilization histogram

7. CONCLUSION

For the M2 model, the cutting patterns are shown in the CAD system and two ways of fitting pieces of a clothing item in the cutting pattern. The length of the necessary material for a unidirectional fitting of the cutting parts in the cutting pattern is 4.47m, while the length of the material necessary for a bidirectional fitting of the cutting parts in the cutting pattern is 4.27 m. The material utilization in unidirectional fitting is 80,40% while in the bidirectional fitting is 83,75%, which is 3,37% more then at the unidirectional fitting. It can be concluded that the material consumption is lower and the percent of the materials utilization is higher in a bidirectional fitting of the cutting parts in the cutting pattern. However, in the jeans clothing, unidirectional fitting is recommended in order not to get diversity during the sanding process.

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