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Influence of Fabric Softeners on Performance Stability of the Textile Materials

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The aim of the research was to explore the effect of household fabric softeners on the textile hand rates after repeated washing cycles. The behavior of three pure cotton and one cotton-PES blended textile materials, which were different in type, structure, thickness and finishing, were investigated in the multifold washing process. The behavior of fabrics was evaluated by the variation of the hand rate's values, which were determined using KTU-Griff-Tester. This device is mountable on a standard tensile testing machine. The dependence of main hand rates versus number of washings was found. Influence of three cationic softeners was presented. The obtained data proves that treatment of textile materials with softener stopped deterioration of hand rates and secured long lasting performance stability.
Keywords: textile, fabric hand, fabric softener, performance stability.

INTRODUCTION

Unfinished textile fibres, in particular natural, have fatty and waxen substances, which cover single fibres and protect them from mechanical effects, give water resistance properties. In the manufacturing process of textile materials these natural fat and wax substances are removed so woven and knitted fabrics provide good wettability. Dyeing and printing of textiles can not be successful without this property. Such textile materials become dry and have unpleasant handle. Fabric softeners are used to provide softness for fabrics to make them appealing for consumers. Nowadays softeners have gained great importance in textile finishing; almost no piece of textile leaves the production facilities without being treated with a softener. This softening treatment is applied to give textiles the desired handle, to make further processing easier and to improve the wear properties [1]. The main ingredients in fabric softeners are cationic, anionic, non-ionic and amphoteric surfactants [2]. Softener and water compose the colloidal solution. Due to water-soluble property between softener molecules and solvent (water) not free ions but ion and solvent molecular compounds are composed [3]. Cationic softeners are the most widespread among all fabric softeners. The surfactant of softeners consists of two distinct parts: hydrophobic and hydrophilic [2, 3]. The hydrophobic (or fatty) part is water repellent, and does not mix with water. The hydrophilic part is water loving, resulting in compounds dispersing in water. During softening process softener's positively charged surfactant ions are drawn toward the negatively charged fibres and stick to them strongly. The surfactant molecules stick to the fabric with their long hydrophobic chains pointing outward. These molecules decorate every fibre in every thread of the textile material, giving them an oily coating. The hydrocarbon chains lubricate the fabric so each fibre slides easily within a thread and each thread slides easily within the fabric. This lubrication enhances the flexibility of the fabric and makes it feel softer and more flexible.

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The aim of this research was to assess the regularity of hand rates' changes of the knitted fabrics after washing and to prove the effect of fabric softeners assuring long lasting performance stability.

METHOD AND INVESTIGATED MATERIALS

The objects of this investigation were textile materials, which are suitable for Lithuania Republic military underwear clothes. These garments are regularly washed in wear. Characteristics of investigated materials are given in Table 1. Testing materials were produced in Lithuanian Textile Institute.

Before the evaluation of fabric softeners effect upon textiles' hand rates washing (using soap powder "OMO") was performed using automatic washing-machine "SAMSUNG" ($T = 40$ °C, $t = 35$ min.) and rinsing was performed in a special bath strongly keeping the instructions given by manufacturer. Cationic softeners SILAN (Austria), LENOR (Czech) and VESTA (Turkey) were applied in this research.

After the washing specimens were dried for 48 hours, i.e. till they become completely dry. 20 cycles of washing were performed during the research. After 1, 2, 5, 10 and 20 cycles tested fabrics were soaked in the baths with different softener solutions. Treatment with the softeners lasted 10 minutes ($T = 15 – 16$ °C). The specimens were spun and dried in horizontal shape. Circular specimens with radius $R = 56.5$ mm ($S = 100$ cm^2) were hacked from the knitted fabrics.

