Changes in Knitted Cotton/ Polyester Fabric Characteristics Due to Domestic Laundering

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Abstract: Clothing should be comfortable during use beside to stability and durability, also to withstand a reasonable number of laundering cycles. Synthetic Knitted fabrics are more stable than Knitted cotton fabrics, while the latter allow garments to fit closely and snugly also it is comfortable and safely concerning static electricity. Therefore, blended cotton with synthetic can increase comfort and stability after washing. The changes in knitted fabric characteristics after repeating laundry, ten cycles, for plain and 1×1 rib patterns produced from cotton, polyester and their blends were studied. From which the effect of cotton addition on comfort and stability was detected. This was obtained by measuring the Static charges built up on the surface, roughness, thickness, areal density, stitches density, loop length, and dimension stability of fabric. The fabrics characteristics were analyzed and modeled using multi regression analysis. The changes in fabric characteristics due to laundering were determined. The significant trends of these changes percentage in relation to the parameters were investigated in equations and their correlation analysis was also obtained. The changes in characteristics due to laundry depend on the fabrics composition, fabric pattern and yarn feeding level. The tendency of electrostatic charge decreased due to repeating laundry however it increased the fabric thickness, areal density, surface smoothness, courses per centimeter, and stitches density. The dimensional stability increased when increase percentage quantity of PES yarns in fabric composition. The characteristics of the fabrics due to laundering can be predicted by applying these models.

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Key words: Knitted fabric, Static charge, Roughness, Dimension stability Laundering, Statistical analysis.

1. Introduction

Garments for hygienic reasons need to be washed; they may lose their aesthetic appeal due to wear, which is due to repeated laundering, abrasion, complex thermal, mechanical and physical actions and forces in dry and wet states, arising from everyday use and service. Therefore textile products must be able to withstand a reasonable number of laundering cycles. This increase the fabric thickness, stiffness and weights and colorimetric values of the fabrics [1]. Consumer expect high standard of performance in clothing even after several number of wash and dry cycles [2]. Therefore the best fabrics' composition is characterized by stability, elasticity, tensility, durability health and other important features [2].

Knitted fabrics are preferred in athletic wear due to its comfort directly in contact with human body; this will interacts with the skin [3]. However, dimensional change in knitted fabric due to laundering is caused by knit structure, yarn type, knitting, finishing and making up. Yarn torsion forces cause a highly distorted state, also laundering causes wear and tear [4]. Knitted fabric shrinkage is due to shrinkage in fabric, yarn and fiber [5]. The geometrical dimensions of cotton knitwear is highly affected by laundering, this effect decrease when increasing the percentage of PES yarns in fabric composition [6].

The areal density of fabric (Weight in grams per unit area) is the most important parameter which is maintained in the factory or industry in all stages in the processing of knit fabric [7]. Fabric weight and dimensions are related to stitch length, while tightness or slackness is related to cover factor [3].

It is advisable to knit with a minimal yarn feeding load to ensure proper physical-mechanical properties and dimensional stability in wearing and care [8]. Fabric constructions have a great influence on clothing comfort [9], that the knitted porous structure allows high mass loading of materials that increases the performance of energy storage devices [10].

Roughness, represents height variation, has influence on subjective hand feeling [11], predispose restorations to increase of bacterial biofilm accumulation, facilitating the development of secondary caries, discoloration and staining, and compromise final brightness and esthetics [12].

Human body's electrical charging, clothing worn and climate conditions can cause discomfort. Risk of fires and explosions of charged human body is present in many spheres specially working environments [13]. This can be reduced by cotton or linen in comparison with wool, silk and synthetic materials [14]. Many synthetic fibers in textile fabrics are insulating materials with much higher resistivity than the desired for anti electrostatic purposes [15].

