September 25-26

2014

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IFKT

Turkish Section

47th International Federation of Knitting Technologists Congress

BOOK OF ABSTRACTS

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47th

INTERNATIONAL FEDERATION OF KNITTING TECHNOLOGISTS CONGRESS

IFKT 2014

25-26 SEPTEMBER 2014
İZMİR - TURKEY

BOOK OF ABSTRACTS

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47th INTERNATIONAL FEDERATION OF KNITTING TECHNOLOGISTS CONGRESS

BOOK OF ABSTRACTS

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Mehmet KÜÇÜK (MSc)	Ege University

PROGRAMME

08:30 – 09:30 REGISTRATION

09:30 – 10:00 OPENING SPEECHES

10:00 – 10:25 Development of Three Dimensional Pressure Relieving Cushions for Prevention of Pressure Sores
S.C. ANAND[1], C. WOOD[2], B. McARDLE[3]
[1]University of Bolton, UK
[2] Baltex Limited, UK
[3] Quality of Life Design and Development, UK 21

10:25 – 10:50 Innovation in Knitting Technologies and Applications
Mathias BEER, Kristina SIMONIS, Viktoria SCHRANK, Yves-Simon GLOY, Thomas GRIES
RWTH Aachen University, Germany 23

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Minoru NAKAMURA
Shima Seiki MFG Ltd, Japan 26

11:35 – 11:55 Open Width Finishes for Knitted Goods
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Jörg HARTMAN
H. Stoll GmbH & Co.KG, Germany 31

12:15 – 12:35 Warming Textiles – Soak Up The Sun
Harald LUTZ
CHT R. Beitlich GmbH, Germany 32

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Section 2: INNOVATION & MACHINE BUILDING IN KNITTING

15:40 – 16:00 Constructive Assumptions of a New Fourcomb Warp-Knitting Machine

Andrzej MICHALAK, Maciej KUCHAR, Zbigniew MIKOŁAJCZYK
Lodz University of Technology, Poland

16:00 – 16:20 A Study of Circular Knitting Machine with Auto-Stripping Module

Yushik SHIN[1], Jonglyel LEE[1], Sukrae KIM[1], Jinsuck YANG[2], Younggu HWANG[3], Shin-Woong PARK[4]
[1] Korea High Tech Textile Research Institute, Korea
[2] JS Knitting, Korea
[3] Ducksan Enterprise Co. Ltd
[4]Ducksan Enterprise Co. Ltd. & INHA University, Korea

16:20 – 16:40 Measurement of Fabric-Take Down Force on Double-Bed Circular Knitting Machines

Zlatko VRLJICAK[1], Marcus WEBER[2], Snjezana BRNADA[1]
[1]University of Zagreb, Croatia
[2] Niederrhein University of Applied Sciences, Germany

16:40 – 17:00 Development of Reversible Different Plush Outdoor-Wear Fabric of 3-Dimensional Warp-Knitted Construction Using High-Multi Micro Fibers

Young-Gu HWANG[1], Shin-Woong PARK[2], Joo-Deuk BANG[1], Joo-Chul BANG[1], JaeSang AN[3], YuShik Shin[4]
[1]Duck San Enterprise Co. Ltd in Pochon, Korea
[2] Inha University of Textile Engineering in Inchon, Korea
[3] KITECH / Ansan, Korea
[4]Korea High Tech Textile Research Institute, Korea

20:00 **Gala Dinner**

Section 3: DESIGN IN KNITTING & CLOTHING

09:30 – 09:50 Imparting Flame-Retardant and Antistatic Properties to Two-Layer Knitted Fabrics
Elzbieta MIELICKA, J.JANICKA, R. KOŹMIŃSKA, A. WALAK, I. OLEKSIEWICZ
Textile Research Institute, Poland 59

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Ellen BENDT, Marina-Elena WACHS
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Zbigniew MIKOŁAJCZYK, Anita BUTWICKA, Kataryzna PIEKLAK
Lodz University of Technology, Poland 63

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Yordan KYOSEV[1], Wilfried RENKENS[2]
[1]Hochschule Niederrhein – University of Applied Sciences, Germany
[2] Renkens Consulting, Germany 69

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Sadhan Chandra RAY
University of Calcutta, India 73

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Beata SZAŁEK, Katarzyna PIEKLAK, Zbigniew MIKOŁAJCZYK
Lodz University of Technology, Poland 77

Section 5: QUALITY & TESTING IN KNITTING

Section 6: EDUCATION & TESTING IN KNITTING

PLENARY SESSION

DEVELOPMENT OF THREE DIMENSIONAL PRESSURE RELIEVING CUSHIONS FOR PREVENTION OF PRESSURE SORES

S.C. Anand[1], C. Wood[2], B. McArdle[3]
[1]Institute of Materials Research and Innovation, University of Bolton, United Kingdom
[2]Baltex Limited, Ilkeston, United Kingdom
[3]Quality of Life Design and Development, Warrington, United Kingdom

Polyurethane (PU) foam is commonly used for seating and cushions in many applications varying from car seats, chairs, wheel chairs, sofas, mattresses and furniture. It is well known that PU foam cushions and seats are not breathable and lack thermo physiological comfort. They are also not washable at high temperatures and are environmentally hazardous both in terms of flammability and recycling.

Warp Knitted Spacer Fabrics are extremely versatile in terms of designing, thickness, comfort, washability, compression and resilience and above all they are extremely efficient in pressure relief. These unique three dimensional (3D) structures can have between 2 mm and 65 mm thickness with good compression, resilience and breathability. The two independent fabric faces can be knitted into any kind of mesh or solid structures and in order to sustain the space between the two faces, and to obtain the required compression and resilience properties in the thickness direction, monofilament yarns are normally used as the spacer yarn.

The paper discusses the systematic research and development of pressure relieving cushions, by combining a series of three-dimensional warp knitted spacer structures in order to achieve the desirable properties, such as good compression resistance and resilience, reduction of peak pressure and pressure distribution over much larger area of the cushion. The fundamental research work was carried out at the University of Bolton, U.K.

The various innovative and unique features of the Airospring® Cushions are as follows:

1. They are much better at reducing peak pressures under the bottom than PU foam cushions.
2. They distribute the pressure evenly over much larger areas of the cushions or seats than PU foam cushions.
3. They conform to the shape of the body and have sufficient compression resistance to support the person without "Bottoming Out".
4. They provide a well-ventilated, comfortable surface that does not unduly restrict movement.
5. They can be laundered in the washing machine, are non-flammable and can be easily recycled.
6. They are particularly beneficial to the persons who are prone to developing pressure sores, due to prolonged periods of sitting in the wheel chair and other support systems.

Airospring cushions have been covered by a patent application and are being commercially developed and marketed by Baltex Limited, Ilkeston, Derbyshire, United Kingdom.

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Comp.T.I; C.Text. F.T.I.
e-mail: sca1@bolton.ac.uk

INNOVATION IN KNITTING TECHNOLOGIES AND APPLICATIONS

Mathias Beer, Kristina Simonis, Viktoria Schrank, Yves-Simon Gloy, Thomas Gries
RWTH Aachen University / Institut für Textiltechnik (ITA) / Otto-Blumenthal-Str. 1, 52074 Aachen, Germany

The Institut für Textiltechnik (ITA) belongs to the top 10-institutes of RWTH Aachen University. Its core competencies are the development of textile machinery and components, high performance fibre materials, manufacturing technologies and comprehensive process chains and the development of innovative textile based products in the sectors of mobility, civil engineering and living, energy and health. The essential technology fields of its research are material and energy efficiency, functional integration and integrated production technologies. The institute employs about 90 researchers graduated in the studies of mechanical engineering, business engineering, physics and chemistry. A major field of research at ITA is textile machinery and within this fabric production, in particular knitting.

Textile companies as well as research institutions, in particular those located in Germany, pursue an ongoing advancement and new development of their existing products and processes. Knitting facilities in Germany and Central Europe have recently increased their production of knits for technical application fields. This trend refers to the application of the produced products as well as the used materials. For example knitted fabrics out of common material (Polyester, etc.) are used for technical applications like base yarn materials for composite structures. On the other hand known applications, for instance home textiles made out of new materials like glass yarn, are researched in the field of flame protection.

A trend of the development of knitted structures is the machining of superfine yarns. From this follow further challenges in machine construction. In particular the machine gauge (number of needles per unit

of length) needs to be adjusted. Through the realisation of finer machine gauges by attending denser knitted structures, new fields of application are opened. One of these application fields is the filtration technology [1].

Furthermore, an important research field at ITA is the investigation of new, mainly technical yarn materials for knitted fabrics. In comparison to other types of machinery in fabric manufacturing (e.g. weaving, warp knitting) there is a high potential for the investigation of innovative materials using knitting machines. In general, knitting machines require a little amount of yarn material for fabric manufacturing – e.g. using small circular knitting machines there is just a need of one single yarn bobbin. The set up and production times are low, so the mechanical properties of knitted fabrics made out of new material can be determined quickly. That is why knitting machines are often used in prototype production. At ITA, the knitting processability of new yarn material, such as melting polyolefin and glass has already been investigated successfully. One important property of glass fibre material is its flame resistance, so brought into fabric it can be used in automotive interior, living area as well as in garment engineering application [2].

Another focus at ITA lies in the automation of entire textile process chains as well as of single textile manufacturing processes. The circular knitting technology including the integrated electronic needle control provides excellent conditions for automation issues. The electronic needle control enables a high range of pattern creation and changing, so product variations can be performed easily during operation. Additionally, integrated material changing systems increase the possibility of product variation [3]. Further research issues focus on the interconnection and intercommunication of the knitting process with upstream and downstream production steps as well as the integration of these production steps into the knitting process. A topical example in industrial application is the Spin-Knit technology. It has been developed by diverse circular knitting manufacturers and enables the integration of the yarn spinning process into the knitting process. [4]. Furthermore, ITA conducts research in online-production supervision. Production defects can be detected and the machines themselves are able to adapt their production parameters. Comparable approaches in self-optimisation have

been recently realised at ITA regarding the weaving process within the scope of the research project „Onloom Imaging" [5].

Keywords: *Yarn material, weft knitting, technical applications, mechanical engineering, automation*

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SHIMA INDUSTRIAL SOLUTIONS

Minoru Nakamura
Shima Seiki MFG Ltd, Japan

Our subject is

- The works in the field of technical textiles of Shima Seiki
- Various type of technical textile production (healthcare, sport, automotive, home textile, safety/protection textiles, aerospace, etc) with the perspective of WholeGarment®
- The machine and material experiences about Shima Industrial Solutions.

Keywords: *Shima Seiki, technical textile, industrial solutions, WholeGarment®, Design*

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[1] http://www.shimaseiki.com

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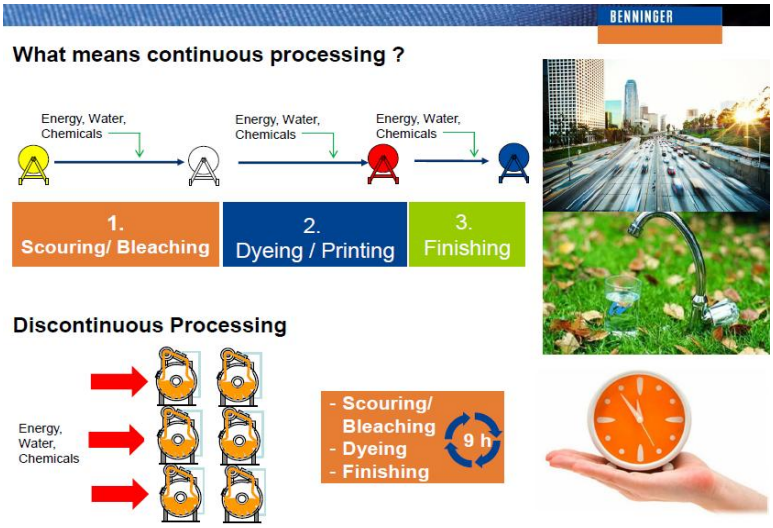
OPEN WIDTH FINISHES FOR KNITTED GOODS

Erdinç Dinçer
Benninger-Dincer, Turkey

Reasons for Open Width Finishing of Knitted Goods

- Water saving up to 75 %
- Energy saving up to 60%
- No salt required
- Smoother surface
- No abrasion marks
- No batch to batch Variation
- 30 % less costs



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Process routes for knitted goods (100 % Co)

Continuous open width

1. Slitting
2. Bleaching
3. Stenter drying
4. CPB- Dyeing with reactive dyes
5. Batching
6. Washing off
7. Stenter drying
8. Compactor

35	m/min
630	kg fabric /hour
18.4	l/kg water
3	kg/kg steam

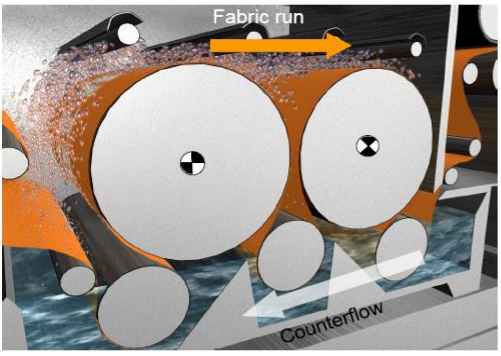
Discontinuous in JET

1. Softflow Bleaching
2. Softflow Dyeing
3. Rope opener and slitting
4. Stenter drying
5. Compactor

9 hours 15 min	
540	kg fabric
96	l/kg water
7	kg/kg steam
400	kg/ton Salt

BENNINGER

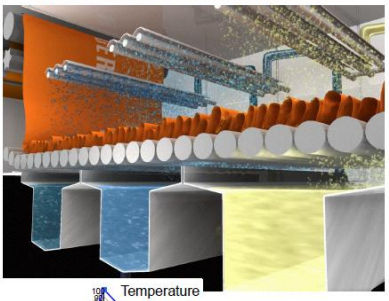
TRIKOFLEX high performance washing for Elastic's

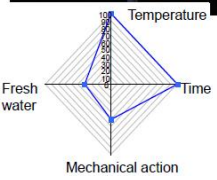


- **Patented TRIKOFLEX Drum**
- **40% higher washing efficiency thanks to front and back washing and counterflow guiding**

BENNINGER

Soaping and dwelling processes





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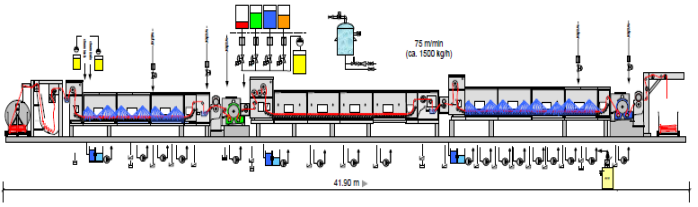
BEN-BLEACH (2)



Demineralizing | Bleaching | Washing/ Neutr.