The mechanical test method used to determine fabrics' characteristics was based on extraction of the disc shaped specimen through a circular nozzle, using device KTU-Griff-Tester mountable on a standard tensile testing machine (FP – 10/1) [4 – 8]. The velocity of extraction was 100 mm/min. Experimental regimes were chosen in respect to the thickness of the specimen, which determines the values of r (the radius of the pads hole) and h (distance between the limiting plates) parameters (when $r = 10.0$ mm $h = 5.6\delta/2$ mm, when $r = 12.5$ mm $h = 4.5\delta/2$ mm) [4, 5]. During testing (Fig. 1) the extraction curve H-P (deflection height – extraction force) was registered.

Table 1. The characteristics of the investigated materials

Material code	Composition	Pattern	Density, dm^{-1} course/wale	Surface density, g/m^2	Thickness, mm	Finishing			
						background	printing	starching	teasing
T-01	100 % cotton	plain	120 / 130	265	1.52	+	+	+	+
T-02	100 % cotton	interlock	130 / 90	129	0.64	+	–	+	–
T-03	96 % cotton + 4 % PES	rib 1×1	110 / 100	261	1.04	+	–	+	–
T-04	100 % cotton	plain	100 / 130	287	1.45	+	+	+	–

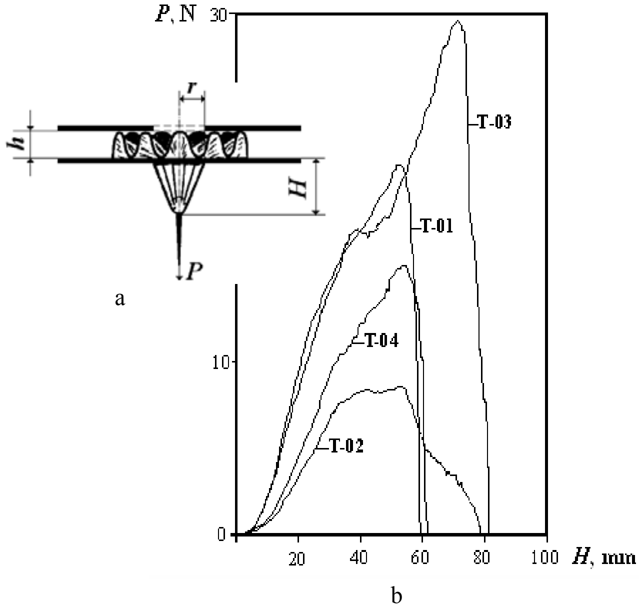

Fig. 1. Principal scheme of the test unit (a) and extraction curves *H-P* of tested materials (b)

The hand of the investigated objects was evaluated by measuring specimen thickness change $\Delta\delta$ (%) under different loads and parameters determined from pulling curve *H-P*: maximum extraction force P_{max}, the tangent of nominal slope angle of the curve tgα, the deformation work A (the area under the curve) and maximum deflection height H_{max} [6 – 8].

RESULTS AND DISCUSSION

According to the earlier researches – textile behavior can be qualified by the character of the *H-P* curve. Pulling curves of soft fabrics are more beveled, with no sharp edges. While curves of though, stiff and solid textiles are sharp, upright and toothed [9]. According to the listed typical pulling curves (Fig. 1) we can state that knitted fabric T-02 is the most soft, and T-03 is the hardest.

The main rates, characterizing fabrics hand properties were set from the registered pulling curves *H-P*: P_{max}, tgα, A and H_{max}. Complex rate Q was set by circular charts [8]. Tested basic hand rates are shown in Table 2. From the obtained results fabric T-02 distinguishes as having the "best" and T-03 the "worst" hand. The first one has minimal P_{max}, tgα, A and complex Q rate forces and maximum – deformation H_{max} and $\Delta\delta$ values, and the second one vice versa, except tgα, H_{max} and Q. Other two fabrics (T-01 and T-04) take intermediate positions (they both are made of the same knitting pattern, both have nearly the same thickness δ and differ only in finishing.