In textile industry static charge generates at high-speed textile processes, and during walking on carpets or static cling in fabrics which become to be complicated by the development of manmade fibers [16, 17]. Also the lower humidity poses the problem of static charge generating. In the main time the textiles generating static electricity can cause its wearer from simple uncomfortable sensation to serious hazards in explosive working environment, or damage to the sensitive electronic equipments [18]. Despite these negatives attributes, textile static is used in some manufacturing processes such as flocking, selected nonwoven fabrics and in electrets filters to assist in the absorption of airborne dust [17].

A better understanding of this phenomenon is critical to the future of the textile industry. The surfaces exchanges of electrons when they contact with one another, if they are conductive excess charges will dissipated to ground, but if they are insulators the charge will retained, separate them and static charge appears and will attempt to dissipate [16,17]. The ionizing atmosphere or air conduction can control static charge. So Fabrics and yarns could be designed to reduce the negative impact of static generation [16]. Two methods are used to control electrostatic energy in power transmission products and reduce the potential for electrostatic energy build-up. First method is to make the non-conductive material sufficiently conductive so the electrostatic energy is dissipated as it builds-up. Making the material static conductive in this manner is the best method for more hazardous environments. Second method consists of adding an anti-static agent to prevent static from transferring between materials, or make the material static non-generating. Anti-static agents have limiting capability in some environment since it depends on atmospheric humidity [19].

The higher efficiency of anti-static protective clothing depends upon the arrangement of electro-conductive fibers, the type of the basic yarn, and the structure of the textile material. This always give better result than using Anti-electrostatic finishes ,regarding their low washing and abrasion resistance during use. In the main time they allow the application of various chemical agents as finish in order to obtain other protective properties [14]. For heavier fabric weight the static charge is decayed faster rate. Also the potential of static charge generation is higher for fiber with higher surface to volume ratio, lower electrical conductivity and hydrophobic nature [18].

2. Material and Methods

The fabrics were knitted from two types of yarns (cotton and polyester yarns (20 Tex) and blend of them (50%: 50%) in plain and rib circular knitting machines. The amount of yarn fed in one machine revolution was changed in three levels in order to produce fabrics with different stitch lengths then the fabrics were scoured in the traditional scouring process. Table (1) indicates the design of experiment for producing fabrics.

Table1: Design of Experiment for fabrics' production

Yarn Feed Level	Type of Yarn Used			
	Polyester (1)	C/P (2)	Cotton (3)	
1	Plain (1)	Plain (1)	Plain (1)	Fabroic Pattern
2	Plain (1)	Plain (1)	Plain (1)	
3	Plain (1)	Plain (1)	Plain (1)	
1	Rib (2)	Rib (2)	Rib (2)	
2	Rib (2)	Rib (2)	Rib (2)	
3	Rib (2)	Rib (2)	Rib (2)	

Part of these fabrics were subjected to laundering process under the same conditions to what the fabrics were expected in home laundering following ten times. After laundry, they were dried on a flat surface in conditioned atmosphere for one week.

The fabric characteristics were determined before and after ten cycles repeated laundry. The fabric comfort -dimensional stability- durability were determined through, electric charges, surface roughness, thickness, areal density, courses/cm, wales/cm, Stitch density, loop length, dimension and changes in lengthwise and widthwise directions. Surface roughness tester Model SE 1700ά was used for measuring fabric surface roughness. And electricity collect type potentiometer model KS-525 (Kasuga Denki, Inc., Japan) was used to evaluate the electrostatic shielding performance of the fabric.

3. The Results and Discussion

The significant relationships between fabric characteristics and the studied parameters were determined using multi regression analysis. The percentage changes in fabric characteristics after laundering were estimated. From which the significant trends of the changes % in each characteristic in relation to the parameters were investigated by applying regression analysis. Also the correlation coefficients between the percentage change in fabric characteristics and parameters under study were obtained .The analysis of results will be discussed firstly for fabric characteristic than for the percentage change in some of these characteristics

The relationships between fabric characteristics and the studied parameters

The equations from (A1) to (A10) indicate the significant relationships between fabric characteristics and the studied parameters.