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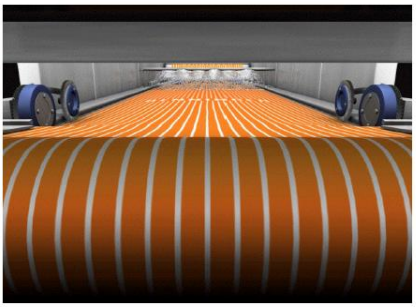
DIMENSA – Mercerizing for Knit



- High lustre
- Uniform and controlled fabric weight (gsm)
- Not wales thickening (side/center /side)
- 40% dyestuff saving
- Designed for CO, CV , Tencel and blends
- Significantly lower consumption data compared to tubular systems

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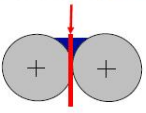
CPB DYEING FOR KNITWEAR
More than 4000 Dyepads (Knit 60 +30) succesfull in operati



- Nip/trough dyeing
- Just in Time Liquor preparation -CONTIDOS
- Temperature Management
- Anti Tailing Software

18.10.2013

KÜSTERS 10
Member of the Benninger Group

KNITTED DENIM LOOK

Jörg Hartmann
Head of Fashion & Technology
H. Stoll GmbH & Co.KG, Reutlingen, Germany

Denim apparel has a long and successful history and has become a fixed part of our modern lifestyle. The market for denim goods is huge and brands compete for market share through price and product differentiation. Crafting individuality by wash and finish has been a key element in defining product, though many of these procedures are not environmentally friendly.

The distressed appearance of Stoll's knit technology is the result of software programs, not post-processing. In addition to aesthetic design features, our technology contributes to economic and ecological advantages, including lower water consumption and less pollution.

Knitted denim goods give denim brands and manufacturers a chance to explore new trends, widen their product ranges and access previously untapped markets.

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WARMING TEXTILES – SOAK UP THE SUN

Harald Lutz
Head of Innovation and Service
CHT R. Beitlich GmbH, Tübingen, Germany

Wear white, feel warm – this is the motto of the new technology solar+, a development inspired by nature. Just like lizards that are also known as children of the sun, textiles treated with solar+ absorb more of the sun's heat rays. Even thin textiles can keep the wearer pleasantly warm which is useful e.g. for the next winter collection. This results in higher comfort and increased performance.

solar+ is not only applicable on outerwear, sportswear or working clothes, but also on home textiles, upholstery fabrics or technical textiles. Wherever textiles are exposed to sunlight or infrared radiation, the higher heat absorption leads to a higher temperature.

solar+ is invisible and can be universally applied to all kinds of textiles, fibres and colours. In addition, a very good wash fastness is ensured due to a special binder system. An independent research institute confirmed and certified in a practical trial the warming effect of solar+. Special requirements in terms of Ökotex and Bluesign are also fulfilled.

In this presentation an insight into the development process and the performance of this technology is given.

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FUNCTIONAL & TECHNICAL KNITTED MATERIALS

KNITTED THREE-DIMENSIONAL STRUCTURES FOR TECHNICAL TEXTILES APPLICATIONS

Subhash Anand
MBE, Professor of Technical Textiles, Institute of Materials Research and Innovation, The University of Bolton, Bolton, UK

Technical textiles market worldwide was forecast to grow by 4 per cent per annum between 2002 and 2010. As a result, in 2010, the technical textiles and industrial nonwovens sector consumed some 23.8 million tonnes of fibre – up from 16.7 million tonnes in 2000 and a value of US. $ 90 billion – and had a value of US $ 126 billion. According to the author's estimates, the world technical textiles market was worth US $ 255 billion in 2013.

Knitted fabric production for technical textiles showed an overall growth of 34.5 per cent from 1995 to 2002 in Western Europe. Over the last decade, knitted fabrics and products have been increasingly designed and developed for a very wide spectrum of technical textiles applications, including automotive textiles, medical textiles, geotextiles, sportswear, safety and protective textiles, and environmental protection textiles, just to name a few major growth areas of technical textiles.

Warp and weft knitted spacer materials are being commercially developed for a very wide range of technical textile products, because of a number of unique design opportunities that they offer. Knitted spacer fabrics are a single composite of at least three different substrates integrated together during a single knitting process. The range of materials and structures that are possible are virtually limitless. It is possible to engineer fabrics with specific tailor-made characteristics and thicknesses ranging from 2 mm to 60 mm in warp knitting and 2 mm to 10 mm in weft knitting.

The paper discusses a number of significant developments in both knitting technology and knitted structures for a wide range of specific product applications. Warp and weft knitting spacer technologies will be

discussed in depth and their present and future potential will be critically analyzed.

It is hoped to demonstrate that both three-dimensional warp and weft knitting technologies have a significant growth potential in the present and future technical textiles markets worldwide.

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COMPARISON OF DIFFERENT YARNS FOR STAB RESISTANT KNITTED FABRICS

Marcus O. Weber[1], Susanne Aumann[1], Beatrice Vidzem[1], Malin Obermann[1], Andrea Brücken[1], Andrea Ehrmann[1], Thorsten Bache[2]

[1] Niederrhein University of Applied Sciences, Faculty of Textile and Clothing Technology, Mönchengladbach, Germany

[2] Bache Innovative, Rheinberg, Germany

Stab resistant textiles are most often produced from woven fabrics. For a jacket which should be used every day by specially endangered occupation groups, such as bus drivers, teachers etc., and people living in dangerous areas, a woven garment, however, may be too stiff and not flexible enough to be worn without any limitations to the wearers' movements.

Thus in a recent research project, a stab resistant knitted jacket is under development. The stab resistance of knitted fabrics produced from different yarns is examined according to the VPAM test instruction "Stich- und Schlagschutz" (N. N., 2011) and compared with the stab resistance of an aramide nonwoven.

The presentation gives an overview on recent results, comparing various yarn constructions combining common fibers like wool and high-tenacity, cut-resistant and other special fibers with knitted fabrics produced from pure high-tenacity yarns. It shows the influence of washing on the stab resistance of the textiles and examines the effect of the knitted fabric orientation with respect to the blade. While former experiments also compared different knitted structures (Vidzem, 2013), this presentation concentrates on double face fabrics only to evaluate the influence of the yarn variation alone.

Our experiments show that, depending on the most important comfort properties, such as the weight of a jacket, the thickness or the bending stiffness, different yarns give the best results. Apparently, taking all these factors into account, a compromise between acceptable comfort

properties and sufficient stab resistance can be found for various degrees of necessary protection.

Keywords: *Stab resistance, aramide, high-tenacity yarn, wool, knitted fabric*

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SPATIAL TEXTILE COMPOSITES WITH A POROUS STRUCTURE

Katarzyna Pieklak, Zbigniew Mikołajczyk
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Composites are materials with non-homogeneous structure. They are composed of two or more components with different properties. Properties of the composites are never the sum or average value of its components properties. Frequently, one of the components is as a bond that ensures its consistency, elasticity and compression resistance. The second one, so-called constructional component, provides most of the other mechanical properties of the composite.

The aim of this paper is a new technology of the spatial textile composites with a porous structure. The material that joins the elements of the composite (matrix) is a foamed resin or other porous synthetic material (e.g. high-strength foam). The reinforcement material of the composite is 3D warp-knitted fabric. The most important parameters from the viewpoint of the optimization of the composite structure is a coefficient of the knitted fabric mass to the mass of the composite and a coefficient of the resin mass to the composite mass.

Commonly, in the production of the composites are used different kinds of resins. In the stage of its processing the manufacturers specially try to remove any air bubbles that could disrupt their final structure and reducing the strength parameters of the product. Because of that the mass of the composites is greater. In the case when the main task of the resin or other synthetic structure is mutual connection of the reinforcement elements, it is not required from the matrix the maximum values of the mechanical parameters. Therefore, it is possible to reduce the volume and mass of the resin by intentional, programmed introduction to its structure of the air bubbles and forming a porous structure.

The second one component of the textile composite is 3D distance warp – knitted fabric. The fabric is built form two external layers and one internal layer. The thickness of the fabric can be even up to 70mm. The external layers are created on the base of the basic and derivative warp-knitted stitches. The internal layer is built from the links of the loops that are located in the external layers. The 3D distance warp – knitted fabric can be manufactured form natural, synthetic and technical yarns. However, it is important to use monofilament synthetic threads in the structure of the internal layer.

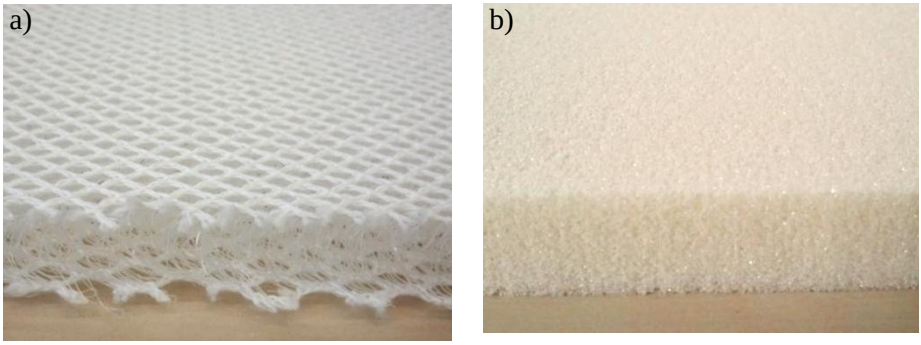

Figure 1. *The components of the textile composite with a spatial porous architecture: a) 3D distance warp – knitted fabric, b) a foamed resin.*

As a result of a mutual combining of the above-mentioned matrix and reinforcement (Fig. 1) is to obtain a textile porous composite with a spatial architecture. The fact that both components of the composite have porous structure, it allows to get the material with a low density and a small surface mass.

In the Department of Knitting Technology was carried out the computer simulation of the differentiated participation of the foamed resin in the range from 5% to 50%. This diversification was designated as a percent of the maximum value of the resin, possible to fill the empty spaces in the structure of the knitted fabric solid. The analysis showed that the tenfold percent increase of a resin caused a decrease of the coefficient of the knitted fabric mass to the mass of the composite by 4.5 times and led to increase of the density also by 4.5 times. The change of the percentage portion shows a significant impact both at the composite

mass, coefficient of the knitted fabric mass to the mass of the composite as well as at the density of the composite reaching differences even of 346%.

Keywords: *Textile composite, distance warp – knitted fabric, foams, foamed resin, porous structures*

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RESEARCH OF KNIT FOR FENCING SUITS ON RESISTANCE AGAINST PERFORATION

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The most important function of a fencing suit is to protect the athlete's body in the event of weapon's breakage. This is common, because modern fencing is a very athletic sport, and the weapons' blades are not always flexible enough to withstand the pressure put on them during the collision athletes [Motovylovets, 2010].

There are mandatory requirements of the International Federation of fencing (FIE) to the resistance of textile materials, which the fencing suits are made of, against the puncture strength (perforation) of blade of one of the sporting weapons' type. The international tournament of category A (the highest category, which include the World Championships, the European and Olympic Games) require the fencing suits that can to resist a pressure of 800 Newton [Higginson, 2010]. These requirements apply for the three major components of a fencing suit, namely fencing jacket, breeches and under plastron. All manufacturers of these products must send fencing suits' material samples to the certified laboratories and research institutes for confirmation of strength of the suits and their subsequent labelling. These institutions must be allowed to conduct such examinations; the main one is located in the home of the Fencing Federation in Germany - (German institutes for textile and fibre research).

This work is devoted to the development of new special purpose double-layer knitted fabric [Galavska, 2010] and the verification of the necessary strength of knit against perforation (penetration - test). To produce a high quality canvas, designing its structure requires a simultaneous examination of its strength. A special setting was used to check the canvas for the strength measure [Bendik, 2004]. To imitate the conditions of the puncture of knit during a fight the special blade puncture conditions were developed at the facility for this study. The

synchronization of the activity at the facility with the computer provided us with the graphs of pressure – deformation, which allows studying the process of fabric puncture over time. It gave us the opportunity to study in detail the process puncture of knitted fabric for improving the strength of knit.

Keywords: *Knitted fabric for fencing suits, resistance against perforation, the puncture of knit*

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INNOVATION & MACHINE BUILDING IN KNITTING

CONSTRUCTIVE ASSUMPTIONS OF A NEW FOURCOMB WARP-KNITTING MACHINE

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The paper presents constructive assumptions of a fourcomb warp-knitting machine used for the manufacturing of the spatial knitted fabrics. The concept of a new warp-knitting machine was developed at the Department of Knitting Technology of the Lodz University of Technology. The constructive assumptions were formulated on the basis of accepted technological conditions, initial criteria of the conceptual design and the simulation results of a 3D model (Fig.1a) and a dynamic model (Fig.1b) of two basic machine units: loops forming zone and yarn feeding zone.

On this basis were determined the parameters related to the geometrical, kinematic and dynamic features of the warp-knitting machine:

- the size and the weight of the working elements and elements of the supporting structure,
- the range and the speeds of movements for four needle combs and holding down sinkers, and for ten guide bars,
- the type of yarn feeding device, including the tension rail with a specified stiffness, that is connected with the parameters of the raw material that can be processed on the machine,
- the size and the capacity of the drive actuators.

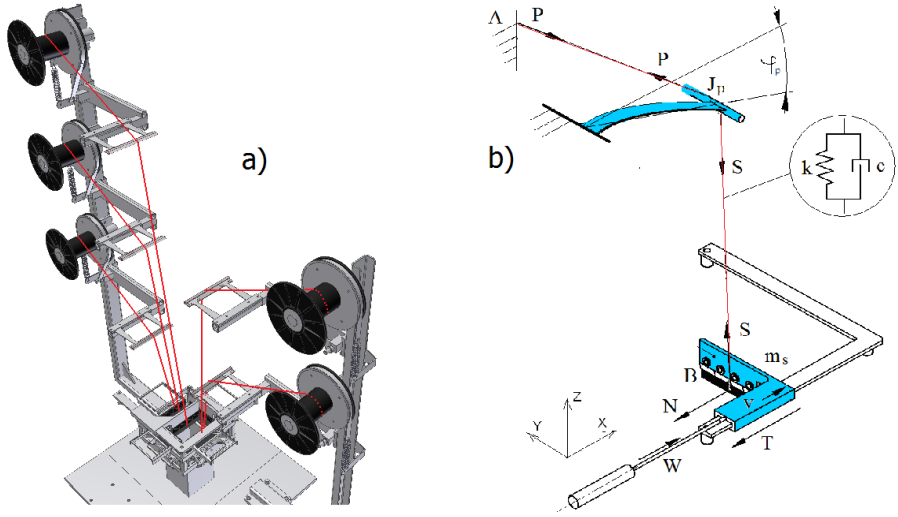

Figure 1. A 3D model (Fig.1a) and a dynamic model (Fig.1b) of two basic machine units: loops forming zone and yarn feeding zone.

