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Investigation of Wear Behaviour of Sewn Assemblies of Viscose Linings with Different Treatment

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Different types of chemical treatment of textile are widely applied in advanced textile. Finishing of textile can provide additional functional properties for products or/and to improve the appearance of final product as well as to improve their mechanical properties. In this research the influence of the industrial treatment of viscose linings on the parameters of fabric surface friction, on fabric surface appearance as well as on the slippage resistance of yarns at a seam was investigated. Raw, dyed, dyed and softened, dyed and non-slip finished plain weaved linings were investigated. The slippage resistance of yarns at a seam in woven fabrics was evaluated according to standard EN ISO 13936-1:2004. The friction was investigated according to the standard DIN 53375 in a fabric-fabric friction pair. Surface of raw, dyed, dyed and softened viscose lining was investigated using SEM. The obtained results have shown that the friction parameters as well as the parameters of seam slippage resistance of dyed or dyed and softened fabrics were higher than the ones of raw fabric. The highest differences in those parameters were obtained for lining that was dyed and treated with non-slip finishing. That type of finishing influenced the break of lining yarns without typical to the other investigated linings slipping near a stitching line.
Keywords: seam slippage, viscose lining, treatment, friction.

1. INTRODUCTION

Application of different types of industrial treatment, e. g. flame retardant, water repellent, softening and others influences the changes in their textile properties increasing the quantity of the fields of fabric usage. Likewise the properties of fabrics can be modified significantly when some layers of coating are formed on fabric [1 – 4]. Meanwhile, fabrics can acquire specific functional property by chemical treatment [1, 4, 5]. It was also proved, that textile treatments influence their mechanical properties, surface friction parameters and etc. [1 – 6].

During assembling textile materials into the garments they are slightly deformed in/near a seam line. Those garment zones experience different deformations during garment wear, too. The performance of the sewn articles depends on the quality of textile as well as on technological parameters of stitching [8 – 11, 15]. One of the seam faults is its insufficient strength that is defined as the maximal force occurring in the moment of seam failure [10 – 15]. The seam failure is characterized differently [15], i. e. as fabric yarns break near a stitching line, as sewing yarn break, as fabric yarn slippage near a seam line or as a combination of some previous conditions. The structure parameters, appliance fields of fabric strongly influence the wear behaviour of sewn textile.

Seam defects usually are important to lightweight textile, especially for man-made linings. The man-made fabrics are very slippery. Their structure is not very stable. Notwithstanding that nowadays the great attention is focused on the manufacture of natural man-made fibers. Regenerated cellulose and cellulose-ester fabrics including viscose or acetate fabrics attain larger attention compared to polyester fabrics because of better hygienic properties. Hygienic properties are very important for textile materials used as linings used inside of garments [11, 16]. Garment lining also must be soft, with low surface friction as well as of stable structure. The stability of woven fabric is dependent on their frictional characteristics, and those characteristics are dependent on textile finishing [2, 5 – 7]. But still there is a lack of the articles analyzing this problem. Therefore, the aim of this work was to investigate the wear behaviour of sewn viscose linings with different treatment.

2. EXPERIMENTAL

Differently treated linings for that research were bought from the textile company. The characteristics of investigated raw (z), dyed (d), dyed and non-slip (d+n) finished with silicon acid sols as well as dyed and softened (d+m) with macro-emulsion (>150 nm), i. e. with modified nonionic silicone elastomer (modified polysiloxane) – Solusoft UP liq+liq h.c., plain-weave viscose linings are presented in Table 1.

Viscose linings were treated in a pad-jig semi-continuous dyeing process using reactive dyes. In this process, a fabric passed through a padding machine where it was impregnated with dyeing bath, and then the dyestuff was fixed on a jigger. The reactive dyes form the covalent bonds with fibers [15]. In cold-dyeing process a fabric was wounded onto a roll and stored at room temperature for 20 – 24 hours. The roll was kept in slow rotation until the fixation of the dyestuffs was completed. During this dyeing process the dyes were gradually fixed on fabric. The finishing of raw fabrics involved washing (boiling), drying, dyeing, weathering normally overnight, washing, drying, starching or softening or non-slip finishing.