Electrostatic= -21.01+5.556 Laundry+ 5.06 Fiber Type R^2= 0.68 (A1)

Roughness = 51.23- 2.82 Laundry- 14.48 Fabric Pattern- 2.9 Fiber type R^2= 0.72 (A2)

Areal Density= 96.43+11.59 Laundry+ 16.81 Yarn Feed +12.1 Fabric pattern R^2= 0.63 (A3)

Fabric Thickness=0.32+ 0.05 Laundry +0.16 Fabric Pattern R^2= 0.73 (A4)

Wales/cm= 9.14+ 0.696 Yarn Feed+ 6.2394 Fabric Pattern R^2= 0.88 (A5)

Courses/cm=19.66+1.42 Laundry+ 3.36 Yarn Feed- 4.989 Fabric Pattern- 0.77 Fiber Type R^2= 0.88(A6)

Stitches Density=177.07+25.1 Laundry+ 81.72 Yarn Feed R^2= 0.74(A7)

Loop Length= 0.25-.033 Yarn Feed+ 0.03 Fabric Pattern+ 0.008 Fiber Type R^2= 0.72(A8)

Widthwise Dimension= 26.79+3.0 Laundry -0.69 Yarn Feed+ 2.17 Fabric Pattern+ 0.667 Fiber Type R^2= 0.63 (A9)

Lengthwise Dimension= 32.1-2.08 Laundry-1.04 Fiber Type R^2= 0.62 (A10)

The above equations demonstrate the following notes:

-The electrostatic properties depend not only on the content of fibers in knitted fabric but also on repeating laundering in the fabric

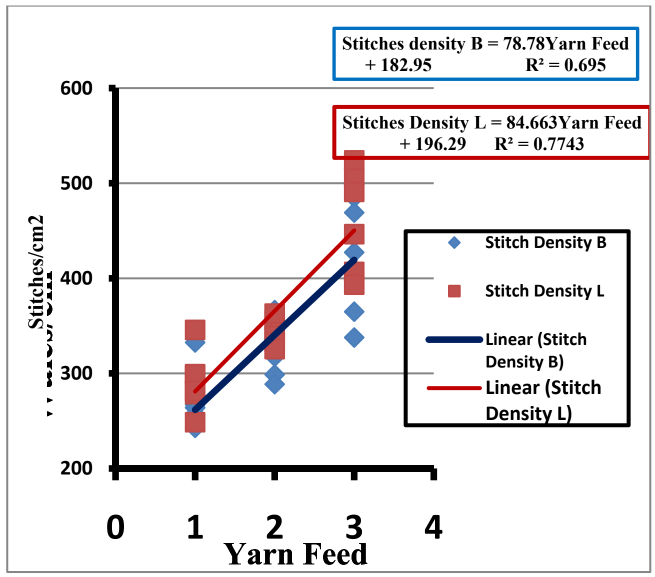
-Significant effects of repeating laundering has determined on mostly all measured fabric characteristics, only the wales/cm and loop length are not affected by the successive washing.

-Repeating laundering increases courses per centimeter and stitches density. The effect of repeating laundering on stitches density is presented in Figure (1). This result led to increase both of areal density and fabric thickness. Also the widthwise dimension increased while the lengthwise direction decreased.

- At the same time, the roughness of fabric surface decreased by repeating laundering, so the fabric will tend to be smoother and more comfort. The actual values and statistical trendiness for surface roughness (µm) are shown on Figure (2).

-The tendency of electrostatic charge decreased due to successive laundering. The generation of static charge on the surface of the fabric is shown in figures (3).