The main constructive assumptions are related to the spatial arrangement of the machine and its construction. In the basic geometric variant, by keeping the same dimensions of all the types of combs, is achieved a 3D knitted fabric in the shape of a continuous solid with square cross section. This cross-section can have full or a-jour structure and it depends on the number of the threading of one single guide bar. In each of the two perpendicular working planes are situated facing each other two needle bars, two holding down sinkers, two double guide bars for the external layers of knitted fabric and one guide bar of the filling. The slide bar of the internal guide bars (of the filling) have to provide a stable conducting at a relatively long stroke of these combs that approximately is equal to one side length of the knitted fabric cross-section. Because of the high threads concentration, the space above the area of the loops forming zone is completely enclosed by yarn feeding system (the figure 1a shows only one yarn feeding plane). Therefore, the drive elements can be placed only at the height of this zone or below. Adopted in assumptions the forces and drive powers values are the result of the dynamic model tests (Fig. 1b), e.g. for the internal guide bar by using in the feeding system the yarn with medium linear mass it is 75N and 80W.

For the purposes of construction solution with the guide bars that have the width of 100mm were taken into account the values of the other parameters of the 3D knitted fabric loops forming process. The most important of them are: the possible shortest time of the combs stroke is 0.1 sec., the stiffness of the tension rail at the level of 50Nmm/deg, the mass elements with the largest dynamic depending on the used materials in the range of 0.35 – 0.7 kg.

Presented in this paper constructive assumptions of the machine includes also the cyclograms of movement of the loops forming elements. They are the basis to develop a control system that provides the fluent implementation of the technological cycle.

Keywords: *Fourcomb warp-knitting machine, guide bar, dynamic simulation, constructive assumptions, physical model.*

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A STUDY OF CIRCULAR KNITTING MACHINE WITH AUTO-STRIPPING MODULE

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Circular knit fabric is a type of textile product that is knitted in tube form made up of successive loop by rotation of circular cylinder and vertical movement of needles connecting with a cam in knitting device.

This fabric is suitable for casual wear, sportswear, and underclothing due to its performance and soft texture. Especially it gives wearing comport to human body with its superior stretch.

Circular knit fabric has developed mainly among small and medium sized companies as it takes lower cost to start up and maintain while being highly productive. It also does not require any complicated preparation process or handling method to make, and is producible in small production facilities.

In this research, we suggest a strategy about miniaturization and modularization of circular knitting devices for striped circular knit fabric that has got attention as a material of casual apparel.

In general, striped circular knit fabric with diverse patterns focused of aesthetic function can be made through two ways: feeder type and striper type.

Firstly, the feeder type produces striped circular knit fabric with diverse pattern, which threading by different color per feeder is being offered. However, in the case, one repeating unit of the pattern to be limited to no more than the number of feeder in circular knitting machine has disadvantages in terms of diversity of pattern.

Secondly, the striper type is used with the striper of equipment changing the thread dependence on the patterns. It is possible to knit by alternately selection of certain thread positions for each feeder.

The weakness of this striper type is that noticeably decreases the number of equipped feeder in circular knitting machine because large-volume devices such as striper, driving equipment, transfer unit should be installed and the productivity is too low in comparing with one of existing common circular knitting machine.

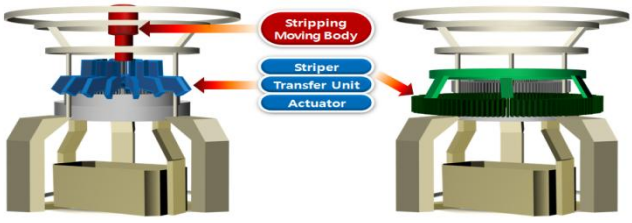
Consequently, to improve the weakness of this striper type we converted synchronous gear driving system into connection of actuator and cylinder.

In addition, we removed transfer unit in changing of thread and applied of finger-direct driving system. Finally, we developed Auto-Stripping module in this research as:

- Auto Striper module development

① Small striper - Applying of finger-direct driving system and removal of transfer unit

② Connection of actuator and cylinder - Integration of driving system in knit and stiper part



A. Striper Type B. Striper module type

Figure 1. Schematic diagram of circular knit machine for striper type & striper module type

Table 1. Characters of striped circular knit fabric manufacturing method

Division	Feeder type	Striper type	Striper module type
Manufacturing method	Fixation of dyed yarn for each Feeder	The striper select dyed yarn	The striper select dyed yarn
The length of one repeat unit	〈 10cm	Unlimited	Unlimited
Productivity	High	Low	High
Equipment utilization	Using existing equipment(Cheap)	Using new equipment(Expensive)	Using existing equipment(Cheap)

Keywords: *Striper, pattern, striper module, striped circular knit fabric*

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MEASUREMENT OF FABRIC-TAKE DOWN FORCE ON DOUBLE-BED CIRCULAR KNITTING MACHINES

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On a double-bed circular knitting machine with a needle bed diameter 8e″ (200 mm), a machine gauge of E17, which knitted with 8 knitting systems, rib fabrics in basic construction were made. The machine is used to knit cotton knitted fabrics to be used for making children's clothing, especially undershirts and undergarments. Yarns counts from 12 to 36 tex can be used for knitting on the machine. Fabric samples were made from single cotton yarns in counts 16, 20, 24 and 30 tex. When making fabric samples, the optimum machine control for 20 tex yarns was applied. From each yarn 5 samples approximately 2 m long were made and fabric take down force was measured for each sample. When the fabric was removed from the knitting machine, fabric-take down force was measured in various different ways. When making samples from finer yarns, average fabric-take down force amounted to 14,0 cN/needle, and when using coarser yarns it amounted to 22,8 cN/needle. Different measuring conditions provide essentially different average tensile forces for fabric-take down force.

DEVELOPMENT OF REVERSIBLE DIFFERENT PLUSH OUTDOOR-WEAR FABRIC OF 3-DIMENSIONAL WARP-KNITTED CONSTRUCTION USING HIGH-MULTI MICRO FIBERS

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The warp-knitted fabrics are composed of more than 2 kinds of yarns; one of them for ground construction, another one for reinforced ground or inter-construction, and also the third one for pile. The density of tricot warp-knitted fabric is very tight and a little bit high gauge, comparatively very complicate and composed of more than 3 types of yarns. This gives us very good idea to develop multi-materials for outdoor wear fabrics. So, we developed 3-dimensional tricot fabrics for outdoor wear by 3 types of yarns and complicate processes. Especially there are many kinds of application for a long time; for example, the optimum specification of fibers, and its ground and pile construction, preset by high temperature, raising and finishing etc. Until now, we established the mass production processing, and we got the Certificate of World Class Product, NEP (New Excellent Product) from Korea Government, export to the world U$ 10 million every year.

Keywords: *Warp-knitted fabrics, ground construction, pile construction, tricot, density, 3-dimensional, outdoor wear, high-multi micro fiber*

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DESIGN IN KNITTING & CLOTHING

IMPARTING FLAME-RETARDANT AND ANTISTATIC PROPERTIES TO TWO-LAYER KNITTED FABRICS

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The technology of multi-functional knitted materials having barrier properties has been developed on the basis of stuff-structural and technical-technological designing.

Barrier properties of knitwears were formed i.a.by using:

1. for external layers- yarns constructed from :
   - 100 % metaramide fibres and mixed (metaramide and viscose FR) fibres responsible for heat protection properties of the materials.
   - mixed metaramide and anti-electrostatic fibres responsible for heat-protection properties as well as for protection against static electricity.
2. for internal layers- yarns constructed from mixed cotton and wool fibres with the supplementation of viscose FR or modacryle Protex, responsible for heat-protection properties and having beneficial physiological properties.

Complexed studies on structural, physic-mechanical, chemical and applied barrier properties as well as on physiological comfort allowed for:

1. designing of double-layer and "platered" structures
2. selection of optimal knitwears useful for construction of multifunctional protection garments on the basis of knitting technology and the final processing
3. development of designing and construction guidelines as well as the production of protection garments on the basis of the knitwears properties analysis.

Designed garments could be useful as an individual protection resources for workers exposed to harmful occupational environment factors, like heat and static electricity.

MATERIAL - CONSTRUCTION – DESIGN CONCEPT: THE CHALLENGES AND ADVANTAGES OF "KNITTED WOOL COUTURE"

Ellen Bendt & Dr. Marina-Elena Wachs, Cooperation Partner: Woolmark International and Marc Cain GmbH, Bodelshausen
Niederrhein University of Applied Sciences, Faculty of Textile and Clothing Technology, Mönchengladbach, Germany

Most people still associate things like women's hobby, woolen socks, elderly ladies in rocking chairs and coziness to the term knitting; here the potential and variety of offers of knitted goods is seldom considered.

To confront this one-sided view was the motivation for the exhibition "Unravel – Knitwear in Fashion" in the fashion museum in Antwerp in 2011: "… It is too often overlooked that it (knitwear) can also be something highly fashionable, experimental and a daring choice for fashion designers. … Body hugging cling, jersey sportswear, raw knits, sculptural volumes, lace-like body nets … the possibilities of knitting make an endless source of inspiration for fashion designers."[1]

In design, especially the knitting technique offers an extraordinary gripping starting point. This is because the design process starts with the yarn, the thread, instead of with an already existing textile fabric and the designing and shaping of fabric and form can basically be defined and developed as with woven goods. Thus, knitting design is the interface between fashion and textile design and allows for a much more-in-depth involvement with the material than classical fashion design. The problem is that most of the designer in the fashion business are not used to work with knitting techniques. Something we want to change.

When in 2012 The Woolmark Company selected us to participate with a group of Master Students at the Wool School Contest we were very happy to work out knitted styles with the technical support of a Cooperation partner, the Fashion Label Marc Cain. The Wool School Project is part of The Campaign for Wool that is a global endeavour

initiated by its patron, His Royal Highness The Prince of Wales, in order to raise awareness amongst consumers about the unique, natural and sustainable benefits offered by wool.

Our goal: We wanted to do something different, to what people would expect us to do but also show the technical and design competences and possibilities of our students and university.

The presentation gives an impression of our on special project "Knitted Wool Couture", that shows that High Class Woolen Yarns, Sustainable Textile Design and Knitting Technology are a perfectly matching together to create Fashionable Haute Couture on a high level.

1 Catalogue of the exhibition "Unravel – Knitwear in Fashion", MoMu Antwerpen, 2011, Tielt: Lannoo Publishers, backcover.

Keywords: *Sustainable Textile Design, Knitted Couture, white and woolen, Campaign for Wool, Wool School Project 2012*

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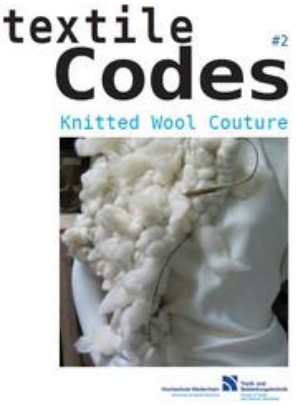

Models of the winning team of the "Wool School"
Documentation: Textile Codes #2,
Competion in the display window of the Marc Cain "Knitted Wool Couture"
Stores, Düsseldorf (Photo: Sharabati, 2012)

Experimental artworks of the participating students of the Master Course "Textile Products" of Niederrhein University. (Photo: Windgassen, 2012)

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DESIGNING OF THE MODELLING – CORRECTIVE KNITTED PRODUCTS WITH THE USE OF THE THERMOVISION TECHNIQUE AND SPATIAL IMAGES OF THE HUMAN BODY SHAPE

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The modelling – corrective underwear was developed in an innovative knitting technology of knit and wear products. This underwear allows for the "slimming" effect of the human body. These products make the waist more slender and they can lift the breasts and buttocks. Additionally they allow to hide unwanted folds making the silhouette more visually attractive. During the design of such products it is necessary to pay attention to aesthetic aspect as well as medical aspect. It is important that this kind of underwear should to be properly chosen from the point of view of ensuring a physiologically acceptable pressure of the product to the human.

The paper presents the main thesis and the research results relating to the technology of the modelling – corrective products. There were formulated assumptions of the design methods for these products in the aspect of pressure measurements with the using of the thermovision technique. The research was conducted for two types of the modelling – corrective products form the brand Gatta Active Sheapwear – dress and shorts (Fig. 1 a and b). The seamless modelling – corrective products have a very complex structure. Their composition is formed by several knitting stitches with a various structure and parameters.
In the analyzed products were distinguished six base stitches that creates the general structure of the product, and two additional stitches that are used to design or information purposes.

The structural parameters of the knitted fabrics in separate parts of the product are significantly different from each other. It has an influence on their different physical properties at individual locations of underwear, for instance: breaking force changes from 49.5 to 1081.0 N, elongation at break is between 184.8 and 413%, Young's modulus takes the values from 184.8 to 379.5 N and the high elasticity varies from 84.91 to 91.73%.

The researches were conducted by using modern 3D scanners: a laser scanner type of Vitus XXL and a white light scanner type of TC^2. It was noted that these products have an influence on the changes of the human body dimensions both lean and obese person. These changes are related to the heights of each body parts and their circuits.

It was stated that the modelling – corrective underwear allows to raise and improve the shape of breasts, the waist slimming, the belly flattening, to lift and rounded buttocks and to cover up the unsightly folds of fat on the belly and back. The result of modeling depends on many things but one of them is the build and human body type. A greater effect of the body correction can be observed for an obese silhouette.

In the pressure measurements of the modelling – corrective products on the human body was used the thermovision techniques. They allowed to check in a non-contact way the values of the temperature on the surface of the human body (Fig. 2). The modelling underwear caused a drop of the body temperature for both persons in the range of 0.4 to 1.62˚C.

Furthermore, it was observed that the size of the product is smaller, the average temperature of the body is lower, that means it is a greater decrease of the temperature.

The pressure of the modelling – corrective products on the body causes the capillaries blocking. The blood flow is reduced and as a result the

metabolism is decreased and the body temperature is lower. The pressure is higher, than the temperature drop is greater.

Too tight or improperly selected modelling – corrective underwear may have a negative affect at the functioning of the human body. Thermovision techniques can be used to visual pressure evaluation of the modelling products on the body. They will improve the selection of specialized corrective underwear for individual needs of user.

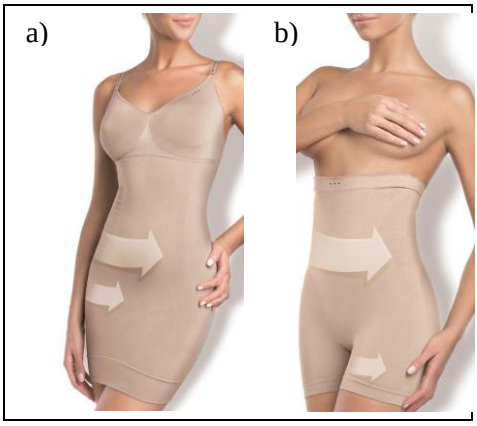

Figure 1. Gatta Active Sheapwear products: a) dress; b) shorts.