Equally main hand parameters of tested fabrics after multifold washing (W) and after washing with softeners SILAN (S), LENOR (L) and VESTA (V) were estimated. The obtained data proved that the number of washing cycles increases the values of P_{max}, tgα, H_{max} and A, i.e. textiles hand declines. After 20 washings hand properties depravation is obvious.

The usage of fabric softeners stops the process of textile damage, and sometimes even improves them comparing with fabric's basic rates (particularly after first washing cycles). Probably it's related with sizes, which were washed out from textile. After multifold washing all hand rates increases intensively it means fabric's hand declines. After 20 cycles of washing, discoloration and loss of elasticity are visible. A huge impact of softener is noticed comparing the gained results not with untreated samples, but with specimens, which were not rinsed in softening bath. After 20 washings P_{max} rate increased from 1.33 up to 3.76 times, tgα – 1.05 – 3.43 times and Q – 1.06 – 3.73 times. Rates characterizing deformation H_{max} (softness) declined accordingly 1.16 – 0.88 times, while specimen's thickness change $\Delta\delta$ – 1.38 – 0.6 times. The most marked changes of all parameters characterizing fabric hand are obtained for P_{max}. The dependence between this parameter's values of tested objects and the number n of washings are given in Figure 2. Analogous dependencies between tgα, A and the number of washing cycles n were determined for all tested materials. Complex hand rate Q dependencies versus the number of washings

Table 2. Tested basic hand rates and their values after multifold washing

Fabric symbol	P_{max}, N	tgα	A, N·cm	H_{max}, mm	$\Delta\delta$, %	$Q/\pi r^2$
T-01	20.2 ± 0.8	1.91 ± 0.09	65.6 ± 2.3	58.5 ± 0.9	11.6	0.147
T-02	8.1 ± 0.3	0.75 ± 0.03	35.2 ± 0.9	79.3 ± 1.2	16.8	0.032
T-03	29.5 ± 1.6	1.55 ± 0.07	121.6 ± 6.0	83.8 ± 2.3	6.0	0.133
T-04	15.2 ± 0.8	1.09 ± 0.07	49.4 ± 2.7	63.1 ± 0.6	11.9	0.106