-Increasing cotton fibers in knitted fabrics increased dimension in widthwise direction and loop length that decreased courses/cm, dimension in lengthwise direction, and surface roughness, also a decrease in the accumulated static charge on surface is obtained as shown in figure (3). The use of cotton fibers in fabrics resulted in the roughest surfaces, and highest chargeability of fabrics, followed by blend of cotton /polyester**.**



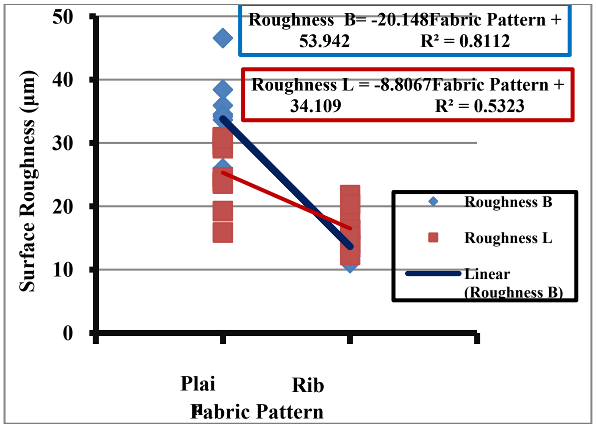
Figure(1): The relation between yarn feed level and stitches density before and after laundering

-Rib fabrics have higher weight, thickness and loop length due to alterations in the loop shape, however plain fabrics have higher surface roughness than rib fabrics as shown in Figure (2).

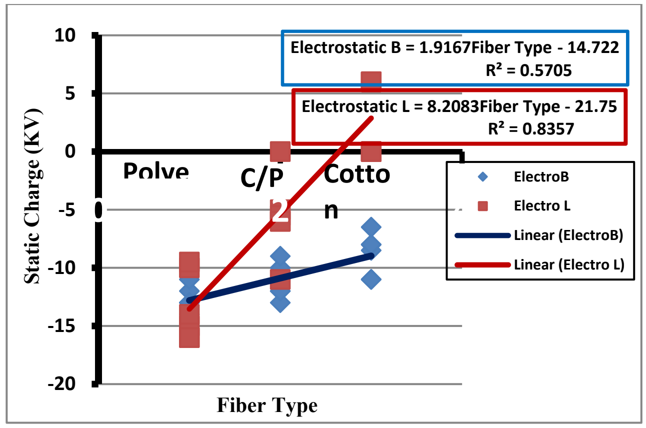
-Due to increasing yarn feeding level, stitches density increased as shown in Figure (1) that led to higher areal density.

Fabric Characteristics Changes due to Repeating Laundering

The changes in fabric characteristics due to laundering were determined as presented in Table (2). A multivariate analysis technique was used to determine the overall changes caused after ten cycles compared to fabric characteristics before laundry



Figure(2): Relation between Fabric Pattern and Surface roughness before and after Laundering laundering



Figure(3) Relation between Fiber Type and Electorostatic before and after laundering

Table 2: Changes in Knitted Fabric Characteristics% after Repeating Laundry

Sample No.	Fiber type	Fabric Pattern	Yarn Feed level	Electrostatic	Roughness	Fabric Weight	Fabric Thickness	Wales /cm	Courses/cm	Stitch density	Loop length	Width Dimension	Length Dimension
1	1	1	1	25	-17	8	-2	-2	6	4	-6	3	-3
2	1	1	2	-23	-34	-2	-4	2	5	7	-4	0	3
3	1	1	3	-14	-11	-3	0	1	3	4	6	0	0
4	1	2	1	0	19	0	-5	6	-3	2	7	17	0
5	1	2	2	23	9	3	0	-8	1	-7	-1	10	0
6	1	2	3	23	-3	2	-2	11	-6	4	2	7	3
7	2	1	1	-50	-24	14	-11	-1	13	12	9	5	-10
8	2	1	2	-54	-29	15	-11	6	0	6	-2	0	-3
9	2	1	3	-33	-31	10	-9	4	7	11	9	0	-8
10	2	2	1	-15	-10	3	-14	-14	25	8	-8	23	-10
11	2	2	2	-100	8	14	-10	-3	15	11	-9	18	-13
12	2	2	3	-50	35	3	0	-3	4	1	10	7	-3
13	3	1	1	-171	-22	18	-20	-7	22	13	-1	7	-13
14	3	1	2	-175	-33	16	-15	0	14	14	-4	7	-13
15	3	1	3	-100	-26	17	-15	2	14	16	-3	3	-10
16	3	2	1	-100	69	6	-13	-13	22	7	-10	30	-17
17	3	2	2	-100	69	6	-14	2	11	13	-14	30	-13
18	3	2	3	-192	19	18	-21	-1	13	12	-4	13	-13