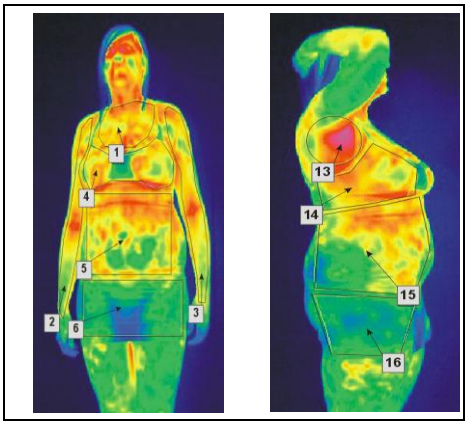

Figure 2. Thermographs of the obese silhouettes in the modelling – corrective product.

Keywords: *Modelling – corrective products, thermovision technique, scanner 3D, pressure of the underwear on the body.*

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SIMULATION & MODELLING

ABOUT THE 3D MODELLING OF JACQUARD WARP KNITTED STRUCTURES

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The aim of this work is to present the theoretical considerations and modelling issues, connected with the three dimensional modelling of jacquard warp knitted structures.

The three dimensional modelling of general warp knitted structures is a very complex task, which requires several steps to be performed in the right way and in the right sequence. The early works in this area (Hart, 1985a,b) present the possible ways for computations of the yarn axes in the 3D space for basic structures, considering or not the bending rigidity of the yarns. Because the introduced coordinate system is not common for the researches and the model requires enough mechanical knowledge it is not known to be implemented or extended in professional system in that form. The later times, where the personal computers became widely available and having 3D library like OpenGL, Goktepe presented in 2002 one of the principles how to build 3D view of the loops of basic loops. His paper became one of the most cited and used in that area and until now several researchers apply this principle; presentating the yarn axis as spline to generate a 3D model of the warp knitted structure (Honglian, 2009; Fang,2012.). This way actually seems not to be followed by the implementations of industrial software, because it has several limitations and difficulties, if it has to be applied with several Jacquard guide bars where the yarns have to be represented without collision. The algorithms, implemented into industrial software have more clear rules about the calculations of the key points of the yarn geometry as presented in (Kyosev, 2007, 2009), (Renkens, 2011) (Kyosev, 2013) which allows straight forward calculation of the yarn axes as well for double needle bed structures .

The later investigations demonstrate that the pure geometrical models cannot give mechanically accurate presentation of the structure and show the advantages and the disadvantages of different numerical algorithms for refinement of the 3D geometry of the warp knitted structures.

This paper presents an extension of the above mentioned works of the authors, which allows the geometrical modelling of jacquard warp knitted structures, which have higher complexity then the normal warp knitted structures, because the single needles of each jacquard guide have additional degree of freedom to change their position.

This additional degree of freedom leads to several tasks, which has to be solved, before the warp knitted structure is simulated:

1) Definition of the warp knitting program for each guide and each needle of the guide in form, which is readable for the user and understandable for the computer.
2) Extension of the available models so that the yarns of each guide build loops and the rules are applied per guide and not per guide bar.
Furthermore some extensions of the presented mechanical models are applied in order the generated structure to be refined under the influence of the forces in the yarns to make the model more accurate.

Keywords: *3D modeling, warp knitted structures, jacquard warp knitted structures*

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VALIDATION AND ANALYSIS OF THE COMPUTERIZED MODEL DEVELOPED FOR THE STUDY OF MECHANICS OF 1x1 RIB LOOP FORMATION PROCESS

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In order to gain an insight into the mechanics of 1x1 rib loop formation on dial and cylinder type double jersey machine, computerised model of the same was developed by the author (Ray, 2003, Ray, 2012 & Ray, 2012). For the same, the geometry of the knitting zone and the geometrical configuration of the rib loop inside knitting zone were developed (Ray, 2003). The concept of robbing back in single jersey knitting (Knapton, 1966), different single jersey loop models (Aisaka, 1971, Peat, 1973 & Banerjee, 1999) as well as different knitting tension and force measuring methods (Hensaw, 1968, Black, 1970, Pietikaeine, 1981, Pietikaeine, 1983 & Wray, 1976) adopted in single jersey knitting were considered for the modelling including the minimum information available for double jersey knitting (Little, 1978, Araujo, 1987,Ray, 2000 & Jeddi, 2006).

The developed computerised model can predict a lot of information about the 1x1 rib loop formation. As ultimate loop length, occurrence and extent of robbing back during loop formation and yarn tension profile are the main output of the model, attempts have been made to validate the developed computerised model in the following manner:

(i) The predicted loop length and occurrence of robbing back have been validated by comparing the actual loop length of 66 number of 1x1 rib knitted fabrics produced under different timing of knitting (synchronised and 2-Needle delayed) in two different double jersey knitting (Ray, 2003).

(ii) An experimental set-up (Ray, 2003) was installed inside the knitting zone of the cylinder for measuring needle butt – cam interactive forces using quartz force link (transducer) and computer (recorder). The profile of measured cam force was compared with the predicted needle butt - cam force profile.

(iii) As the machine in which the cam force measuring set-up was installed could be adjusted up-to 3-Needle delay timing, force measurement experiments were extended also for 1-Needle and 3-Needle delayed timings (Ray, 2012).

(iv)By varying the important input parameters which may affect the mechanics of loop formation, 128 sets of combinations were generated and different relevant output parameters were predicted for those 128 sets of input parameters. Those output parameters were subjected to critical analysis for identifying the critical input parameters of rib loop formation as well as their response to the loop forming system (Ray, 2012).

The degree of matching obtained between predicted and measured values of loop length and cam forces in the study as well as theoretical analysis of the model justify the acceptability of the model developed for the purpose. Loop length in general decreases with increase in yarn tension from synchronised to gradual increase in delay timing. The model can well predict the occurrence of robbing back in rib knitting under both synchronised and two needle delayed timing. The robbing back in rib knitting occurs in two or three phases instead of one as established in single jersey knitting, but the magnitude of robbing back is lesser than single jersey knitting. A very wide range of loop length can be produced in the same rib knitting machine in one hand and same loop length can be produced under different knitting timings under different yarn tension by manipulating the combination of input parameters according to requirement.

Keywords: *Cam force, cylinder, dial, knitting zone, loop length, model, yarn tension*

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MODELING OF THE MECHANICAL PROPERTIES OF THE HIGH-DEFORMABLE TEXTILE ROAD BARRIERS

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The paper presents results of research, whose the main goal was the analysis of the mechanical properties of the road barriers, including first of all high-deformable textile barriers. In the automotive industry, as well as in the road construction we can often encounter the concept of "road safety". This term is associated with the safe mobility of all road users. It is possible to distinguish a few types of the safety connected not only with the cars but also with other of its users. One of them is so-called active safety [5]. The most common active safety devices are protective road barriers. The road barriers, due to imposed on their tasks, are included to the systems that limiting the road and they take second place in the classification of the road safety components [1].

The main task of road barriers is to prevent in critical situations rolling off the vehicle beyond the edge of delimitation of the traffic lanes. It leads to the most minimal contact with other road users.

Among the all well-known road barriers we can distinguish constant barriers: hard barriers, steel barriers and rope barriers. Hard and steel barriers are characterized by high stiffness and low deformability. Because of that they are classified into the rigid protective barriers. Hard barriers after a collision with a vehicle are not deformed. The collision of a vehicle with a solid hard barrier causes not only significant damages of the vehicle, but also leads to serious body injuries of the passengers. The steel barriers are included in to the deformable safety barriers. Those barriers after a collision with a car they undergo permanent deformations. However, they do not provide full security of the travelers because often as a result of the collision the barrier is damaged (its continuity is interrupted). It leads to falling out the vehicle outside the barrier [2]. The rope barriers, in relation to the two previous, are characterized by a much

larger transverse deformations during the collision. They may increase even to 2.5-3.5 m. None of the existing construction of barriers used in present days is a full satisfactory solution and it does not fulfill the tasks which are posed the road barriers. It is very important when we talk about barriers used on the bridge structures, viaducts and embankments, especially if its height reaches or exceeds the limits above which exit of the vehicle from the embankment can be dangerous [4].

An alternative to permanent road barriers can be barriers of the Swiss company GEOBURRG. They are constructed from a combination of metal meshes. These meshes often take a double structure, composed of two separate grids with a different construction [3,6].

After analyzing process of the barriers construction of the GEOBURRG company was established an alternative concept of replacement of permanent road barriers by elastic knitted barriers. The elastic knitted barriers have to perform other functions than the traditional barriers. For this purpose were carried out the calculations of the overloads, that interact on a human during a collision of the vehicle with the barrier. There were also determined the values of the pressure force of the human body on a safety belt, which is formed as a result of a car collision. We also calculated the size of the impact energy generated in the moment of contact of the vehicle with the barrier. Simulations were carried out for the four types of barriers: constant (hard) barrier, steel barrier, rope barrier and elastic multiaxial knitted barrier. The analysis of the results showed that sixfold speed increase from 40 km/h to 220 km/h for each type of considered barrier causes 30-fold increase of overload. The highest values of overloads were achieved for a hard barrier that at the speed of the vehicle 140 km/h, is 154g (permissible maximum value which a human can survive is 40g). The textile elastic barrier for the same speed of car obtained the lowest value of the overload equal to 20g. The value of pressure force of the safety belt on the human body created at the time of collision with a hard barrier is 9558kG, on a rope barrier 2747kG, and at the elastic knitted barrier 687kG. It can be concluded that the relationship between barrier deformations and interacting forces is a linear relation, because 13-fold

increase of the barrier deformations causes a 13-fold reduction of the forces [6].

The calculation of the impact energy showed that for cars at a speed of 80-140 km/h and the vehicle mass of 900-1500 kg, for angles of collision with the barrier α=8-90°, the impact energy value is at the limit from 4,3 to 1133,7 kJ.

Assuming that the high-elastic textile barrier will absorb the impact energy to 5000 kJ , it can be concluded that they will be a very good solutions to protect during a collision of passenger cars, trucks at normative parameters of impact (α=8-20°, ν=80-110 km/h) for which E max=2071 kJ, and for buses at the border parameters: α=8-60°, ν=80-100 km/h) for which E max=4627 kJ.

Keywords: *Road safety, road barriers, elastic multiaxial knitted barriers, impact energy, pressure force of the safety belts.*

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MODELLING OF POROSITY IN KNITTED FABRICS

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Air permeability is often used in evaluating and comparing the "breathability" of various fabrics (coated and uncoated) for end uses such as raincoats, tents, and uniform shirtings. Also, it helps in evaluating the performance of parachutes sails, vacuum cleaners, air bags, sail cloth, and industrial filter fabrics (Ogulata, 2006; Ogulata & Koc, 2001; Tokarska, 2008). Air permeability is defined as the volume of air (in liters) that is passed in 1 min through 100 cm (10 cmx10 cm) of the fabric at a pressure difference of 10 mm head of water (TS 391 EN ISO 9237, 1999).

This value has significance with respect to the usage area. Since knitted fabrics have a loop structure, they have more pores than woven fabrics; therefore, in general, the air permeability of knitted fabrics is higher than that of woven fabrics of the same weight (Figure 1). In this study, it has been attempted to establish a theoretical model for the porosity and predicted air permeability of plain knitted fabrics. A theoretical model was created to predict the porosity and air permeability of a knitted structure depending on the geometrical parameters, such as the courses per cm, wales per cm, stitch length, fabric thickness, yarn count, diameter of yarn and fiber density. For this purpose, a theoretical model of porous systems based on D'Arcy's law was used, the validity of which was confirmed by experimental results using 100% cotton plain knitted fabrics produced from ring and compact yarns of different yarn number linear density and tightness.

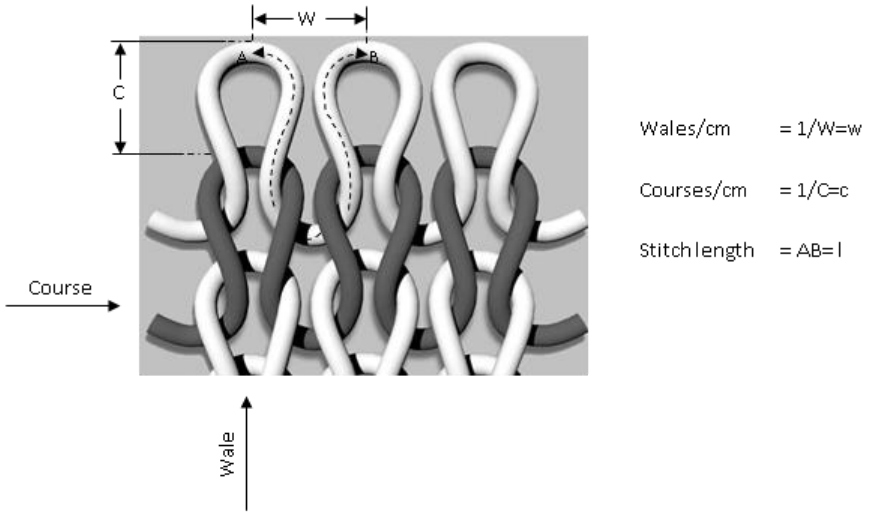

Figure 1. Representation of a plain knitted fabric

Establishing a more complex theory to express air permeability related to all fabric parameters will have difficulties. To simplify the matter, certain important parameters such as the pore of the fabric were taken into account in the calculation of air permeability. Three factors are mainly considered that are related to the pores in fabrics.

1) Cross-sectional area of each pore,
2) Depth of each pore or the thickness of the fabric and
3) The number of pores per unit area or the number of courses and wales per unit area.
In this work, these parameters are considered to develop a theoretical model for porosity and air permeability.

CONCLUSION

An experimental study was carried out to develop a theoretical model to predict air permeability values for knitted fabrics. The theoretical model predicts the value of the air permeability using the pore size and some fabric properties before manufacturing. D'Arcy's formulation was used to establish an equation expressing the relationship between the air permeability of knitted fabrics and fabric structure parameters. Due to the differences between ideal and real geometry and the random variation of

the fabric structure, there are no exact dependences between experimental air permeability and predicted air permeability values. However, the closeness of the results of predictions based on calculated values from the theoretical model and experimental values show that our model can be successfully used for the prediction of the air permeability of knitted fabrics (R2 = 0.87). This model is simple and efficient.

Keywords: *Knitted fabric, porosity, air permeability, geometric modelling.*

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QUALITY & TESTING IN KNITTING

A MULTICRITERIAL DECISION APPROACH ON PROPERTIES OF WEFT KNITS FOR SHOE LININGS

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INTRODUCTION

Footwear uppers are partly or completely lined. Considering that the interaction between foot and footwear is made by linings, it is obvious that main functions are appearance improving, comfort increasing, softness or protection where is needed, and durability increasing of the footwear (Tyrrell, 2008). Special attention has been paid to the orthopaedic footwear for diabetic patients, which should be correct selected, both in terms of shape and materials used for the uppers (Uccioli, 2007). These materials should be soft and flexible, as well as adaptable to any surface irregularities in such a way as to guarantee perfect fitting and to avoid the threat of friction (Maciejewski, 2004). Weft spacer fabrics are known for their excellent compression elasticity and cushioning, high breath-ability and air permeability, high thermal insulation and temperature regulation, surface and wash resistance, being thus capable of meeting the requirements of various applications, from protective clothing to mattresses and composites.

