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Textile Hand: the Influence of Multiplex Washing and Chemical Liquid Softeners

Abstract
In this article, we analyse the behaviour of cotton shirting fabrics during multiplex washing. The behaviour of fabrics was evaluated on the basis of the changes to hand parameters as determined with the KTU-Griff-Tester. The relationships between the 5 hand parameters and the cycles of fabric washing were determined. The influence of the 2 chemical liquid softeners was analysed with the intention of stopping the deterioration of the hand parameters of woven fabrics, and stabilising the performance properties of fabrics.

Key words: *textile hand, pulling textile disc through a hole, chemical liquid softener, cyclic washing.*

Introduction

Recently, many factories' products require the use of hundreds of various chemical softeners. Chemical softeners are liquid, and easily watered-down. The dosage and usage of softeners are easy; during usage, the fabrics rinsed with softeners do not yellow.

Softeners are cation-active, anionic, non-ionogenic surfactants. The softeners' contents include waxes, paraffin, micro emulsions and other polymers. Cationic softeners are used widely. The charge to the softener molecule has a significant influence on the action of the softeners. The molecules of the cationic softeners in the acid substance have a slightly positive charge. So, the distribution of the softener on the surface of fibre depends on the charge of the fibre, and the interaction between the molecules of the fibre and the molecules of the softener. The molecules of cotton have negative charges. So, in the case of cotton, the cationic softeners should ideally join the ionic ends of the fibre, so that the hydrophobic ends (which give soft handle) are directed outwards and the hydrophilic ends are directed towards the fibre. Some of the softeners can create cross-links with the fibre molecules [1, 2].

The film is formed on the fibre surface during fabric rinsing with the chemical softeners. Thanks to the film formed, the textile become usually softer, more pleasant to handle and some of the properties of the sewn products improve [1]. The amount of softener on the fibre surface must not be too large. An excess of softener on the fibre surface makes the fabric fatty and unpleasant to handle.

The goal of this research was to determine the peculiarities of the changes to textile hand parameters which take place after multiplex washing of fabrics, and to evaluate the influence of liquid softeners on stabilising the performance properties of fabrics.

The goal of this research was achieved by working on these problems:

- testing the suitability of the KTU-Griff-Tester for determining the changes to fabric properties which occurred after technological finishing;
- determining the peculiarities of the deterioration of the main hand parameters after multiplex fabric washing (20 washing cycles);
- analysing the influence of the chemical softeners with the intent of stabilising the process of textile hand deterioration.

Table 1. *Characteristics of textile fabrics. Note: wr – warp, wf – weft.*

Fabric symbol	Fabric content	Fabric wave	Number of threads per centimeter, wr/wf	Mass per unit area, g/m²	Thickness, mm
A-B	33% cotton, 67 % PES	Plane	46/24	143	0.28
A-M	33% cotton, 67 % PES	Plane	63/30	126	0.42
A-Z	33% cotton, 67 % PES	Plane	35/23	196	0.25
A-F	100% cotton	Plane	20/32	191	0.80

Table 2. *The summary of the main hand parameters. Note: r=7.5 mm, h=7.5δ/2 mm, washing powder TIDE.*