The significant trends of the changes% in each characteristic in relation to the parameters were investigated in regression equations from (B1) to (B5).

As shown in the five equations, changes in fabric characteristics due to repeating laundering have affected significantly in with the fabric content of fibers. The changes in roughness of fabric surface, due to repeating laundering, have increased by increasing cotton fibers in fabric content as shown in Figure (4). That mean cotton fabrics have significantly affected by laundering that threaten their long life.

Change in Electrostatic% =83.93-72.69 Fiber Type R^2=0.79(B1)

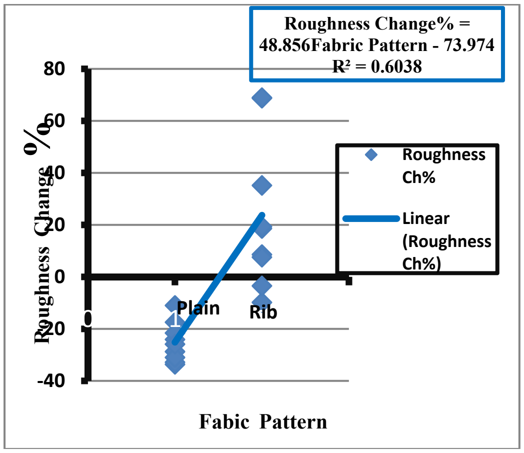
Change in Roughness% = -93+48.86 Fabric Pattern+ 9.58 Fiber Type R^2=0.67(B2)

Change in Thickness% =4.86 -6.99 Fiber Type R^2=0.76 (B3)

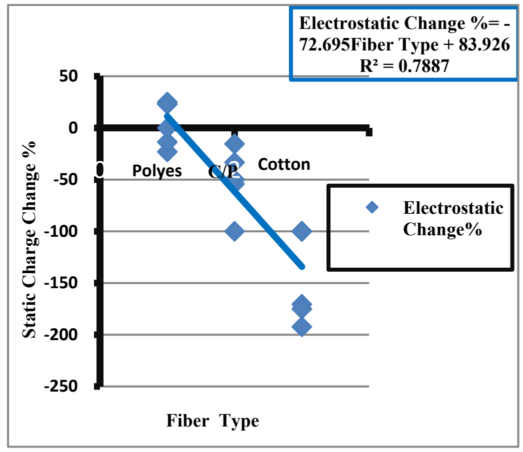
Change in Widthwise Dimension = -11.39 -4.58 Yarn Feed +14.4 Fabric Pattern+ 4.44 Fiber Type R^2=0.86(B4)

Change in Lengthwise Dimension =6.94-6.94 Fiber Type R^2=0.8(B5)

Changes in static charges built up on the surface of polyester fabrics have the lowest percentages maintaining the charges on fabric surface followed by blended fabrics C/P, however repeating laundering for cotton fabrics improved their electrostatic ability that increased the change %.