EXPERIMENTAL

An attempt of producing such type of fabrics as diabetic shoe linings has been made, and some preliminary conclusions are presented through their measured properties. In this paper, an investigation on the behaviour of weft spacer knitted fabrics, produced in electronic flat knitting machines CMS 530 E6.2, including the use of a dedicated studio of CAD/CAM, M1Plus, made of different yarn combinations, is presented. Two structures were produced, namely double jersey (interlock), denoted as S0 and one spacer type, S1. The fabrics were manufactured from yarns,

with count of Nm 20/1, of various type: Cotton, open end spinning and ring spinning, blended Cotton/Lenpur, blended Cotton/Seacell, blended Cotton/Bamboo, Outlast® and Coolmax® yarns. Combining the two structural types, the yarns, and the face/back combinations, a number of 32 samples have been resulted for being investigated.

RESULTS AND DISCUSSIONS

After the knitting, the fabrics were relaxed in dry state and the values of the fabric structural parameters that refer to the vertical density cpc, horizontal density wpc, thickness [mm] and mass per unit area [g/m^2] were measured, as primary information about the produced materials. In case of fabrics for footwear linings, the measured properties so far, on the unfinished samples, are: breaking resistance and breaking elongation, extensibility, friction coefficient and water vapour coefficient.

The first step of fabrics evaluation is a quantitative analysis of the samples. The primary selection is made in accordance to their breaking resistance and friction coefficient, as eligible conditions for the subsequent footwear production stages and wear requirements. A minimum value of 2 [N/mm^2] force have been considered necessary for the shoe stage production, and consequently, a number of samples were eliminated, mostly the fabrics made of combinations of blended Cotton/Lenpur, Cotton/Seacell and Cotton/Bamboo fibers. The lowest values present samples made of 100% blended Cotton/Lenpur and Outlast yarns. The frictional properties of textile fabrics are of considerable importance in case of shoe linings, especially the friction coefficient, which for most of the linings must be take a minimum value of 0.7 (Blaga, 2011). Excepting the Cotton/Seacell interlock fabric, the other interlock structures showed lower value of frictional coefficient, so they are eliminated according to this criterion.

The next step analysis is considering the other five criteria (breaking elongation, extensibility, thickness, square mass and water vapor coefficient) by employing the imposed decision technique (Belousov, 1992, Seghedin, 2008), which is facilitating the establishment of the fabrics hierarchy and their availability for the designed end use. This technique is based on the values obtained by each fabric, through the five criteria, each one being weighted according to their importance level for the fabric destination. After sample analysis, the best performances are

proven by the spacer fabrics, most of the interlock fabrics being disqualified, due to their poor properties as shoe linings.

Key Words: *Weft spacer fabrics, electronic flat knitting machines, physical and mechanical properties, diabetic shoe linings.*

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MULTIAXIAL TENSILE TESTING OF TEXTILE FABRICS

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The textile fabrics are structures produced by the characteristic interlacing of the yarns. The type of the structure results in a usually non-isotropic mechanical behaviour. The trivial tensile tests are limited in the warp and weft directions in the case of woven fabrics or in the bursting test in the case of knitted fabrics. Bursting test is considered as a multi-directional tensile test. The basic aim of that test is the determination of the breaking strength. Both testing methods with the different load application, cannot give enough information about the directional mechanical behaviour of the fabric. The breaking strength is an important information, however the low-stress testing gives important data necessary for the implementation of the textile fabrics in technical and precise applications especially if it could be measured in many directions and not only in the two of them. The related literature review gives an idea of the importance of the multiaxial testing (and not only loading) of the textile fabrics. The earlier publications focus on the measurements for technical applications of the textile fabrics (Goldsmith, 1996), (Hufenbach, 2006). The work done in the technical textiles and composites area continues until today (Olsson, 2011), (Christ, 2012), (Chowdhury, 2014). Two very important works appeared recently (Ozipek, 2013) and (Lima, 2013). Ozipek has correlated various methods for the determination of bi/multi axial loading and testing of fabrics. Lima reports the construction of a multi-axial in plane tester of fabrics.

In the frame of the current work a new device has been developed for the multi-axial testing of the textile fabrics. In the first test weft and warp knitted fabrics have been used for the determination of the performance of the testing method. The tester is capable for the measurement of the mechanical behaviour of the fabrics on four axes and on eight directions.

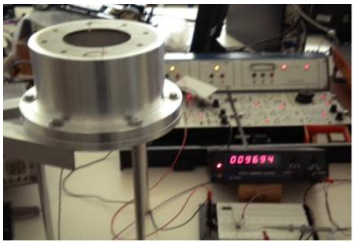

Figure 1. The multiaxial tester

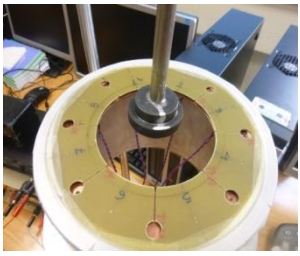

Figure 2. Detail of the measuring sectors

The measurements show that the behaviour of the sensors is mainly linear and the measurements are repeatable.
Typical measurements for warp and weft knitted fabrics are as follows:

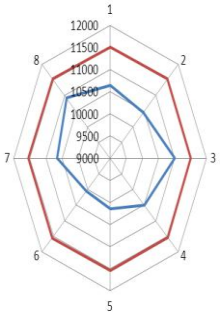

Figure 3. Warp knitted fabric

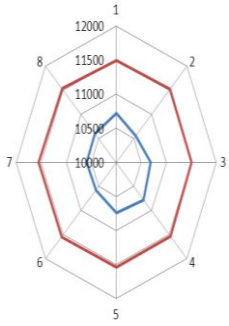

Figure 4. Weft knitted fabric

The first results of the new measuring setup are promising and the investigation continues for the correlation and the evaluation of the results.

Keywords: *Multiaxial, test, fabrics*

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AN INNOVATIVE CONSTRUCTION OF THE MULTIFUNCTIONAL KNITTED CLOTHES FOR THE PREMATURELY BORN CHILDREN

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The problem of premature babies is very important for social reasons. The largest number of premature babies is born in the African and Asian countries - it is about 85% of the all children born before the time in the world. The problem of premature babies is also present in highly developed countries like USA that has one of the highest birth rate of premature babies among of the other industrialized countries, it is 12.3%.

The children, who were born between 25 and 37 week of pregnancy, are completely underdeveloped from the physiological point of view. The most common problems of an underdevelopment is an undeveloped epidermis, that to the 25th week of pregnancy is adapted to aquatic life and it does not meet any of the protective functions. This kind of child very quickly loses the water through the skin by evaporation, radiation and convection process [1]. The skin of the premature babies is very thin and has gray or brown color. It has underdeveloped glands. Through the skin can be seen small blood vessels, and it does not protect an infant from the harmful effects of the environment and the microorganisms [2]. The premature babes are not able to keep proper body temperature, because they have not sufficiently formed subcutaneous adipose tissue, and their muscles are too weak to produce heat [3]. Children born before 30 week of pregnancy are particularly vulnerable to hypothermia [4].

Based on the physiological functions of premature baby was designed and manufactured a model of textile incubator. The main goal of this incubator is to maintain an adequate microclimate. "Cocoon" is built from four layers: an external layer was made form terry fabric, a heating - cooling element in the form of a knitted fabric with channel structure

and a tube conducts liquid, a rescue blanket that prevents heat loss and an removable internal layer that is subjected to maintenance and sterilization process. Moreover, the "cocoon" in its structure contains some interchangeable disposable components.

Figure 1. Constructional model of the textile incubator.

The construction of the textile incubator was developed in two ways. The first solution was to combine following elements by using three-thread overlock: terry fabric, knitted fabric with channel structure – a heating - cooling element and a rescue blanket. The construction of "cocoon" closes by hook and loop fastener. The hood also has a "peak" that covers the eyes of newborn baby. An important element of the textile incubator structure is its division into three zones: back, legs and mouth with cheeks. The figure 1 shows made model of "cocoon" for premature babies. The second constructional solution of "cocoon" connected with its conservation is the sewing process of delicate zip in the side of the product. It allows to remove the heating - cooling mat to the sterilization process. Instead of the delicate zip to close the incubator was used a flat magnet. The most important element of the "cocoon" construction is the heating - cooling mat that protects the premature baby against the heat loss. Textile part of the mat was made from knitted fabric with channel structure that was manufactured on a rib knitting machine. There were applied two constructional solutions related to the tubes with the heating - cooling

liquid inside the channels of the knitted fabric. In the first case was used silicone tube that was connected to the dosing pump. In the second one solution was used the tube and additional collectors that support even heat distribution in the mat. The liquid flow is controlled by a handler. In order to heat the liquid inside the tube was used a blood warmer system. To the mat were connected temperature and humidity sensors. The measured values are transferred to the computer station in order to control and change the settings an appropriate parameters suggested by doctors (Fig. 2).

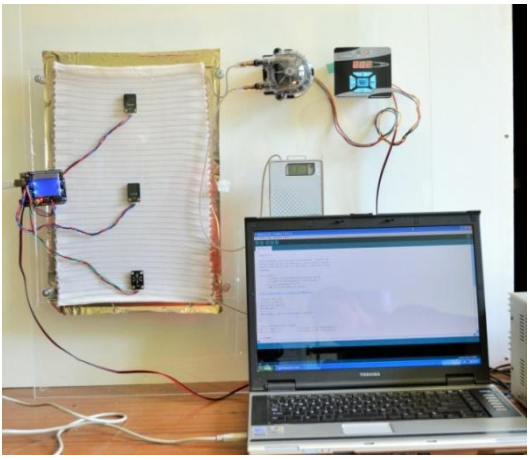

Figure 2. The heating - cooling mat with associated sensors to control the liquid flow.

From a medical point of view, the textile incubator can be used in the following areas of medical care for "premature babies":

- transport of a newborn baby qualified to thermal hypothermia (medical emergency services - transport infants in an ambulance),
- protection of a newborn baby in the first days of its life,
- newborns that require surgical treatment (suitable discovery of the operating field), during the operation the child is heated lying on his back [5].

Keywords: *Premature babies, physiological functions of infants, heating - cooling mat, textile incubator.*

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A MULTICRITERIA DECISION APPROACH ON PHYSICAL PROPERTIES OF SOCKS MADE FROM DIFFERENT FIBER TYPES

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During the daily life, owing to the fact that socks are connected with skin and shoes directly, they are subjected to more physical forces than other types of garments. As a result, they need to perform better physical characteristics than the others. For this purpose, in this study, a multicriteria decision making method, TOPSIS, was used in order to select the sock with best physical properties. A decision making problem is the process of finding the best option from all of the feasible alternatives. Multi-criteria decision making may be considered as a complex and dynamic process that includes one managerial level and one engineering level. TOPSIS is a kind of multi-criteria method to identify solutions from a finite set of alternatives. The basic principle is that the chosen alternative should have the shortest distance from the positive ideal solution and the farthest distance from the negative ideal solution [1-4]. New regenerated fibers such as modal, micro modal, bamboo, soybean and chitosan were selected for the study. Also, due to the limited number of studies about the performances of these fibers, in an intention to compare their properties with conventional ones, cotton and viscose were also edited to the study. Unlike ordinary socks, nylon and elasthane were not utilized in the production of the plain jersey socks for the work in an attempt to investigate the effect of fiber type on physical properties of the samples. The socks were produced at the same knitting settings. For performing the TOPSIS evaluation; weight loss, bursting strength, width wise and lengthwise dimensional stability were taken as a weight. Analytic hierarchy process was used to determine the relative weights of four decision criteria according to their relative importance for fabric performance. The detail of the fabric physical properties is given in Table 1.

Table 1: Fabric properties

	Weight loss (%)	**Bursting strength (kg/cm^2)**	**Widthwise shrinkage of the socks (%)**	**Lengthwise shrinkage of the socks (%)**
Cotton	7,04	6	-4,84	-10,94
Modal	9,80	4,2	1,25	-5,31
Viscose	5,14	4,8	-0,16	-14,69
Micro modal	19,00	4,8	-2,97	-8,75
Bamboo	6,88	3,8	-7,50	-10,31
Chitosan	5,21	4,7	-4,06	-6,72
Soybean	3,86	7	-5,00	-11,25

The multicriteria approach showed that socks made from modal fiber are the best and preferable ones from over all. They were followed by the socks made from viscose and chitosan fibers. On the other hand, it was the bamboo socks which offered worse physical properties. Table 2 shows the preference order of alternatives.

Table 2: Preference order of alternatives

Fabrics	d+	d-	Relative closeness	Rank
Modal	0,0524	0,2865	0,85	1
Viscose	0,1268	0,2329	0,65	2
Chitosan	0,1581	0,1686	0,52	3
Micro modal	0,1668	0,1515	0,48	4
Soybean	0,1961	0,1374	0,41	5
Cotton	0,1919	0,1235	0,39	6
Bamboo	0,2655	0,0976	0,27	7

In this study, it was shown that TOPSIS can be a beneficial tool for this kind of researches. By using TOPSIS, a single ranking taking into account preferences of the decision-maker and priorities arranged according to the final goal can be obtained.