The differences between the behaviour of sewn specimens of raw, dyed, dyed and softened and dyed and

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Table 1. Fabrics characteristics of investigated linings

Fabric characteristics	P11d+m	P11d	P11z	P14d+m	P14d+n	P14z
Surface density, g/m^2	76 ±1	72 ±1	66 ±1	75 ±1	72 ±1	72 ±1
Thickness, mm	0.09 ±0.00	0.09 ±0.01	0.17 ±0.02	0.09 ±0.01	0.12 ±0.01	0.12 ±0.01
Warp density, cm^{-1}	48 ±1.04	45 ±1.11	42 ±1.04	53 ±1.11	53 ±1.42	45 ±1.04
Weft density, cm^{-1}	25 ±1.04	25 ±1.04	25 ±0.68	33 ±1.04	33 ±1.24	28 ±0.68
Warp linear density, tex	8.7 ±0.1	10.7 ±0.1	7.8 ±0.1	7.7 ±0.1	10.6 ±0.1	8.4 ±0.1
Weft linear density, tex	14.1 ±0.1	13.1 ±0.2	13.5 ±0.1	8.7 ±0.1	12.9 ±0.2	13.4 ±0.1

Note: z – raw fabric; d – dyed; d+m – dyed+softened fabric; d+n – dyed and treated with non-slip finishing fabric. Surface and linear density was measured according standard LST ISO 3801:1998 [17], thickness – LST EN ISO 5084:2000 [18], warp/weft density – LST EN 1049-2:1998 [19].

treated with non-slip finishing viscose linings were investigated analyzing their surface friction parameters, the parameters of the slippage resistance of yarns of fabric near a seam line, the shapes of strain-force curves as well as the photos of the fabric surface. Lining fabrics were tested for seam slippage resistance according to EN ISO 13936-1 standard [17]. Here an unseamed and a seamed part of 100 mm gauge-length specimen are separately extended using CRE-type tension machine ZWICK TI-FR005 TH A50 at 50 mm/min extension rate up till 200 N tension force producing two force/extension curves originating from the same abscissa (Fig. 1).

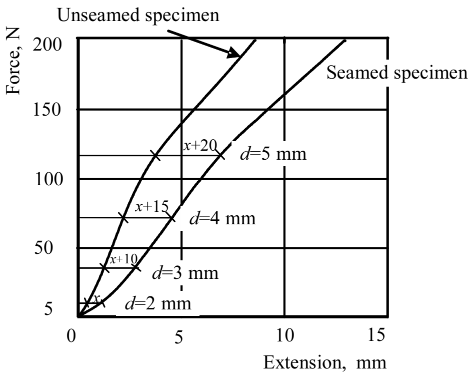


Fig. 1. Example of calculating the seam opening manually from a chart recorder (*d* – seam opening)

In this case, the investigated fabrics are considered to meet the minimum quality standards of Euratex TCG recommendations [21]. Therefore, the quality of seamed fabrics concerning characteristics and faults in fabrics to be used for high quality garment in the case of 4 mm seam opening that must be formed at not lower than 100 N loads were investigated. There were also considered that a seam slippage is defined as the displacement of fabric yarns due to a force applied perpendicularly to a seam and producing an opening parallel to a seam. But the seam opening formed due to yarn sliding accompanied with their break was not assumed as a typical seam slippage and was considered as seam strength. These breaks of fabric yarns near a seam were captured using a digital photo-camera.