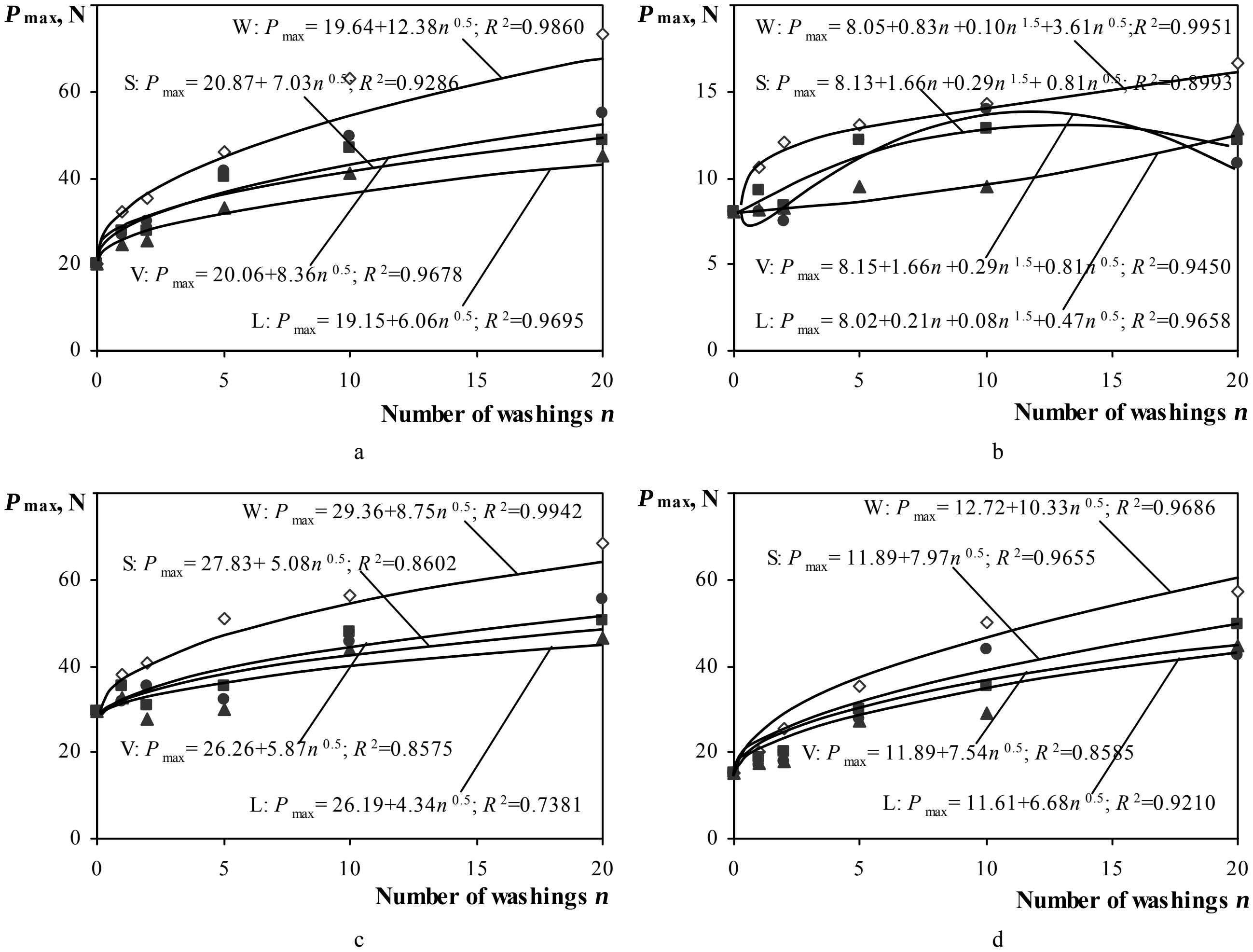

Fig. 2. Maximum extraction force P_{max} versus the number of washings n for tested objects: a – T-01; b – T-02; c – T-03; d – T-04

are shown in Figure 3. Almost all of them (except some T-02 material case) follow power or exponential laws.

Data analysis of multifold washing of knitted material show that with the increase of washing cycles number the values of parameters P_{max}, tgα, A and Q increase while variation character of parameters H_{max} and $\Delta\delta$ reflecting deformation features depends on the type of material and often alternates in pulsating regime. Two groups of tested textile materials can be excluded T-01 – T-04 and T-02 – T-03. In the first group H_{max} gradually increases while $\Delta\delta$ has a tendency to decrease. Changes of both parameters have tendency to decrease in the second group. It's probably related with similarity of knit pattern. Fabrics T-02 and T-03 are dissimilar depending on main P_{max}, tgα and A value, but they are similar by variation order of parameters H_{max} and $\Delta\delta$ in multifold washing result. This type of H_{max} and $\Delta\delta$ variation order determines fabric's complex hand rate Q alternation, which especially differs in T-02 case (Fig. 3, b). T-01, T-03 and T-04 fabrics' parameters P_{max}, tgα and A changes in multifold washing period are described fairly credibly (R^2 = 0.7365 – 0.9977) by simple type of function $y = a + bx^{0.5}$ (Fig. 2), while the variation of parameter $Q – y^2 = a + bx$ (R^2 = 0.8024 – – 0.9960) (Fig. 3), In the case of T-02 sufficient load precision (R^2 = 0.8529 – 0.9661) could have been obtained only through complex polynomial function.