Keywords: *Sock, comfort, new regenerated fibers, multicriteria decision making,*

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EDUCATION & TESTING IN KNITTING

FUSION: THE INIS MEAIN KNITTING COMPANY AND UNIVERSITY OF ULSTER COLLABORATION PROJECT

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This paper discusses the impact of work-based learning in education and the importance of developing partnerships between university and industry. This is in the context of the Ba (Hons) Textile Art, Design and Fashion Course (Fashion knit) University of Ulster and Inis Meain Knitting Company, Galway, Ireland. The paper will discus the outcome of a recent *IntertradeIreland* Fusion project, which involved Inis Meain Knitting Company (the Industrial partner) the University of Ulster (the academic partner and knowledge provider) and a recent graduate (the knowledge carrier). The paper will focus on the impact on teaching and learning pedagogy, the knowledge transfer between the tripartite relationship of the industrial partner, academic partner and the graduate. It will consider skill acquisition and the flow of innovation and ideas developed throughout the 12-month project and measurable outcomes recorded in quarterly evaluations evidencing both qualitative and quantitative data. It will also assess the impact on all stakeholders over the prevailing year. *IntertradeIreland* describes the Fusion as
"… An all-island technology transfer programme, which can help you to bolster your business's bottom line and get ahead of the competition by partnering your company with a third-level institution with the specialist expertise you need and a high calibre science, engineering or technology graduate. With innovative training, talented graduates, award-winning knowledge transfer and a strong track record of challenging business thinking." [anon] Inis Meain Knitting Company has been described by the financial times as, "A stylish knitwear boutique based where its heritage-rich clothes are made - the Aran Islands It's a far-flung spot for a spending spree, but this knitwear boutique on Inis Meain, one of the three Aran Islands at the mouth of Galway Bay in Ireland, is in a league of its own, being the most westerly and remote shopping destination in Europe." (Financial Times, 2011) This investigation into work-based

learning and the potential outcomes for the tripartite stakeholders have been described as, "…A class of programmes that bring together universities and work organisations to create new learning opportunities in workplaces… Such programmes meet the needs of learners, contribute to the longer term development of the organisation and are formally accredited as university courses." (Boud, et al, 2003) The changing landscape of the UK Higher Education sector has identified that while student numbers continue to increase with widening participation, staff numbers have decreased since 2009. The availability of resources both in technological and human terms has created difficulties for Universities. "Higher Education is in the midst of an unprecedented era of change. Governments are keen to reduce public expenditures. There are demands to increase numbers and diversity of students. Alongside these continuing imperatives looms a crisis in the nature of knowledge for which Universities previously stood." (Boud, et al, 2003)

In conclusion the paper will consider the delivered outcomes for the Industrial partner, academic partner and graduate. It looks at the unique input of graduate designers who are eager to extend their knowledge and understanding of the subject area. The graduates understanding of trends and innovative approach and the impact on the company, challenging accepted practices. The potential for the Industrial partner's use of resources and breadth of knowledge of the academic partner, including access to periodicals and a wide range of journals and also websites such as WGSN (Worth Global Style Network) only accessible by University intranets. The benefits to the academic maintaining a design ethos; working with an industrial partner fosters good understanding of current market forces, practices in sales and retail and an insight into design for the curriculum and scholarly activity based on current practice. Access to state of the art CAD CAM systems and knitting technology, networking events and in this particular project designers, buyers, Industrial trade fairs, design and production teams. Benefits for the student, were seen in increased skill acquisition, understanding of key roles and responsibilities in Industrial approaches to design, cutting edge CAD/CAM technology. Access to all aspects of the design, development, production, manufacture, sales and marketing, promotional activities

resulting in a thorough understanding of all aspects of manufacturing and therefore future employability.

Keywords: *Knowledge transfer, technology, fashion, knit,*

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OBJECTIVE AND SUBJECTIVE EVALUATION OF PILLING

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Piling is defined as the entangling of fibers during washing, dry cleaning, testing or wearing to form balls or pills that stand proud of the surface of a fabric. They are of such density that light will not pass through them, so they cast a shadow. During pilling, fibres become entangled, and the different fibers around them join this structure, causing a more significant default on the fabric surface (Göktepe, 2002; Ukponmwan, 1998).

Products of knitted fabric are characterized as being elastic, resilient, and soft, they have good draping properties, and cling well to body to inhibit movement. However during exploitation, pills form on the surface of the knitted fabric, remaining on the surface of the product and worsening its exterior (Busiliene, 2011). Generally, the level of pilling which develops is determined by the rates of the following parallel processes: • fibre entanglement to pill formation • development of more surface fiber • fibre and pill wear-off. The rates of these processes depend on the fiber, yarn and fabric properties (Esteves, 2004).

Simulating the pilling and evaluation are two stages of pilling evaluation. Fabric pilling is commonly tested in laboratory by using specific machines to generate pills and the pilling samples are generally assessed by subjective method. Experts with long training and experience assign a degree of pilling by looking at the sample processed by the machine. However, a common drawback of these subjective methods based on estimations by experts is their inconsistency and the inaccuracy of the rating results. One observer can grade differently than other observers. Further, different grades can be made in different testing laboratories, creating costly supply chain inefficiencies and disagreements. The problems caused by subjective assessments led to the investigation of new techniques based on objective and noncontact

methods, such as image analysis (Gunavathi, 2008; Xi, 2002; Kim, 2005; Biermann, 2001, Millan, 2001).

Since pills are fiber balls, or clumps, that sit on top of the fabric, straight down 2D imaging of the sample is insufficient to measure pills. Pill height is a critical factor in determining the degree of pilling. Besides depending upon the degree of fuzzing, the pills can be camouflaged by the fuzz. Fabric patterns or the weave/knit structure can confuse pill detection, measures, and grading. In 2003, a major US polyester fiber producer realized a need for an objective pilling measurement device as part of their project to improve the pilling resistance of polyester staple fiber and PillGrade Automated Pill Grading System was developed. It detects, measures, and grades pills by scanning the specimen's horizon as the specimen is rolled over a rotating drive rod. By scanning the horizon of the fabric, the height of each pill and fuzzing can be measured, while the fabric patterns and weave/knit structure is disregarded. (Jackson, 2005; PillGrade Manual).

In this study, it was aimed to determine the compatibility of PillGrade Automated Pill Grading System with subjective pilling evaluation. For this, by using interlock knitted fabrics produced from Ne 30/1 carded cotton yarns, pilling tests were carried out with Martindale pilling tester. Since among the pilling testers simulating the wearing conditions in laboratory environment, the most severe pilling formation is generally occurred in Martindale method due to the direct abrasion forces between the fabric surfaces, Martindale method was preferred in this study as well (Özçelik, 2011).

After conditioning the fabric in standard atmospheric conditions (20±2ºC and 65% relative humidity), the fabric samples were tested in 250, 500, 1000, 1500, 2000, 3000, 4000 and 5000 revolutions (lissajous figure) in Martindale tester according to EN ISO 12945-2 standard. After pilling test, the samples were evaluated subjectively by three experts working in textile laboratory and the mean values were calculated. The same test samples were also measured in PillGrade instrument according to two different sensitivity levels. In PillGrade instrument, it is possible to evaluate the pills on the fabric surface in different sensitivity levels by

changing pilling curve. Therefore, it allows the user to customize the pilling grade formula for any product type to match the user's specific grading requirements for any particular product type.

The results of the subjective evaluation and PillGrade evaluation in default and high sensitivity settings are given in Table 1 and Figure 1.

Table 1. The pilling grades according to the subjective and PillGrade evaluations

The number of lissajous figure	Subjective evaluation	PillGrade evaluation (default setting)	PillGrade evaluation (high sensitivity setting)
250	3,25	4,02	3,37
500	3,00	4,07	3,02
1000	2,50	3,97	3,05
1500	2,25	3,44	2,61
2000	2,50	3,50	2,81
3000	2,25	3,46	2,66
4000	2,00	3,58	2,67
5000	1,80	3,05	2,23

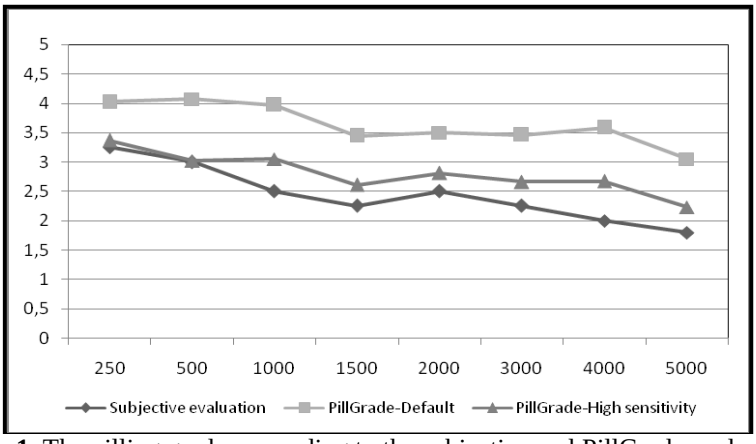

Figure1. The pilling grades according to the subjective and PillGrade evaluations

As it can be seen from Figure 1, the tendecy of all evaluation methods is the same. However, according to the subjective evaluation, the lowest pilling grades were obtained, whereas the highest values belonged to the PillGrade default sensitivity evaluation. The pearson correlation coefficients between the results of subjective and PillGrade default setting was found as 0.859 and statistically significant (p=0.006). The

correlation coefficient between the results of subjective and PillGrade high sensitivity setting was 0.925 and statistically significant (p=0.001). According to the comparision of the evaluation methods, it can be stated that the results of PillGrade Automated Pill Grading System is quite coherent with subjective evaluation and can be used especially for the comparison of the fabrics having different pilling tendencies.

Keywords: *Pilling, Martindale, PillGrade, interlock knitted fabric*

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POSTER PRESENTATIONS

BIODEGRADATION TEST METHODS USING FOR KNITTED FABRICS

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The consciousness relative to the environment has been important in recent years. It has been seen that the approaches relative to green-marketing or green-manufacturing have significant role in all industries besides textile industries. It is inevitable that the increasing pollution both in the atmosphere and land fills will affect the life in the world.

The disposals of the materials which are not biodegradable are extremely dangerous and harmful on the environment. The term biodegradation is getting more importance nowadays, as it converts the materials into water, carbon dioxide and biomass. There have been lots of researches which are going on developing biodegradable polymers. It is important to understand the biodegradational phenomenon of the materials. While new textile structures are improving, it should take into consideration that the materials can be easily disposed with no harmful effects on the environment after their use (1).

Degradation is a process of break into its components by a physical, a chemical or a biochemical process. There are two types of biodegradation, aerobic and anaerobic. When material is biodegraded in the presence of oxygen it is called aerobic biodegradation and if it is biodegraded without oxygen it is called anaerobic biodegradation (2).

There are many test methods for determining biodegradation of materials under controlled composting conditions. Specific ASTM, ISO, EPA, OECD testing methods have been existed. For example, ASTM D5511, ASTM D5526, ASTM D5338 , ASTM D6400, ASTM D6954 , BS ISO 15985, ISO 14855-1/2, ISO 14851, ISO 14852, ISO 16929, ISO/DIS 20200, ISO 17556, ISO 17088,OECD 301,OECD310,OECD311... (1)

The aim of this study is to understand the processes of biodegradation of the materials and improved a point of view about the test methods which can be easily applied to the textile materials. In this context, the best convenient test method has been offered for knitted textile structures.

Keywords: *Biodegradation, composting conditions, knitted fabrics, test methods*

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ELECTROMAGNETIC SHIELDING EFFECTIVENESS OF CONDUCTIVE KNITTED FABRICS

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Intensive integration of the technology in human life, and increasing use of electronic devices and instruments cause the emission of electromagnetic waves that results in electromagnetic pollution. Electromagnetic waves are known to have harmful effects on electronic devices as well as human health in different dimensions and therefore many researches work about screening for the prevention of these effects. Electromagnetic shielding effectiveness of the textile surfaces vary depending on type of material that is used. Also it is depending on the structure of textile surface. The aim of this project is to investigate the application of knitted textile materials for the purpose of protection against electromagnetic waves and the effect of raw material, yarn and fabric parameters on electromagnetic shielding properties extensively. We used copper and silver filaments and produced core yarns. By using conductive yarns single jersey, rib, and Futter (2 threads) knitted fabrics were produced.

Thereafter the shielding properties of the fabrics were tested by using EMC test system with real electromagnetic waves. The results show that conductive fabrics have high EMSE (Electromagnetic Shielding Effectiveness) values when compared to cotton fabrics. Futter knitted fabrics show better values when compared to jersey and rib. Also the fabrics that contain copper have high EMSE values.

Keywords: *Electromagnetic waves, electromagnetic shielding, conductive knitted fabrics, technical textiles*

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STRESS AND STRAIN ANALYSES OF CIRCULAR KNITTING NEEDLES BY USING FINITE ELEMENT METHOD

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The lifetime of knitting needles is an important issue due to high cost of needles in the long term. This is a cause of both cost of changing the needles regularly and losing working time during this changing process. Also any breakages or failures of the needle can cause irreversible errors in the quality of fabric. In this study, different from the theoretical studies available in the literature [1-11], we examined stress and strain analyses of the needles in dynamic process using finite element method. In this respect, we developed a model which could be utilized to estimate forces acting on the needle without making several measurements which are time consuming and costly. For the work under discussion, a E18 10" knitting machine was employed. Three dimensional models of cam, cylinder and needle were created by using coordinate control machine (CCM) and three dimensional images of them can be seen in Figure 1. In the light of the literature survey; needle material type, machine velocity and cylinder-cam gap were taken as the major factors which affect the lifetime of the needle and then the distribution of the stress–strain on the needle was evaluated.

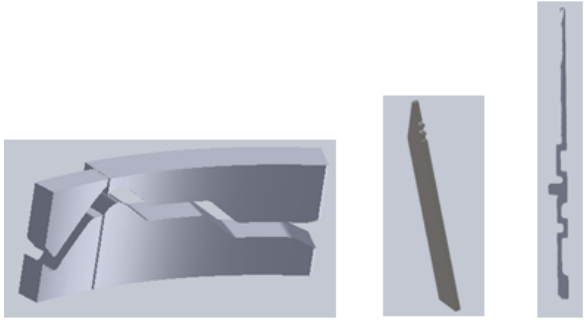

Figure 1: A- Cam model B- Needle model C- Cylinder

The results showed that material type had an important effect on the strain of the needle. The needle whose elastic modulus was high deformed less. Although both top and bottom parts of the needle stem were subjected to stress throughout the cam way, the highest stress values were obtained from butt edges of the needle. Also for all steel types, reaction forces on the needle rised when machine speed was increased. At three different velocities, the effects of cam-cylinder gap were investigated with AISI 1060 steel and the results showed that reaction force reduced when the cylinder-cam gap was increased to 0.2 mm for all velocities under discussion.

According to the results, the findings were compatible with the literature survey. In this respect the parameters that are affecting needle were compared and analyzed very clearly. These data and model help us to save both time and energy in addition to reduce cost.

Keywords: *Finite element method, needle, circular knitting*

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BURNING PROPERTIES OF KNITTED FABRIC CONTAINING FLAME RETARDANT FIBER AND COTTON FIBER

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Protective textile is a branch of technical textiles. Protective textile against high temperature is defined as a material that can be used continuously at temperature over 200 ^{0}C without decomposition and without losing its major physical properties. Firefighters clothing, military clothing, children's clothing can be given examples of flame resistant protective clothing.Flame retardant product is symbolized as FR. In general a properly designed flame resistant fabric will prevent the spread of flame when subjected to intensive heat or flame. Flame retardant ability is generally measured by the Limiting Oxygen Index.Flame retardant textiles can be produced by different methods. In this study, flame retardant Trevira CS fiber was used. Flame retardancy is brought to Trevira CS fiber during the fiber spinning. Trevira CS fibers are similar to conventional PES fibers except flame retardancy properties of them.

The purpose of this study is to improve flame retardant protective clothing. Ne30/1 open-end yarns were spun by 100% Trevira CS (1.3 dtex and 1.7 dtex, fiber length 38 mm) and 100% cotton. Double sided knitted fabrics were produced by circular knitting machine (with one side 100% cotton and the other side Trevira CS). Flame spread test, heat transmission test and limiting oxygen index (LOI) tests were applied on the produced fabrics. The thermogravimetric analysis (TGA) was made for thermal characterization of the fabric.

Heat and flame resist performance is good, although the fabrics contain cotton. Using of cotton fibers can reduce the manufacturing cost. In addition, the 100 % cotton inner face of the fabric also provides comfort.