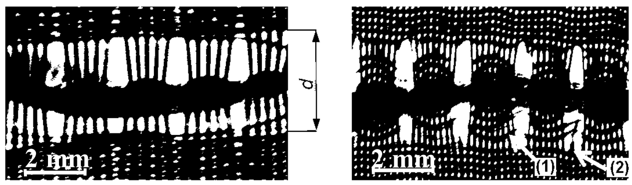
Test of friction between two layers of the same fabric was carried out according to DIN 53375 standard at 50 mm/min sliding rate under 5.1 N/m^2 pressure.

Fabric surface was investigated using a FEI Quanta 200 FEG scanning electron microscope (SEM).

3. RESULTS AND DISCUSSION

3.1. Investigation of the slippage resistance of yarns of viscose fabrics with different treatment near a stitching line

During tension of sewn viscose linings two different cases of seam failure, i. e. seam slippage of raw, dyed, dyed and softened P11 and P14 fabrics (Fig. 2, a) as well as break of yarns of fabric near a stitching line (Fig. 2, b) for dyed and treated with non-slip finishing P14 fabric were determined.



a b

Fig. 2. Photos of sewn specimens during tension: a – seam slippage, where *d* is a seam opening; b – fabric yarns' break parallel (1) and perpendicular (2) to a stitching line in warp-cut specimen of P14d+n fabric

Non-slip finishing applied to P14 lining changed textile assembly behaviour that is typical for raw and for dyed fabrics (Fig. 1, a), i. e. a seam opening was formed due yarns' slipping accompanied by breaks of separate yarns (Fig. 1, b). The changed behaviour of sewn specimens of P14 lining treated with silicon acid sols could be additionally influenced by mechanical finishing that, supposedly, decreased yarn's strength due to high friction between yarns of fabrics. The results presented in Table 2 prove that the slippage resistance of the yarns at a stitching line is dependent on the treatment of investigated viscose linings.

Table 2. Seam slippage resistance at 4 mm seam opening

Fabric	Force *F* (N), when *d* = 4 mm	
	Warp direction	Weft direction
P11z	70 ±1.2	73 ±5.6
P11d	88 ±5.8	116 ±4.1
P11d+m	94 ±4.2	148 ±4.5
P14z	129 ±6.6	72 ±5.0
P14d+m	87 ±5.1	90 ±5.8
P14d+n	yarns of fabric break at 113 N ±7.1 N	yarns of fabric break at 140 N ±6.1 N

The slippage resistance of sewn dyed P11 fabric is higher in 26 % in warp direction as well as in 59 % in weft direction compared with the ones of raw lining fabric. Similarly, the slippage resistance of dyed and softened P11 fabric is higher in 34 % in warp direction as well as in 103 % in weft direction compared with the ones of raw fabrics. The slippage resistance was also higher in 25 % for weft-cut specimen of P14 fabric, but it was lower in 33 % in warp-cut specimens of P14 fabric. Supposedly, that was influenced by the changes in fabric warp crimp from 3.4 % (P14 z) to 1.2 % (P14 d+m) (Table 3).

Table 3. Parameters of yarn crimp of investigated linings

Fabric	P11d+m	P11d	P11z	P14d+m	P14d+n	P14z
Warp crimp, %	0.8 ±0.1	0.8 ±0.1	2.7 ±0.1	1.2 ±0.1	1.6 ±0.12	3.4 ±0.12
Weft crimp, %	3.1 ±0.12	3.1 ±0.16	0.8 ±0.1	2.7 ±0.1	4.9 ±0.2	1.2 ±0.1

Note: Yarn crimp was determined according standard ISO 7211-3:1998 [22].

Additionally, it must be considered that it could be influenced by strong hydrogen bonds that were formed between hydroxyl or amino groups of the modified silicones after cellulose fabric treatment [4]. These bonds act as an anchor for silicone, which forms an evenly distributed film on fibre surface [4], which has significant influence on yarn slippage of the linings.

3.2. The influence of surface friction on the behavior of sewn linings with different treatment

Based on the results presented in Table 4 it is evident that the parameters of surface friction are dependent on the type of textile treatment.