Symbol of fabric and washing cycle	P_{max}, N	tgα	A, N·cm	H_{max}, mm	Q	Mass of specimen, g
A-B-K	39.0±0.9	7.75±0.33	151.8±2.9	57.1±0.5	1.00	1.43
A-B-1c	36.5±0.8	6.39±0.19	143.8±3.5	57.1±0.4	0.67	1.45
A-B-2c	38.7±0.6	6.60±0.25	155.3±2.6	57.4±0.6	0.88	1.45
A-B-5c	44.2±1.3	7.44±0.21	176.2±2.0	57.2±0.2	1.72	1.45
A-B-10c	46.2±0.5	7.52±0.21	185.3±5.0	57.9±0.4	1.60	1.48
A-B-20c	60.2±0.2	8.71±0.05	230.4±3.8	58.0±0.2	3.19	1.49
A-M-K	42.4±2.4	7.51±0.14	161.9±4.5	56.4±0.4	1.00	1.26
A-M-1c	42.1±0.6	7.73±0.25	168.2±18.6	56.9±0.3	1.02	1.27
A-M-2c	46.7±0.8	8.33±0.29	186.3±2.4	57.6±0.6	1.24	1.27
A-M-5c	51.2±1.2	9.39±0.37	207.3±6.0	58.1±0.4	1.65	1.26
A-M-10c	54.5±1.4	9.49±0.40	225.5±4.9	58.3±0.3	1.88	1.29
A-M-20c	67.1±2.1	11.11±0.51	279.2±11.7	59.7±0.7	2.51	1.32
A-Z-K	74.9±2.8	9.83±0.19	258.9±7.2	57.1±0.4	1.00	1.96
A-Z -1c	70.5±1.2	8.52±0.36	240.2±6.8	57.6±0.3	0.72	1.96
A-Z-2c	79.8±3.0	9.11±0.62	265.1±12.2	58.1±0.6	0.84	1.96
A-Z-5c	95.8±4.8	11.42±0.38	328.5±15.9	58.5±0.3	1.33	1.96
A-Z-10c	94.6±4.1	10.66±0.47	313.0±9.6	58.0±0.2	1.31	2.02
A-Z-20c	143.7±7.0	14.47±1.11	461.0±36.2	59.4±1.3	2.53	2.09