Therefore the structure of tested fabrics is thought to be suitable for production of children's clothes and work wear. It is found that the fiber fineness have not significant effect on heat and flame resistant feature of fabric. On the other hand, the heat transmission feature of fabric is affected by fiber fineness.

Consequently, it is found that the produced fabrics are more suitable for the production of flame retardant conventional product instead of high performance technical textiles.

ACKNOWLEDGEMENTS
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Keywords: *Flame retardant fiber, Trevira CS fiber, limit oxygen index (LOI), protective clothing*

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THE BURSTING STRENGTH OF WARP KNITTED LAMINATED FABRICS AFTER THE WRINKLE RESISTANCE FINISHES

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ABSTRACT

In this study ten different warp knitted fabrics were produced as two groups; with and without lamination. The purpose of this production was to select the most wrinkle resistant fabric type. Therefore the wrinkle resistances of the samples were determined. The aim of this study was to find out the effect of these methods on the bursting strength of the fabrics. At the end of the study the most convenient fabric production method was chosen in accordance with both wrinkle resistance and bursting strength test results of the sample knitted fabrics.

Keywords: Warp knitted fabric, lamination, wrinkle resistance, bursting strength

INTRODUCTION

Warp knitted fabrics are different from weft knitted fabrics like production method, type of machine, used yarn types and of course application areas. Warp knitted fabric are generally stronger than the weft knitted fabrics so they are usually used for technical purposes. Although the wrinkle resistance of warp knitted fabrics is more than that of weft knitted fabrics, wrinkle of warp knitted fabric is an undesirable problem. Therefore there are many different processes which improve the wrinkle resistance of warp knitted fabric. The aim of the study is to determine the effect of wrinkle resistance improving methods on the bursting strength of warp knitted fabrics.

EXPERIMENTAL

In this study two groups of fabrics were studied: laminated and non-laminated fabrics. Each group includes five different fabrics; one of which is the reference fabric All fabrics were produced at a commercial warp knitting mill and lamination of second group was carried out at the same mill. Consequently, totally ten fabrics were tested as laminated and non-laminated were tested in this study. Lamination method used in this study was flame lamination. With the process of lamination the fabric became three layered. As shown in Figure 1, the top or surface layer which was also named as non-laminated fabric in this study was knitted from 100 % polyester by three bared tricot type warp knitting machine. The middle layer (Figure 1) was foam layer and it was produced from Polyurethane (PUR) with 2 mm thickness and 28 kg/m^3 density. The lower or bottom layer as shown in Figure 1 was used as lining fabric and it was knitted from 100 % polyester by two bared tricot type warp knitting machine. In Table 1 tested fabrics were summarized.

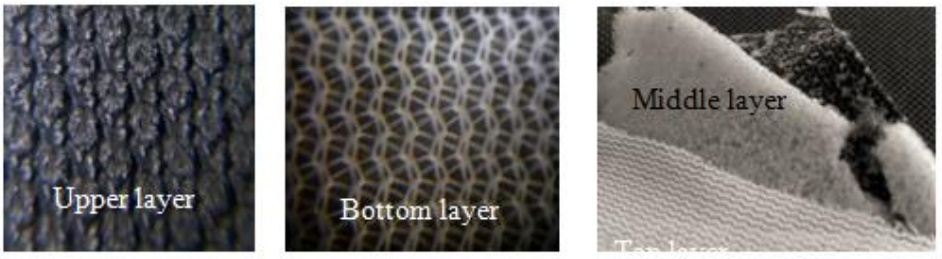

Figure 1. Laminated fabric with layers

Table 1. Fabrics descriptions

Codes	Descriptions
A	Reference Fabric
B	Softening agent addition while dyeing
C	More elastic yarn using while knitting
D	Elimination of the first fixation
E	Softening agent addition after dyeing

Wrinkle recovery tests were done according to AATCC Test Method 128-1999, and bursting strength of the fabrics were measured with the standard ISO 13938:2 1999.

RESULTS AND DISCUSSION

Wrinkle resistance of the fabrics were evaluated by using "AATCC Wrinkle recovery replicas" after 24 hours. The wrinkle resistances and bursting strength test results of the fabrics were presented in Table 2.

Table 2. Fabrics wrinkle resistances and bursting strength test results

	Wrinkle Resistances (grade)		**Bursting Strength (kpa)**	
Fabrics	Without Lamination	With Lamination	Without Lamination	With Lamination
A	4	4	470	636
B	4	4	488	594
C	4	3	541	673
D	4	3	480	614
E	5	5	464	612

CONCLUSION

In general lamination deteriorated the wrinkle resistance of sample C and sample D and it was clear that only the method as using softening agent at foulard improved the wrinkle resistance of the reference fabric. Using the softening agent during dyeing developed the bursting strength of the fabric without lamination. Using more elastic yarn improve the bursting strength of the fabric with and without lamination because elasticity was an effective parameter. Elimination of the first fixation had not significant effect on the bursting strength of the samples statistically. Using the softening agent at foulard deteriorated the bursting strength of the fabric a little. According to the wrinkle recovery and bursting strength test results together, it was decided that sample E was the optimum type whose wrinkle resistance was the best and the bursting strength was high.

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FORECASTING OF INTEGRATED DOUBLE-LAYER KNITTED FABRIC QUALITY METRICS

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Production of integrated double-layer knitted thermal underwear for specified functional properties requires a comprehensive analysis of interaction the parameters of the process of knitting and quality assessment of the finished knitted fabric. Such problems, which considers multiple interconnected quality indicators are solved using mathematical optimization and involve the use of modern computer technology. Use of mathematical optimizing means and methods for research and mathematical description of the process not only provides an objective basis for the engineering, but also allows to predict the functional properties of knitwear and to manage the knitting process in order to find the optimal variant of the process.

The aim of research is to develop a mathematical algorithm of parameters structure engineering and functional properties of knitted fabrics, as well as rational technological modes of its production on the basis of modern computing application. The problem put by the mathematical planning of experiments method is solved, which allows optimizing the technological processes in the course of the experiment with determined set of parameters [1, 3].

For the functional underwear manufacture we have proposed a double-layer weft knitting structure with press connection layers by basic yarns. To give the fabric its polyfunctionality one layer formed from a hydrophilic kind of raw material, namely of a cotton yarn and the other layer, and the connecting elements - hydrophobic: modified polyester or polypropylene yarn.

On the basis of the realized full three-factor experiment [4] revealed the influence character of knitting parameters on the structure parameters integrated double-layer knitwear and its physical and mechanical properties. With the use of the method of data statistical manipulation

install the mathematical regressions that describe the correlation between the knitting parameters and quality knitwear metrics. On the basis of these regressions developed a specialized computer program [2], which allows to computer design the overall knitting turnaround from set parameters of knitting equipment to the parameters of its structure and properties. In basis of the solution algorithm the multicriterion optimal control problem put simplex method of linear programming.

Using the developed software product provides a search solution of rational technological modes manufacturing of the integrated double-layer knitted fabric for functional underwear with the given structure parameters and properties and to reduce material costs to development and manufacturing application, increase labor and equipment productivity, and efficiently using a knitting machine and raw materials capabilities. Optimization of quality metrics and process producing of knitted fabrics for functional purpose by computer aids provides a significant economic effect and is a component of the successful functioning of any modern knitting enterprises.

Keywords: *The integrated knitted fabric, double-layer knitted thermal underwear, linear programming, a simplex method.*

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ANALYSIS ON GREEN KNITTED FABRICS MADE OUT OF ORGANIC COTTON YARNS, AND NATURAL DYED

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Textile companies are nowadays facing the need to reorient production in terms of sustainability being, therefore, supposed to implement sustainable production practices. Moreover, consumers are increasingly aware of the major changes to the environment and resources, and progressively show positive attitudes about the green consumer market; among other things, they start requiring the "proof" of green traceability for the products.

The inclusion of the organic cotton as a raw material can help to improve the chances of starting a green textile supply chain, but the need for its continuation is also important, therefore, a green finishing of textiles should be included.

Under the given conditions, this paper aims to emphasize the impact of the raw material selection for knitwear, by considering adequate features to the end use. More precisely, 100% cotton and 100% organic cotton yarns were considered as raw materials for plain knitted fabrics and natural dyeing of fabrics was performed. Several physical analyses, assumed to be important for the comfort and aesthetics of knitted garments, have allowed pointing out that a certain raw material could affect the expected features of the final product.

The outcome of this paper was a preliminary approach in pursuing of the real contribution to the sustainable textile practices, by means of the achievement of green knitwear made of organic cotton and naturally dyed.

Keywords: *Organic cotton, yarn, knitted fabrics, natural dyeing, green knitwear, sustainability*

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KNITTING YARNS FROM WOOL NOIL/ACRYLIC BLEND SPUN ON THE COTTON SYSTEM

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The intense competition and cost pressure caused by the rising raw material and energy prices led companies to focus on improving raw material exploitation. A solution for cost reduction is the recycling of waste resulted from production process into another useful application. The wool noil, the waste generated during wool combing in the process of worsted yarn manufacturing, represents a valuable resource of raw material for the woollen spinning system. Because of the continuous trend in the production of lighter-weight fabrics, research studies were conducted on manufacturing good quality medium (to fine) yarns with content of wool fibres at economic production costs. In this respect different types of wool (cut top or stretch-broken top wool, short shorn wool, mechanically cleaned and shortened scoured wool stock, noil) have been blended on the cotton system with other fibres (Bel, 1984; Inoue, 1997; Louis, 1985; Lupton, 1980; Sava, 2004). In comparison to woollen system the cotton system allows the production of finer yarns and in comparison to worsted system the cotton system allows the production of cheaper yarns.

In this study knitting yarns of medium counts (Nm 28/1 and Nm 32/1) from 30/70 wool noil/acrylic blend were processed on the cotton system using rotor spinning machine and the plied yarns were converted into knitted panels for children and women apparel end-use. The addition of wool to the blend improves comfort, aesthetics, drape, handle, and flame resistance, while the addition of acrylic fibres provides strength.

The waste removed during combing includes short fibres, neps, and vegetable matter. In order to eliminate the vegetable matter, the wool noil fibres were subjected to carbonizing, neutralization, and shaking. The differences between the whiteness levels of the fibres were homogenized by bleaching. After the last rinsing the fibrous material was treated with an anti-static agent, centrifuged at low intensity and dried. Because of the

felting tendency, the wool noil fibres were subjected to a supplementary opening on a two-roller opener. The blend of 30/70 wool noil/acrylic fibres was obtained by manual mixing of components using "sandwich" (horizontal) layers. On the basis of a preliminary experiment, in order to obtain the preset ratio of the two components in the yarn, the percentage of wool noil in the mixing bed has been increased by 5 %. The layers were sprinkled with an anti-static agent in order to avoid the accumulation of electrical charge on fibres. Rotor spun yarns of Nm 28/1 and Nm 32/1 counts were obtained using standard mill procedures and practices and yarn properties have been assessed.

Yarn preparation for knitting involved the following processes: winding, folding, winding, skeining, shrinking, degreasing, dyeing, scouring, centrifuging, drying, winding and waxing. Three colors of yarns have been obtained by two bath dyeing method using combinations of dyes: 2:1 premetallized and cationic dyes or acid and cationic dyes. The Protty flat knitting machines, E 8 and E 10, were used for knitting the yarns of Nm 28/2 and Nm 32/2, respectively. The knitted fabrics have been evaluated in respect of color fastness to washing, perspiration and rubbing.

Based on the results of this research, the following conclusions can be drawn:

1. In order to maintain the number of yarn breakages to an acceptable level, higher twist has been inserted to the experimental single yarns.
2. The breaking strength of the experimental yarns is lower by 10% - 15 % than the breaking strength of the worsted yarns spun from virgin wool and wool-like acrylic fibres.
3. The experimental yarns are more even in terms of breaking strength irregularity than the worsted yarns spun from virgin wool and wool-like acrylic fibres.
4. The yarns from wool noil/acrylic blends spun on the cotton system are finer than the yarns that can be obtained on the woollen system from the same blends and much cheaper than the yarns spun on the worsted system from virgin wool/acrylic blends.

5. The best values of color fastness to washing, perspiration and rubbing showed the knitted fabric samples dyed with combination of acid and cationic dyes (Nylosan Violet FBL-1.2%, Melacril Blue FM- 0.3%, Melacril Red BL-0.2%).

Keywords: *Wool noil, cotton system, rotor yarn, knitted fabric*

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LOOP LENGTH MODEL OF FILLET STRUCTURE

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It is well known, that unit element of a knit structure is a loop. The loop configuration that is obtained in the knit depends on both qualitative and quantitative factors, the most important of which is the loop length. The loop configuration in the knit fabric of same interlooping from yarns of the same composition and same linear density is different and varies depending on the loop length. Thus, it is necessary to have a geometrical model of knitted loop configuration.

Few studies have been undertaken on the geometry of warp-knitted structures. The first geometrical model for warp knitted structures (Allison, 1958) was quite simple model, in which the unit stitch shape consisted of semi-circle plus two converging straight legs and straight underlap section. Second geometrical model of loop configuration was presented and improved by Grosberg for two bar warp knitted fabric (Grosberg, 1964). It is based on physical configuration of the yarn. He assumed that the loop and underlap are effectively isolated from each other by friction, the root end of the loop lays at the widest section of the previous loop and the underlap is a part of a circle. Other geometrical model, in which loop was described by the sum of lines, parts of circles or ellipses, was proposed by Dalidovich for single bar warp knit structure (Dalidovich, 1970). He assumed that yarn has same diameter, deformation property and a circle in the section at each part of loop. These models are flat mostly, but at real knit structure loops are unfolded, bent and curved. So it is logical to represent them as spatial curves in 3D model.

General 3D loop and underlap models for basic two-bar full-set warp knitted structures were developed by CAD program to obtain a three dimensional loop model that is suitable for visual computer representation of warp-knitted structures (Goktepe, 2002). A 3D straight line model also should be used to predict the behavior of two-guide-bar

warp knit fabric (Dabiryan, 2011). The accurate calculation of the run-in values verifies the proposed 3D loop models. But all these models were developed for full-set basic warp knit structures.

Also, it is well known, that net warp knitted fabric can be produced by using half-set two-guide-bar fillet interlooping. However, few loop configurations differ by size, form and shape in such structure (Ermolenko, 2011). In previous study (Ermolenko, 2013) presented 3D loop models of net knit structure with hexagonal cell which is formed by alternation of tricot and atlas courses at repeat. The aim of this research is to develop our loop model for net knit structure with hexagonal cell which is formed by alternation of tricot and chain courses. Vertical ribs of such net structure consist of tricot closed loops of identical configuration while diagonal ribs consist of tricot and chain loops of different type, shape and form. In this study each loop is presented as sum of planar and spatial lines, the length of which can be easily calculated by the well-known formulas. Numerical dependences for loop length calculation are determined as a result of mathematical transformations.

To verify the suggested model few variants of fillet warp knit structures were produced from polyester yarn. The investigation showed that theoretical average loop length of repeat corresponds to experimental value. It is concluded that the model can predict geometrical properties of half set two guide bar warp knitted fabric.