Table 4. Surface friction characteristics of investigated linings

Fabric	P11d+m	P11d	P11z	P14d+m	P14d+n	P14z
Dynamic friction coef. μ_d^*	0.15	0.13	0.02	0.09	0.41	0.04
Static friction coef. μ_s^*	0.23	0.21	0.13	0.13	0.55	0.18

Note: *Variation coefficient not exceeded 5 %.

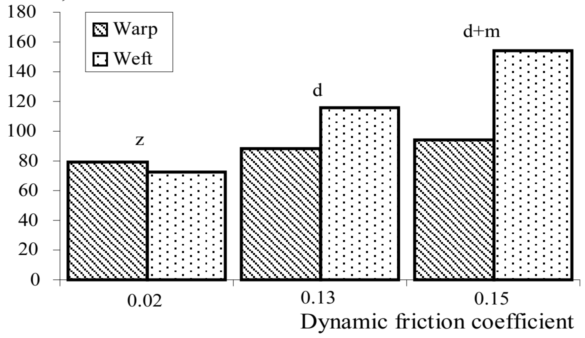


Fig. 4. The relationship between dynamic friction coefficient and seam slippage resistance of dyed and softened (d+m), dyed (d), raw (z) P11 lining

The lowest dynamic friction coefficient was determined for raw P11 and P14 linings and it was higher in 7.5 times and 2.3 times for dyed and softened P11 and P14 fabrics, respectively. The highest coefficient of dynamic friction was determined for P14 dyed and treated with non-slip finishing lining, i. e. it was higher in 4.6 times than the one of P14 dyed and softened lining as well as was higher in 10.3 times compared with one of raw fabric.

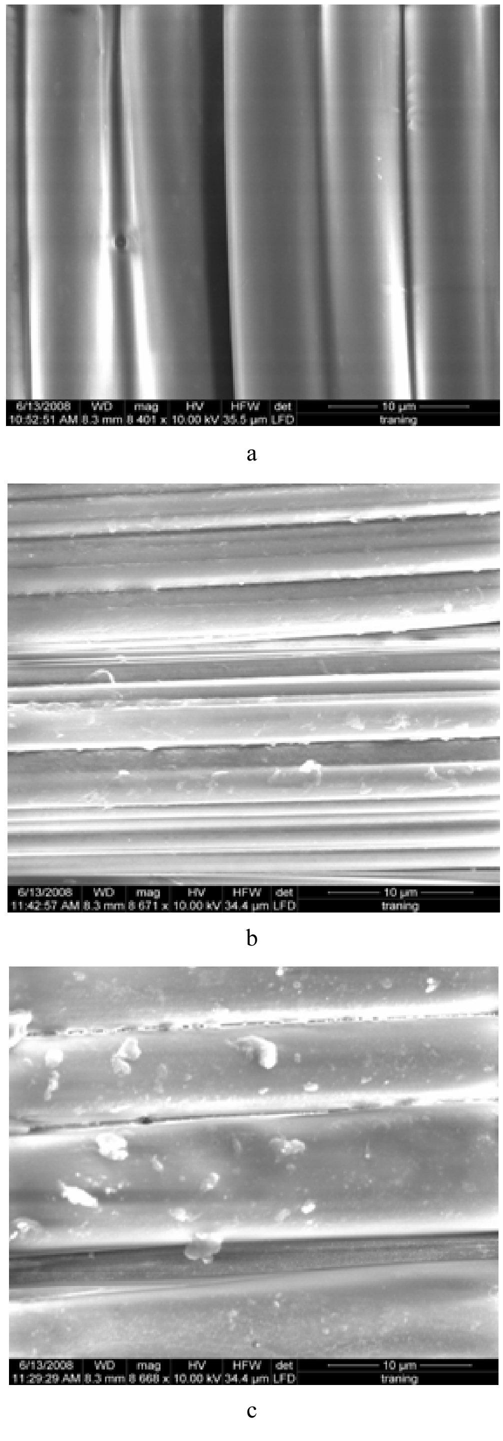


Fig. 3. The SEM photos of P14 viscose lining: a – raw (z), b – dyed and softened (d+m), c – dyed and non-slip treated (d+n)