Figure(4): The Relation between Fabric Pattern and Roughness Changes Due to Laundering



Figure(5): The Relation between Fiber Type and Electorostatic Changes Due to Laundering

Table 3: Correlation Coefficients between changes% in Fabric Characteristics and each other Beside to the Studied Parameters

		Fiber Type	*Fabric Pattern*	*Yarn Feed level*	Electrostatic	Roughness	Fabric Thickness	Areal density	Wales /cm	Courses/cm	Stitches density	Loop length	Widthwise Dimension
Electrostatic		*-0.9*	*0.1*	*-.1*	1								
Roughness		*0.2*	*0.8*	*-.1*	-.1	1							
Thickness		*-0.9*	*0.1*	*0.2*	.8	-.02	1						
Areal Density		*0.7*	*-0.3*	*-.01*	-.7	-02	-.8	1					
Wales /cm		*-0.3*	*-0.2*	*0.5*	0.2	-.3	0.3	-0.1	1				
Courses/cm		*0.7*	*-.04*	*-.4*	-.6	0.1	-.8	0.5	-.7	1			
Stitches Density		*0.7*	*-0.4*	*.03*	-.7	-0.2	-.8	0.7	0.1	0.6	1		
Loop length		*-0.4*	*-.2*	*0.3*	0.3	-.3	0.4	-0.2	0.3	-.5	-.3	1	
Dimen-sion	**Width**	*0.4*	*0.8*	*-0.4*	-0.2	0.8	-.3	-0.1	-.5	0.4	0.1	-.6	1
	Length	*-0.9*	*-0.1*	*0.2*	0.8	-0.3	0.8	-0.7	0.5	-.9	-.7	0.5	-.5

The correlation coefficients between changes% in fabric characteristics and each other beside to the studied parameters were also given in table (3). This table indicates that most changes in fabric characteristics is correlated significantly to each other, and correlated also to the fabric parameters. The fabric composition of fibers has a great significant effect in most changes.

This phenomenon is critical to better understanding of these types of fabric characteristics in order to be able to produce fabrics fulfilling the end-user needs

Conclusion

Due to wear, fabrics characteristics may change by several factors like repeated laundering, and the application of forces in dry and wet states. The behaviours of these changes are different by changing the composition of fabrics and the construction.

With respect to the experimental results, the significant regression equations indicate that both fiber type and fabric constructions have the higher effect on fabric comfort. Also laundering has a positive effect on both electrostatic and roughness. Laundering increased the fabric thickness, areal density, surface smoothness, courses per centimeter, and stitches density. Rib fabrics have higher weight, thickness and loop length, however plain fabrics have higher surface roughness than rib fabrics. The tendency of electrostatic charge decreased due to repeating laundering. Increasing yarn feeding level tends to increase stitches density. The changes in characteristics due to laundry are different by changing the composition of fabrics and its construction. Fabrics produced from cotton have less stability than polyester and blended fabrics of Cotton/Polyester. The cotton fabrics have the roughest surfaces that increased after repeating laundering however they achieved the lowest values of static charge on their surfaces. The static charges built up on the surface of polyester fabrics have the highest static charge values and increased after repeating laundering. The surface roughness is dependent on fabric pattern, repeating laundering and the content of fibers composed the fabrics. Additionally, the percentages of changes in fabric characteristics due to laundering were obtained by regression equations. The correlations between these changes were meaningful. Developing products and services that include customer-specific products can be achieved by applying the obtained regression equations; also the performance of the product due to laundering can be predicted.