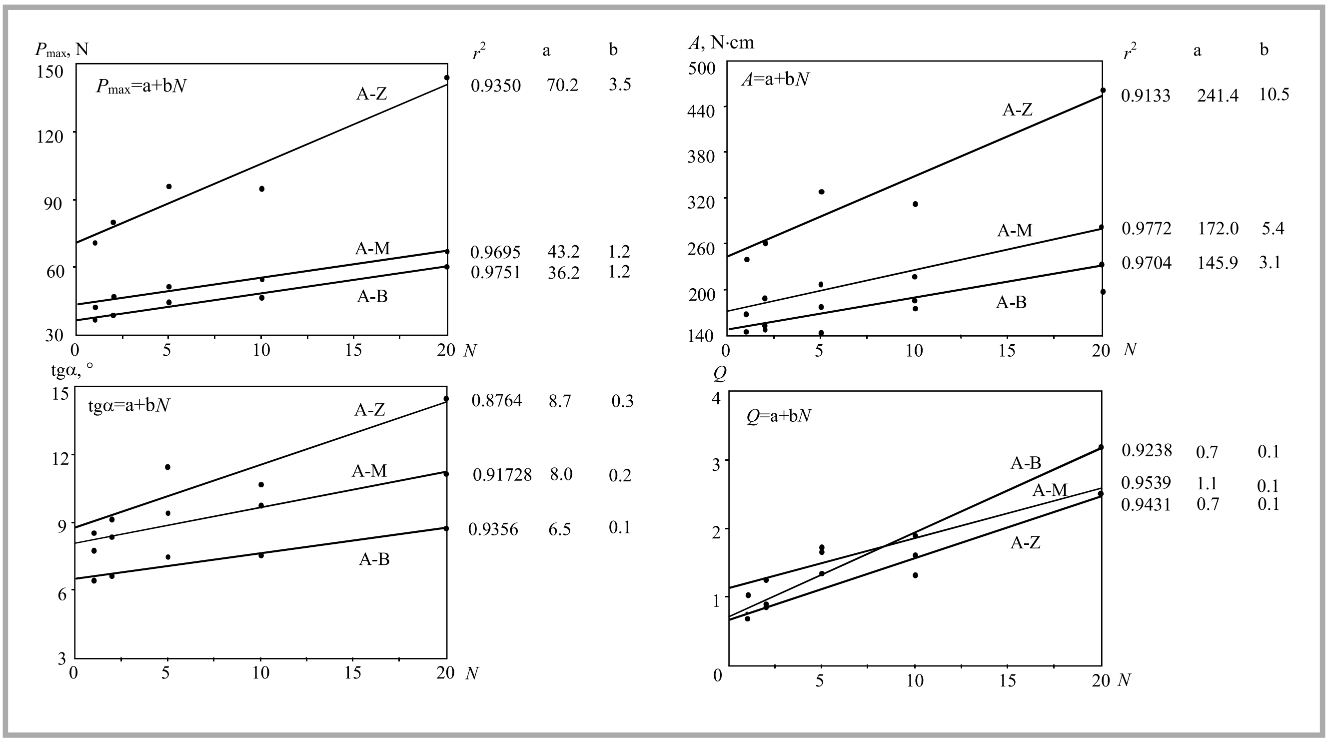

***Figure 1.** The dependencies between the main hand parameters P_{max}, tgα, A, and Q of woven fabrics A-B, A-M and A-Z and the number of washing cycles N (r=7.5 mm and h=7.5 δ/2 mm).*

Methodology

The textile hand was checked with the KTU-Griff-Tester [3-5]. Disc-shaped specimens were cut from fabric washed in different washing solvents, and were used for the study of hand by pulling the fabric specimens through a central hole (the radius of the hole is r, h is the distance (space) between the limiting plates of the device) [4, 5]. The modes of the experimental testing were chosen according to the thickness of fabric δ and the peculiarities of specimen jamming in the hole of the device, i.e. when r=7.5 mm, h=7.5×δ/2 mm, when r=10.0 mm, h=5.6×δ/2 mm. Textile hand was evaluated on the basis of the 5 parameters (P_{max}, tgα, A, H_{max} and Q) determined from the typical pulling curve H-P (the deformation – force curves are presented as examples in Figure 2 [6-8]. The value of the complex hand parameter Q was determined as the area of a pentagon drawn on a circular chart. The hand parameters H_{max}, P_{max}, tgα, A and Δδ were included in the constitution of the complex hand parameter Q. The specimen thickness δ, on which the parameters of the hole radius r and the plate distance h depend, was measured under two different loads; the ratio between them was 1:5. The difference between the measured fabric thicknesses was signerds as Δδ.

We tested four woven fabrics suited for shirts, housecoats, pyjamas,because these are garments which are usually washed during their use (Table 1). The influence of the chemical liquid softeners on the hand parameters was evaluated after the fabrics were washed in the automatic washing machine and rinsed in a small bath (typically a developing dish used in photography), within the norms of the chemical softeners which were stated in the technical instructions by producers. Two cationic liquid softeners Silan (Austria) and Surcare (England) were used for the study. The concentrations of the chemical softeners were (Silan) 1.8ml/l H_20 and (Surcare) 3.0 ml/l H_20. The amount of the solution of the chemical softener was 5 litres in all cases, for all the fabrics investigated. The bath (loading) ratio was 80%. The fabric was rinsed with the softener (T=15-16°C) for 5 min. The rinsed specimens were twisted, dried and placed on the horizontal plane.

Results and Discussion

The influence of the multiplex washing was evaluated on the basis of the results presented in Table 2.

The table summarises the values of the hand parameters P_{max}, tgα, A and H_{max} determined from the curves H-P and the complex parameter obtained for the three tested fabrics. The results show that the values of all 5 parameters increase after the increase in the number of washing cycles from the first to the 20th washing cycle (although the values of some of the tested parameters, after the first washing cycle, decrease compared to the value of the control specimens. The errors of the measurements in all cases do not exceed 5% (the number of specimens in the each group was 8).

The dependencies between the main hand parameters and washing cycles are presented in Figure 1. From the figure, it can be seen that the dependencies between the four hand parameters (P_{max}, tgα, A and Q) and the number of washing cycles N can be described reliably (r^2=0.8764÷0.9772) by the linear equation y=a+bN.