Keywords: *Geometrical model, warp knitting, fillet interlooping, loop length*

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USABILITY OF SOME SPECIAL YARNS FOR AUTOMOBILE UPHOLSTERY

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Car seat upholstery generally consists of three components. (Figure 1) The top is surface fabric, the bottom is backing fabric and foam is located in between these two materials. Choice of yarn raw material of surface fabric is very important for car seat upholstery fabric that improved thermal comfort properties. The yarn used in the fabric surface, while improving the comfort properties of the automobile upholstery at the same time it has to meet the expected physical properties. For this purpose in the study carried, four different high thermal comfort featured yarns and standard polyester yarns were used to produce special type pique structured knitted fabric.

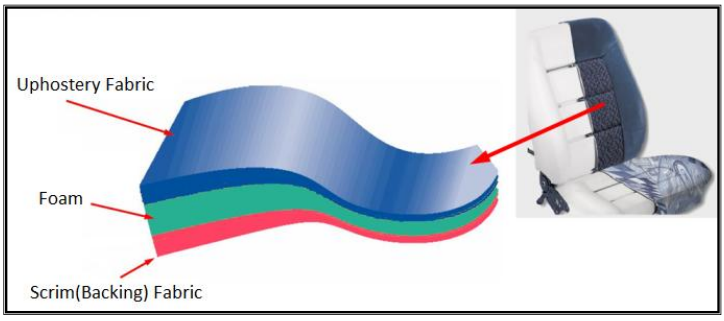

Figure 1: Automotive seat upholstery fabric components (Armakan vd.,2010)

Critical tests for automobile industry as abrasion resistance, combustion rate, fogging and light fastness were carried out for pique type of knitted fabrics that was produced with high thermal comfort featured yarns supplied from different suppliers. Knitted fabrics with polyester yarn that is used as a standard automobile upholstery was produced with same

parameters to compare with knitted fabrics that was include special yarn and tests were carried out.

The aim of this study is to determine whether the special yarns that have high thermal comfort met the specifications of automobile upholstery or not.

Keywords: *Automobile upholstery fabric, comfort featured yarns, automobile upholstery specifications, thermal comfort*

RESEARCH ABOUT THE USE OF KNITTED WIRE MESH IN DIESEL PARTICULATE FILTERS

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Today one of the major problem is the environmental pollution and motor vehicles significantly cause this problem. This situation has become mandatory in the development of emission control technologies. Because of diesel engines' operating costs, high durability and reliability, they become important in the heavy-duty vehicle market. The most important pollutants emitted from the exhaust gases of diesel engines are particulate matters(PM), nitrogen oxides(NO_x), hydrocarbons (HC), and carbon monoxides (CO) [1, 2, 3]. For filtration of these gases, there are some kind of material options; ceramic monolith, ceramic foam, steel wire meshes, ceramic silicon fiber, porous ceramic honey comb [4]. Besides coated metallic wires, glass fiber and carbon fiber are also used for filtration material [5].In the literature, especially knitted steel wire meshes are ranked first for its collection efficiency of PM. The other properties of knitted steel wire meshes known are thermal stability during regeneration, good mechanical properties, long durability, easy availability and less cost [4, 6]. In this paper we have given some information about the knitted meshes in different gap size, from different wire diameter and different materials (metal, glass fiber and carbon fiber).

Keywords: *Knitted meshes, filters, diesel engines, pollution.*

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STUDY OF ANISOTROPIC BEHAVIOUR OF COATED KNITTED FABRIC

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Although previous studies suggest that coating reduces the anisotropy of textile materials, this study shows that the polyurethane coating of knitted fabrics increase the anisotropic behaviour of knitted fabrics.

The advantages of the polyurethane layer, as compared to other polymers, are increased resistance to abrasion, tearing, they are water repellent and permeable to water vapour [1, 2]. Knitted fabric, as the substrate of the composite, can be designed to meet different physical and mechanical requirements. Regardless of the chosen knitted structure, knitted substrate is always different in a direction of courses, then in a direction of wales; it is impossible to avoid this. This is a foundation for anisotropy. Accordingly, anisotropy cannot be avoided in coated knitted fabrics. It is a great elongation and unpredictable behaviour of coated knitting fabrics under the influence of a force, which rejects producers and users of the coated knitted fabrics, and it seems important to explore this field.

Mechanical properties of coated knitted fabrics are studied [3]. Well researched is woven fabric anisotropy [4, 5] and coated woven fabrics anisotropy [6, 7]. Studies of the mechanical properties of coated knitted fabrics in different directions are generally limited to multiaxial warp knitted fabrics [8, 9]. It has been found that such coated knitted fabrics exhibit anisotropic properties under uniaxial loading. Yet the same knitted fabrics exhibit isotropic behaviour under multiaxial loading. In addition, from the literature [10] is known the anisotropic behaviour of coated single jersey knitted fabric. The anisotropy was very noticeable, maximum measured force was in the direction of the courses, but maximum elongation was in the direction wales.

For this study seven knitted fabrics (warp knitted simplex, charmeuse, power-net, voile and another power-net, and weft knitted single jersey and interlock) were chosen to cover a wide range of properties. The mass of the knitted fabrics is in the range from 47 to 184 g/m2, and thickness is from 0,26 to 0,74 mm. Knitted fabrics were coated with polyurethane under the same conditions, on the same laboratory coating line. One component polyurethanes were used. Polyurethane was coated on a knitted substrate using transfer process.

Measurements were carried out according to EN ISO 1421 Rubber or plastic coated fabrics - Determination of tensile strength and elongation at break. Mass of coated fabrics was obtained according to EN ISO 2286-2:2008. Thickness was measured according to EN ISO 5084: 1996. Samples were statistically analysed.

After coating, fabrics increased elongation in the direction of wales and courses. Elongation of coated knitted fabrics in the direction of wales was increased by an average of 16% compared to elongation of knitted fabric. It is significant that elongation in the direction of courses was increased after coating by an average of 102%. Because of the large increase in the elongation of fabrics in the direction of courses after coating, anisotropy of the elongation of coated knitted fabrics on average increases, and not decreases as previously reported.

After coating, breaking forces in the direction of wales increases in average 24%, and in the direction courses approximately 27%. By coating the average anisotropy of the breaking forces is not reduced, but the difference of the breaking forces in the direction of the courses and wales increases from 31% to 38%.

Keywords: *Coated knitted fabric, polyurethane, anisotropy, elongation, breaking force*

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THICKNESS OPTIMIZATION OF A SINGLE HETEROJUNCTION FIBRE ORGANIC PHOTOVOLTAIC USING A SIMULATION TECHNIQUE

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The photovoltaic fibres are important for the production of textile fabrics with multifunctional properties. The photovoltaic textiles will contribute to the energy harvesting field on a personal or on a structural basis. On the personal level the target is to assure the power supply for the wearable or the portable devices. On a structural level, the photovoltaic fabrics can be architectural functional elements like tents, curtains etc. with an essential contribution on the operational electrical energy consumption of the buildings. Both application levels are of high importance and the design optimization issue is of increased interest.

Fiber photovoltaics for smart textile applications may be approached by two different configurations, namely the single heterojunction [1] and the bulk one [2]. The materials, the deposition techniques and the optimized design differ for each type. The single heterojunction fiber photovoltaic is based on two discrete materials of p and n type respectively, that are separately deposited as two different layers one on top of each other. The deposition of the proposed materials is conducted by using the vacuum evaporation technique which provides more accurate layer thicknesses, although more sophisticated equipment are required. Alternatively, the bulk heterojunction fiber photovoltaic configuration uses easier techniques for its development, although the thickness of its layers' is more difficult to control. Concerning their quantum efficiency, both configurations could be considered as suitable for fiber solar cell applications.

The procedure for an optimized design regarding a single heterojunction fiber solar cell takes into account the spectral complex refractive indices of the proposed materials and may calculate the optimum layer thicknesses for the maximum external quantum efficiency (EQE). By considering internal quantum efficiency =1, the EQE may be estimated and the short circuit photocurrent will be derived through the calculation of the optical intensity at the position of the heterojuction interface. An optimized design procedure for thickness calculation takes into account the distribution of the optical-electric field across the photoactive layer and its relative integration in order to calculate the maximum short circuit photocurrent. For the aforementioned calculations, the transmission line method is adopted as it has been previously applied [3, 4] for the planar organic photovoltaics, following the necessary modifications.

Keywords: *Fiber photovoltaics, transmission line model, smart textiles*

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BITCOINS: AN OPPORTUNITY OR A THREAT FOR THE TEXTILE PRODUCTS TRADE?

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Bitcoins appeared in the world in 2008 through a paper of "Shatoshi Nakamoto", obviously a pseudonym. It became operational in the first months of 2009. Since that time more and more users "work" in order to gain Bitcoins. That work is known as Bitcoins mining. It presupposes the accomplishment of a very big computational load. The basic idea of the Bitcoins system is the building up of a system of secure financial transactions without the engagement of the traditional banking system. The Bitcoin system alternative promises secure money transfers at no or at a very low cost, compared to the one of the traditional bank transfer today [1]. The Bitcoin system is considered as the most important result of the use of the internet. Its global impact is extremely important because it competes the traditional trading and banking systems. Since it is highly revolutionary, there is a lack of central control as it happens in the traditional banking and monetary systems. The lack of the systematic control for some of the people is its main benefit, while for the rest is the main danger. The implementation of the Bitcoin system has been based on an open source software code, open and available to everyone, ensuring though the absolute transparency or the rules and the operating procedures. The most important part of the operating issues is the cryptography, the coding of the transactions, so that the security of the transfer of the amount to be extremely high. Another big part of the software must guarantee that for every transaction the respective record will be unique and in the correct chronological order, avoiding double charging of the accounts in acceptable short time [2],[3]. Nowadays the total number of Bitcoins is about 12,3 millions. There are exchange services for buying and selling Bitcoins using any known currency. Everybody can buy and sell Bitcoins, and the demand and offer balancing mechanism influences a lot the apparent value of the Bitcoin unit. On the other hand more and more companies accept Bitcoins as transactions

currency. The volume of the transactions in Bitcoins increases steadily and the typical number per day is about 60.000. The typical daily transactions volume is around 200.000 Bitcoins. The equivalence of the Bitcoins however is very sensitive for the moment, taking in account the interest in the currency and its trend values, approaching in January 2013 the amount of 690 Euro per Bitcoin [4], [5].

The scepticism related with the Bitcoin system mainly focuses on the basic approach of the unknown owner of the money wallet, although the transactions are transparent [6],[7]. Also security issues, the problem of the money laundering and the lack of control, are additional issues of criticism [8],[9]. However an increasing number of companies accept Bitcoins for their payments. Consumer goods, from software and video games up, to books, jewelery and textiles are sold in the internet with payment in Bitcoins. Even Lamborghini cars company added itself in the list of companies accepting Bitcoins [10]. Step by step a big number of directories are available for the listing and promotion of mainly online shops accepting Bitcoins. A lot of Textile and Clothing companies are included in this category [11]. Bitcoin with it's positive and negative sides, is a reality and it is a new and challenging tool for transactions. As it always happens, in front of big changes, there is a risk but also there is an opportunity from the use of the novelty offered. The Textiles and Clothing sector is growing in the field of internet sales and Bitcoins can be a tool to support its expansion [12].

In the frame of the current work, an extensive survey has been made in the enterprises using Bitcoins in order to study the range of the penetration of the Bitcoin system in the Textile and Clothing internet market. Also the basic characteristics of the respective goods has been listed, so that the suitability of the various categories to be represented. For the current situation of the Bitcoin system, it is proved that it is a strong potential marketing tool for the growth of the textile and clothing sales over the internet. It simplifies the transactions and up to a certain extend it supports the financial liquidity for the benefit of the consumption and the increase of the sector turnover. A realistic approach based on the consideration of the risks and also on the benefits of the opportunities appearing shows that the Bitcoin system can not be

ignored, and in the opposite it must be used for the development of the international Textile and Clothing market. The power of the Bitcoin system could be beneficial especially for the industrial companies and trade organizations which are in the first steps of their penetration phase in the international market, when any kind of support could create a multiplication effect. For the increase of confidence, time will play a significant role since it will show the degree of the acceptance or the integration of the Bitcoin system in the regular and acceptable transactions tools. On the other hand this will be "de facto" achieved, if the potential of the Bitcoin system will be increased by its acceptance and use in the daily trade actions. The near future, will show the result of this equilibrium stage and the companies with benefits from their decision concerning the use of the Bitcoin system.

Key Words: *Bitcoins, e-commerce, monetary system, textile trade*

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A STUDY ON A FAULT DETECTION SYSTEM FOR CIRCULAR KNITTING MACHINES

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In knitting factories, the fabric control process has a great importance and it is applied as a standard procedure. Generally used method is based on the visual inspection of the fabrics on the illuminated control tables. When the number of defects in the fabric exceeds a certain limit, the whole fabric is regarded as second quality. Consequently, this fabric control method causes a significant amount of material loss besides labor and time loss.

The ideal solution for the fabric control is to detect faults during the knitting process. By detecting and eliminating the fabric faults during the production, knitting industry would gain many advantages in terms of decrease in cost and energy consumption beside increase in productivity. Furthermore, the detection of the number and duration of the stops occurred during the knitting process is essential to evaluate the productivity of the process. These considerations evince the importance and necessity of the automation systems for the process control and fault detection.

Tellerman and Stream (1964) invented a fault detection and stop-motion system for knitting machines and more particularly involved an electronic control circuit for stopping a knitting machine when a fault occurs. Rosenquist et al (1984) have developed a detector for controlling operation of the cylinder of a circular knitting machine. The logic circuit includes a timer and counting mechanism for stopping rotation of the machine cylinder if a predetermined number of signals are emitted within

a predetermined time period. Anagnostopoulos et al (2001) have reported that faults had traditionally been detected by human visual inspection, however, human inspection was time consuming and could not achieve a high level of accuracy. In their work, they have described the software core for fabric inspection on the basis of simple image-processing operations. Catarino et al (2004) have developed a system for knitting process monitorıng and fault detection on circular knitting machines.

In this study, it is aimed to develop a control system for circular knitting machines to detect and record faults occured during the knitting process. When the process stops, the system enables the worker to record the cause of the fault on the touchscreen with one move. The cause of the defect, such as yarn breakage or needle breakage, and its location will be detected and recorded during the knitting process in this way. The system also allows the integration with the automation system available in the factory.

The advantages of this system can be summarized as follows:

- The time spent for recording the fault information will be decreased. Therefore the number of the machines in control of a worker can be increased.
- With the elimination of the risks regarding the negligence of the worker, accurate data acquisition will be provided.
- With the online data flow to the quality and/or production responsibles, the productivity of the plant can be keeped under control.
- Owing to the integration with the automation system available in the factory, the flow of the work orders and plans will become faster and the data storage will get easy.

Keywords: *process monitoring, fault detection system, fabric control, circular knitting machine, productivity*

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