The silicon acid sols were deposited on the fiber surface of non-slip finished lining (Fig. 3, c). It was proved [4] that the non-slip finishes containing increased adhesion

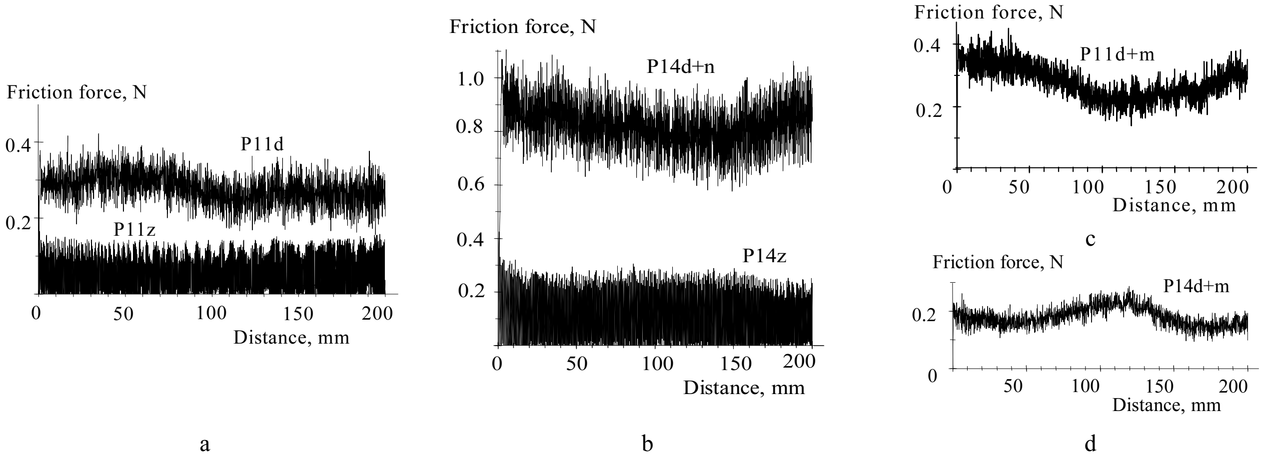


Fig. 5. Friction curves of P11 and P14 linings: a – raw (P11z), dyed (P11d); b – raw (P14z), dyed and treated with non-slip finishing (P14d+n); c – dyed and softened (P11d+m); d – dyed and softened (P14d+m)