When fabric softeners were used curves witnesses that Q rate values decreased to the level of untreated specimen after first washings (Fig. 3). Probably depravation of hand rate while increasing number of washings is related with rinsing out waxy and adipose textile features, which roughens the structure of knitted fabric in yarn strings, and in increase of density because of textile shrinkage. The total weight of the specimen after 20 washings increased from 3.3 to 22.0 % therefore fabric had roughened and lost initial elasticity, which in pulling of the specimen through the KTU-Griff-Tester hole plays decisive role. All the fabrics rinsed out in fabric softeners shows superior Q values comparing with fabrics rinsed in plain water. The distinctions are big enough and are counted in tens of percents. These main distinctions proved that the usage of fabric softeners in the process of washing plays positive role in stabilizing garments performance.

Depending on the most sensitive complex Q rate value after 20 washings the best effect was obtained for fabric T-01 softener LENOR (Q = 51 %) and VESTA (Q = 31 %) and in case T-04 – LENOR and VESTA (Q = 26 %) comparing with washings with no softeners (Fig. 3). By the sensitivity to fabric softeners tested fabrics can be set in priority: T-01 – T-02 – T-03 – T-04 and used softeners by their efficiency: LENOR – VESTA – SILAN.

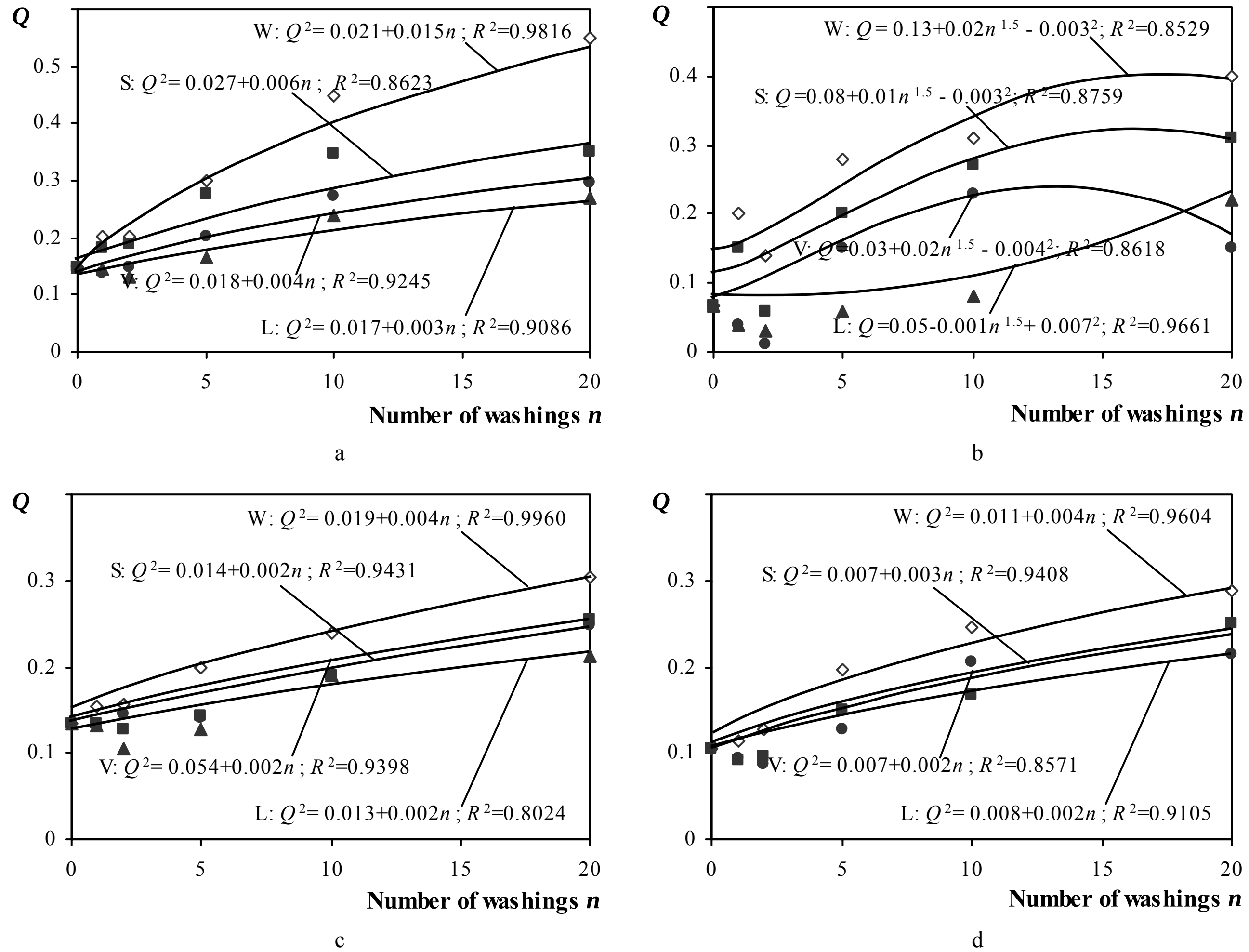

Fig. 3. Complex hand value Q versus the number of washings n for tested objects: a – T-01; b – T-02; c – T-03; d – T-04

CONCLUSIONS

During this investigation the effect of household fabric softeners on the textile hand rates after repeated washing cycles was evaluated. Data analysis show that cyclic washing of knitted garments reduce their hand rates. Particularly intensive reduce of this property is observed till 10 washings. Within the pale from 0 till 20 washings the main hand rates compared with untreated fabrics values became 3.4 – 4.1 times worse. In all cases the usage of fabric softeners substantially qualifies reduction of hand rates. These values comparing with analog values of specimens washed in plain water are better; some of them are better till 50 % (Q – T-01 – LENOR). Treatment of fabric with the softeners in the process of washing plays positive role in stabilizing garments performance.