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4. References

1. Mezarcioz, S.M. and Ogulata, R.T. Investigation of Effects of Repeated Laundering on the Cotton Knitted Fabrics with Biopolishing Treatment, 7th International Conference - TEXSCI, September 6-8, Liberec, Czech Republic 2010.
2. Urbelis, V., Petrauskas, A., and Gulbiniene, A. Stress Relaxation of Clothing Fabrics and Their Systems, MATERIALS SCIENCE (MEDŽIAGOTYRA) 2007;13(4): 327-332
3. Burcak, K. Characterization and Role of Porosity in Knitted Fabrics, M.Sc. Thesis, NC State University, Raleigh 2004.
4. Anand, S.C., Brown, K.S.M., Higgins, L.G., Holmes, D. A., and *et al.* Effect of Laundering on the Dimensional Stability and Distortion of Knitted Fabrics, AUTEX Research Journal; 2002;2(2): 85-100.
5. Sakthivel, J. C., and Anbumani,N. Dimensional Characteristics of Preshrink Resin Treated Spun Viscose Weft Knitted Fabrics, Journal of the TEXTILE Association 2011;72(2): 99-102.
6. Mikučionienė, D. The Dimensional Change of Used Pure and Compound Cotton Knitwear, MATERIALS SCIENCE (MEDŽIAGOTYRA) 2004; 10 (1): 93-96.
7. Akter, N., and Akter, N. Effects of Combed and Carded Yarn on Weft Knitted, International Journal of Engineering & Technology, IJET- IJENS 2011; 11(6): 113-119.
8. Fatkić, E., Geršak, J., and Ujević, D. Influence of Knitting Parameters on the Mechanical Properties of Plain Jersey Weft Knitted Fabrics, FIBRES & TEXTILES in Eastern Europe 2011; 19, 5 (88): 87-91.
9. Emirhanova, N., and Kavusturan,Y., Effects of Knit Structure on the Dimensional and Physical Properties of Winter Outerwear Knitted Fabrics, FIBRES & TEXTILES in Eastern Europe 2008; 16, 2 (67): 69- 74.
10. Liangbing Hu, Pasta, M., Fabio La Mantia, F. L. and *et al.* Porous, and Conductive Energy Textiles, American Chemical Society, DOI: 10.1021/ nl903949m | Nano Lett. 2010;10: 708-714.
11. Militiky, J., and Novakova, J. Anisotropy of Fabric Surface Roughness, 2nd International Textile Clothing & Design Conference - Magic World of Textiles, October 3˗6, Dubrovnik, Croatia 2004.
12. Schmitt, V.L., Puppin-Rontani, R.M., Fabiana Scarparo Naufel, F.S., and *et al*. Effect of Finishing and Polishing Techniques on the Surface Roughness of a Nanoparticle Composite Resin, Braz J Oral Sci. 2011; 10 (2): 105-108.
13. Kowalski, J. M., and Wróblewska, M. Premises for Practical Evaluation of the Anti-electrostatic Properties of Protective Garments, FIBRES & TEXTILES in Eastern Europe 2006; 14, 5 (59): 23-28.
14. Industrial Accident Prevention Association. A Health and Safety Guideline for Your Workplace, Static Electricity 2008. www.iapa.ca
15. Šafarova, V., and Gregr, J. Electrical Conductivity Measurement of Fibers and Yarns, 7th International Conference – TEXSCI, September 6-8, Liberec, Czech Republic 2010.
16. Seyam, A.M., Liu, L., Hassan, Y.E., and *et al*. Static Generation and Dissipation of Textile Fabrics and Films, the Proceedings of the Textile Institute 86th World Conference, Hong Kong, China, November 18-21, 2008: 1681-1694.
17. Seyam, A.M., Oxenham, W., and Castle, P. Static Generation and Control in Textile Systems, National Textile Center Research Briefs: June, NTC Project C04-NS07 2007: 1-3.
18. Kothari, V. K., and Bhagwat, V.M. Electrostatic Behaviour of Textile Fabrics, the Proceedings of the Textile Institute 86th World Conference, Hong Kong, China, November 18-21, 2008: 1713-1719.
19. Gates Corporation, Electrostatic Properties of Power Transmission Belts, Gates Product Application Notes, 17654-5 2007; 54 (5): 1-2.
20. Pinar, A., and Michalak, L. Influence of Structural Parameters of Wale-Knitted Fabrics on their Electrostatic Properties, FIBRES & TEXTILES in Eastern Europe 2006; 14, 5 (59): 69- 74.

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