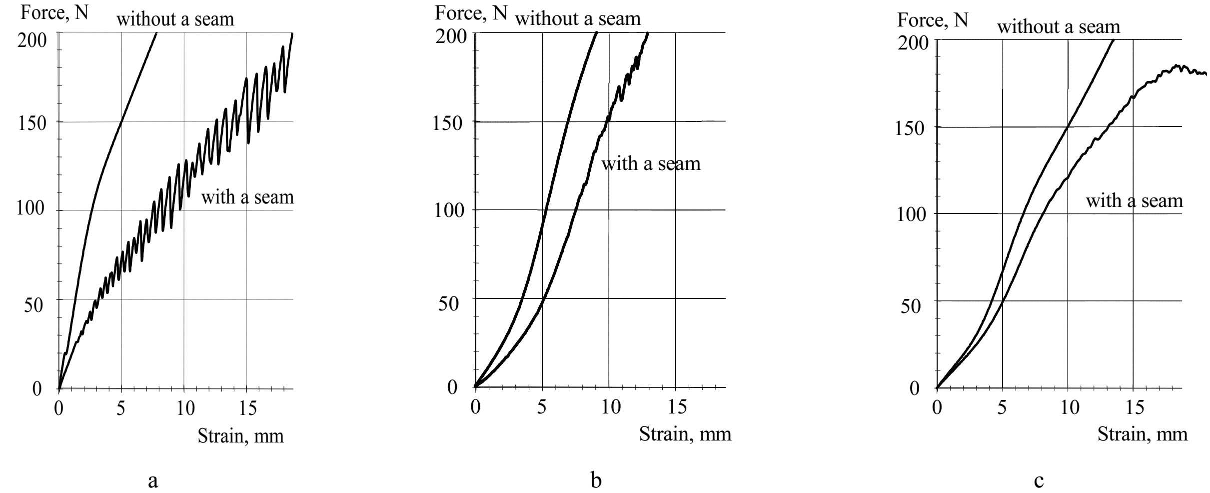


Fig. 6. Influence of treatment on behavior of weft-cut specimens of P11 lining: a – raw (z), b – dyed (d), c – dyed and softened (d+m)

between fibers bond filaments consequently increase frictional forces. Based on the SEM photos presented in Fig. 3, b, it is seen also that surface of fabric dyed and softened P14 was different from the raw viscose fabric. The surface of raw viscose lining (Fig. 3, a) is smooth and clean, and otherwise the uneven distribution of chemical material can be seen on surface of dyed lining (Fig. 3, b).

The results presented in Fig. 4 show that the increase in coefficient of dynamic friction μ_D influences the increase in slippage resistance of dyed or dyed and softened P11 lining. The similar effect was observed in both warp and weft directions of lining fabric.

The dynamic friction coefficient (Table 2) as well as seam slippage resistance (Table 4) of P14 dyed and softened lining in weft direction were the higher than the ones of raw lining. The seam slippage resistance of P14 dyed and softened lining in warp direction was lower than the one of raw lining in warp direction. The seams of P14 lining treated with non-slip finishing were ruptured by break of separate yarns of fabric. Break of the separate yarns influenced sudden decrease in stress or slipping of separate yarns with slight stops as well as following slip of all yarns together near a seam line [23].

An oscillating value of frictional force in the experimental curves shows the stick-slip effect describing specific behaviour of fabric surface friction (Fig. 5). The stick-slip oscillating amplitude of frictional force is different for raw, for dyed, for dyed and softened as well as for dyed and treated with non-slip finishing linings. The amplitude of oscillation of frictional force of P11 and P14 dyed and softened lining (Fig. 5, c, d) are lower than the ones of raw fabrics (Fig. 5, a, b). Because of changed surface of fabrics due to applied finishing the friction curves became smoother and thinner similarly to strain-force curves of sewn fabrics (Fig. 6).

Analyzing the strain-force curves (Fig. 6) also it can be seen the different behaviour of the investigated lining with their different treatment. The strain-force curves of P11 sewn dyed or dyed and softened fabrics (Fig. 6, b, c) are smoother than the one of raw lining (Fig. 6, a). That could be influenced by decreased cohesion between fibers after treatment with dyers and softeners. The softeners lubricate fiber surface and increase their softness [4].

4. CONCLUSIONS

1. Based on the obtained results, it was proved that analyzed surface friction parameters, the parameters of the slippage resistance of yarns of fabric near a seam line, the shapes of strain-force curves as well as the photos of fabric surface show significant differences between the behaviour of sewn specimens of raw,

dyed, dyed and softened or dyed and treated with non-slip finishing viscose linings.

2. There were determined that the sewn specimens of dyed viscose lining treated with non-slip finishing are ruptured due to break of separate yarns of fabric near a stitching line without slipping of fabric yarns that is typical to other investigated viscose linings. The coefficient of surface friction of dyed and treated with non-slip finishing P14 lining was highest.
3. There were shown also, that in the most cases the seam slippage resistance of dyed, dyed and softened viscose linings at 4 mm seam opening as well as the coefficient of dynamic friction was higher than the ones of raw viscose lining.
4. The surface friction curves as well as strain-force curves of sewn linings demonstrated their oscillating character having different oscillating amplitude that was dependent on the type of lining treatment.

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