By the intensity of main hand rates changes to multifold washings tested fabrics can be set in priority: T-01 – T-02 – T-03 – T-04.

The efficiency of softeners used in this work for cotton knit fabrics is very similar, but in conformity with complex hand rates changes the preference is given to fabric softener LENOR.

REFERENCES

1. **Weber, R.** New Aspects in Softening. CHT R. *Beitlin GMBH*, 1999: 30 p.
2. **Guo, J.** The Effect of Houshold Fabric Softeners on the Thermal Comfort and Flammability of Cotton and Polyester Fabrics *Thesis Blacksburg, Virginia* May, 2003: 121 p.
3. **Frotsher, H.** Chemistry and Physical Chemistry of Subsidiary Materials for Textiles *Veb Verlag Technology Berlin,* 1953: 203 p. (in German).
4. **Martišiūtė, G., Gutauskas, M.** A New Approach to Evaluation of Fabric Handle *Materials Science (Medžiagotyra) ISSN 1392-1320* 7 (3) 2001: pp. 186 – 190.
5. **Strazdienė, E., Papreckienė, L., Gutauskas, M.** New Method for the Objective Evaluation of Technical Textile Behaviour *Proceedings of the 6th Dresden Textile Conference "Textile Future of our Life Spheres-2002",* 2002, CD ROM Page 1 – 8 of 8 (http://www.fiz-technik.de).
6. **Strazdienė, E., Daukantienė, V., Gutauskas, M.** Bagging of Thin Polymer Materials: Geometry, Resistance and Application *Materials Science (Medžiagotyra) ISSN 1392-1320* 9 (3) 2003: pp. 262 – 265.
7. **Daukantienė, V., Papreckienė, L., Gutauskas, M.** Simulation and Application of Pulling Textile Fabric through a Central Hole *Fibres and Textiles in Eastern Europ ISSN 1230-3666* 11 (2/41) 2003: pp. 38 – 42.
8. **Daukantienė, V., Zmailaitė, E., Gutauskas, M.** Influence of Concentrated Liquid Softeners on Textile Hand *Indian Journal of Fibre and Textile Research ISSN 0971-0426* (in press).
9. **Pan, N., Yen K. C.** Physical Interpretations of Curves Obtained Through the Fabric Extraction Process for Handle Measurement *Textile Research Journal* 62 1992: pp. 279 – 290.