The analysis of the changes of the parameters of fabric hand (Table 2 and Figure 1) show that in all cases, with the exception of the first washing cycles, the hand parameters deteriorate. The evident deterioration of the hand was determined after 20 washing cycles. The parameter P_{max} deteriorated 1.5-1.9 times, the parameter tgα, 1.12-1.48 times respectively, the parameter A (characterising the pulling work) deteriorated 1.52-1.78 times, and the complex parameter Q – 2.5-3.2 times. It must be noted that after the first

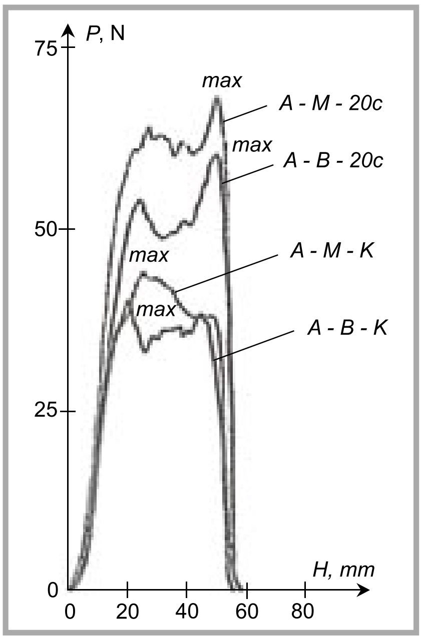

Figure 2. The typical curves H-P of woven fabrics A-B and A-M while pulling them through a rounded hole, before and after the washing.

cycles of washing, the some parameters (P_{max}, tgα, A and Q) were better, i.e. their values decreased. This decrease was essential as the difference between the measured values exceeded the sum of the errors (e.g. the parameter P_{max} for the fabrics A-B and A-Z). We believe that these changes to the parameters occurred because the finish materials were washed out from the tested fabrics. Regrettably, after multiplex washing all the parameters deteriorated. The reasons for this deterioration may be two in number: the further washing-out of fatty and waxy materials from the elementary fibres constituting the spun yarn and roughening the structure of woven fabric; and the thickening of the fabric because of its growing shrinkage. After 20 washing cycles, the mass of the specimen increased very slightly (4.2-6.6%) but the fabrics became rough, thick and stiff, and the greater stiffness of fabrics has a negative influence on the fabric hand when pulling the specimens through the central hole of the measuring device.

While analysing the experimental results, it was noticed that after the multiplex washing of some woven fabrics the shapes of the curves H-P were changed (Fig. 2). The position of the curve point coincident with the force P_{max} usually changed position in respect to the curve H-P after fabric washing. While pulling the control specimens through the central hole, the point P_{max} was at the beginning of the registered pulling curve, and after 20 cycles of washing, the point of the maximal force appeared at the end part of the curve. The changes of the positions of the points P_{max} show that as the outer contour of the specimen nears the central hole of the device, the specimen gathers heavily and slides though a central hole. This confirms the presumption that multiplex washing of fabrics causes them to roughen, which can be checked by using the parameters of textile hand.

After determining the significant deterioration of the hand parameters caused by multiplex washing, we decided to use one fabric, whose content was 100% cotton (without PES fibre) and whose hand after

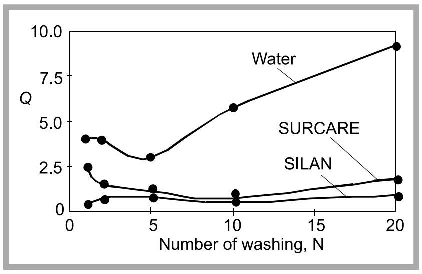

Figure 3. The dependency of the complex hand parameter Q of flannel on the number of washings N.

the multiplex washing deteriorated most of all, and to apply the finishing with the two liquid chemical softeners to this fabric. The situation changedfundamentally. The deterioration of the hand parameters of flannel fabric was more significant (P_{max} 1.9, tgα 1.4, A 1.9 and Q 9.2 times) compared to those of the other 3 fabrics after 20 washing cycles and being rinsed in pure water. After the fabric was rinsed with the liquid softener Silan, only 2 of the 5 hand parameters deteriorated slightly (P_{max} – 1.16 and A – 1.06); the use of the liquid softener Surcare caused a slight deterioration of 4 hand parameters: P_{max} – 1.17, tgα – 1.06, A – 1.19 and Q – 1.76 times (Table 3 and Figure 3). The majority of the hand parameters were better when compared to the ones of the control specimen (without applying the liquid softener) after some washing cycles.This was particularly evident in the case of the liquid softener Silan. The complex Q parameter determined after the first washing cycle and after every other cycle up to the 20th varied within the range of 0.25-0.85, i.e. the rinsing of the fabrics using the liquid softeners clearly showed the positive influence of such washing on stabilising the fabric's performance properties. However, when rinsing the fabric with the chemical softeners, the dispersion of the results was larger compared to when the fabrics were rinsed in pure water. This can be influenced by manual rinsing in the bath, after which different amounts of the liquid softeners remained in the fabrics' structure because of the different level of fabric twist.

Table 3. The hand parameters of flannel A-F after the cyclic washing and rinsing in the solution of chemical liquid softeners. Note: r=10.0 mm, h=5.6δ/2 mm, washing powder BOLD

Codes of fabrics and washing cycles	P_{max}, N	tgα	A, N·cm	H_{max}, mm	Q	Mass of specimen, g
K-0	29.6±0.4	3.58±0.27	104.2±2.0	59.4±0.3	1.00	1.91
1c	38.7±1.1	3.89±0.19	139.9±4.1	61.4±0.3	4.16	2.06
2c	42.4±2.6	3.99±0.11	147.7±3.4	62.7±0.3	3.92	2.03
5c	40.3±1.2	3.79±0.14	143.7±2.2	62.4±0.9	2.98	2.05
10c	49.1±1.3	4.57±0.21	174.9±3.9	64.0±0.6	5.77	2.14
20c	56.6±1.2	5.08±0.36	197.3±5.7	64.1±0.6	9.21	2.08
1 SIL	29.8±1.3	3.11±0.01	111.4±3.6	61.6±0.6	9.25	2.05
2 SIL	30.7±0.7	3.22±0.17	114.7±3.1	61.5±3.1	0.75	2.11
5 SIL	27.5±0.6	3.02±0.10	100.6±2.9	60.9±0.6	0.75	2.04
10 SIL	31.5±1.2	3.28±0.19	117.0±7.2	62.3±0.3	0.47	2.12
20 SIL	34.4±3.5	3.56±0.16	110.7±10.5	62.8±0.6	0.85	2.15
1 SUR	35.7±1.4	3.19±0.13	129.7±4.7	61.9±0.6	2.42	2.08
2 SUR	32.0±1.4	3.27±0.21	114.5±4.6	61.5±0.6	1.48	2.10
5 SUR	29.9±0.7	3.12±0.18	106.9±2.8	61.3±0.3	1.06	2.04
10 SUR	34.3±1.3	3.47±0.14	122.4±3.6	61.5±0.3	0.65	2.07
20 SUR	34.6±1.1	3.79±0.41	122.4±5.9	60.8±0.6	1.76	2.08

Conclusions

1. The modes of textile technological finishing (washing, rinsing, cleaning and others) can be checked by using sufficiently simple and reliable testing methods based on the determination of hand parameters, especially with the use of the KTU-Griff-Tester.

2. Cyclic washing causes the deterioration of textile hand parameters. A significant deterioration in textile hand was observed after 20 washing cycles.
3. Fabric finishing with chemical liquid softeners significantly influences the slower deterioration of the hand parameters during the use of the fabric.
4. The fabrics can be classified according to the changes in the main hand parameters which occurred after fabric cyclic washing in an order depending on the deterioration of fabric properties: A-B→A-M→A-Z→A-F.
5. The efficiency of both chemical liquid softeners used for the treatment of flannel fabric was similar; however, preference must be given to the softener Silan according to the dispersion of the determined values of the complex hand parameters.

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