The Influence of Washing on Fabric Wearing Properties

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The behaviour of woven and knitted fabrics during their washing is investigated in this work. The influence of the washing conditions and chemical liquid softeners on the mechanical properties of textile fabrics was evaluated. The dependencies between the main hand parameters and the washing temperature were determined. The influence of the washing temperature on the changes of fabric mass and thickness as well as on fabric flexibility was evaluated. The analysis of the friction parameters during fabrics sliding on the different surfaces (glass or organic glass stands) was done according to the standard DIN 53375. It was determined that the values of the friction parameters (friction coefficient μ_D and dynamic friction force F_D) vary in the wide range. It was shown also that the specimen resistance to pulling through the central hole increases due to the increase of the temperature of washing solution, but after the fabric treatment with the liquid softener the hand parameters noticeably change for the better. Thus, it was presented that the device KTU-Griff-Tester is suitable to evaluate the changes of mechanical properties of the woven and knitted fabrics after their washing, softening and other relatively sensitive factors occurring during exploitation period.
Key words: *textile material, friction, hand, flexibility, softener*

1. Introduction

Textile materials are exploited under the cyclic hydrothermal treatment (washing) influencing the longer exploitation period of the product as well as the improving their hygienic properties and aesthetic appearance of the garment. But this treatment negatively influences the fabric physical and mechanical properties, i.e. it stimulates shrinking, increase of surface roughness and decrease of flexibility of fabrics and etc. These changes can be effectively decreased using the industrial chemical liquid softeners, mostly of the cationic activity [1, 2].

It is known that the changes of material strength (breaking tenacity) due their treatment (washing, dry-cleaning and etc.) during exploitation period are very low and complicatedly measurable using standard mechanical tests. But the changes of hand parameters of textile materials after the material washing are essential [3, 4].

The aim of this work was to evaluate the influence of washing conditions and softening on the mechanical properties of different textile materials.

2. General part and results

The six different textile materials were tested, (Tab.1 and 2).

The samples (the size of 40×60 cm) were cut from the each fabric. The objects of investigations were very different between themselves according to their fiber composition, structure and finishing, but the influence of these characteristic separately was not analyzed. So, the main aim of investigations was to present the common peculiarities concerning the behaviour as well as the changes of hand parameters of different textile membranes during their extraction (pulling) though a central hole. The recent investigations had shown that the hand parameters of linen woven fabrics became better after their treatment with softener “Lenor” [5], except LI-W woven fabric with special mechanical and softening finishing 50+C_1 (the parameters of this finishing is not declared for commercial purposes). This treatment initiates the positive charging of fabric surface which as well as in the case of PES-W fabric block the orientation of molecules of cationic softener with the fabric surface.

The samples were washed using the domestic washing machine „Fagor“ at 30, 60 or 90° C temperature with

Tab.1 Structure parameters of investigated materials

Fabric symbol	Fabric type	Fabric content	Weave/Knitting type	Fabric density (cm^{-1})	
				Warp /Wale	Weft /Course
CO-W	Woven fabric	100% cotton	Twill	39	23
LI-W		100% flax	Plain	18	18
PES-W		100% polyester	Plain	40	30
CO-K	Knitted fabric	100% cotton	Plain jersey	12	16
PA-K		100% polyamide	Warp-knitted locknit	15	20
CA-K		80% acetate, 20% polyamide	Double jacquard	14	P_{fs}^{*}=5 P_{bs}^{*}=10

*P_{fs} - coefficient of course density of fabric front side; P_{bs} - coefficient of course density of fabric back side

Tab.2 The parameters of control (unwashed) investigated fabrics

Fabric symbol	Hand parameters				Geometrical parameters		Dynamic friction coefficient μ_D	Sign of electric charge of fabric surface
	P_{max} (N)	$tg\alpha$	A (Ncm)	H_{max} (mm)	w (g/m^2)	δ (mm)	G/OG*	
CO-W	20.5±0.4	16.168±0.4	71.7±2.1	56.6±1.0	208±3	0.47±0.01	0.27/0.21	low –
LI-W	14.5±1.2	13.838±0.7	46.9±2.7	56.4±2.0	210±2	0.45±0.01	0.31/0.15	low +
PES-W	12.2±0.6	9.699±0.7	43.72±1.97	58.8±1.0	57±1	0.09±0.01	0.45/0.51	low +
CO-K	6.0±0.1	2.961±0.2	19.7±0.5	61.4±1.1	107±1	0.46±0.01	0.32/0.16	low –
PA-K	3.8±0.4	2.184±0.3	14.2±1,5	58.1±2.8	60±1	0.27±0.01	0.34/0.23	low –
CA-K	14.6±0.6	7.066±0.5	55.35±3.64	63.5±2.3	154±2	0.58±0.01	0.58/1.46	low –

*G/OG - glass/organic glass stand

the washing solution containing the same norm of the powder „Ariel“ (50 ml in one washing cycle) in the all tested cases.

The half quantity of washed samples was taken and rinsed with the solution of liquid softener „Lenor“ (1.8 ml/l H_2O), 20 min., prepared according the recommendations for its concentration provided by the producer of softener. The samples were dried out placed horizontally.

The specimens for the determination of hand, flexibility and friction parameters were cut from washed and rinsed samples.

The hand parameters were determined using the KTU-Griff-Tester [6-9]. The flexibility of investigated fabric was evaluated using the conventional cantilever method [10]. The change and stability of the investigated parameters were evaluated relatively comparing them to the parameters of control specimen (C) which was equal to 1.

The changes of the parameters of fabric surface after their chemical treatment were evaluated according to the friction parameters determined according to the standard DIN 53375. Also, it must be assumed, that the interaction between the fabric surface and the cationic softener depends on the electrostatic charge of fabric, thus the parameters of electric charging were controlled using the device FMX-002 (Holland) (Fig.1).

The specimen had been placed horizontally on the nonconducting pad below the search window of device FMX-002 and then the sign (+ or –) as well as the potential E of electrostatic charge generating on fabric surface was determined from the special scale.

3. Discussion

The summary of the results for the all investigated fabrics are presented in Tab.2, from which the geometrical, hand, friction and electric parameters of tested textile materials can be seen and compared between themselves.

The results presented in Tab. 2 show that the hand parameters of woven fabric P_{max}, $tg\alpha$ and A are higher in about 3-4 times compared to these ones of knitted fabrics be-

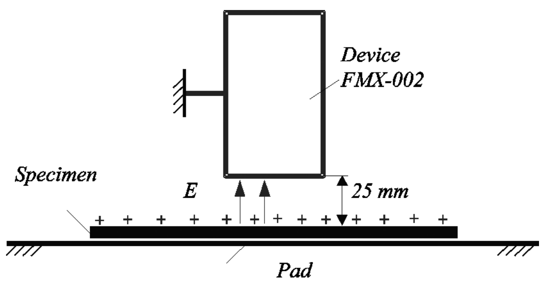

Fig.1 Sheme for the measurement of electrostatic charge parameters (sign and potential)

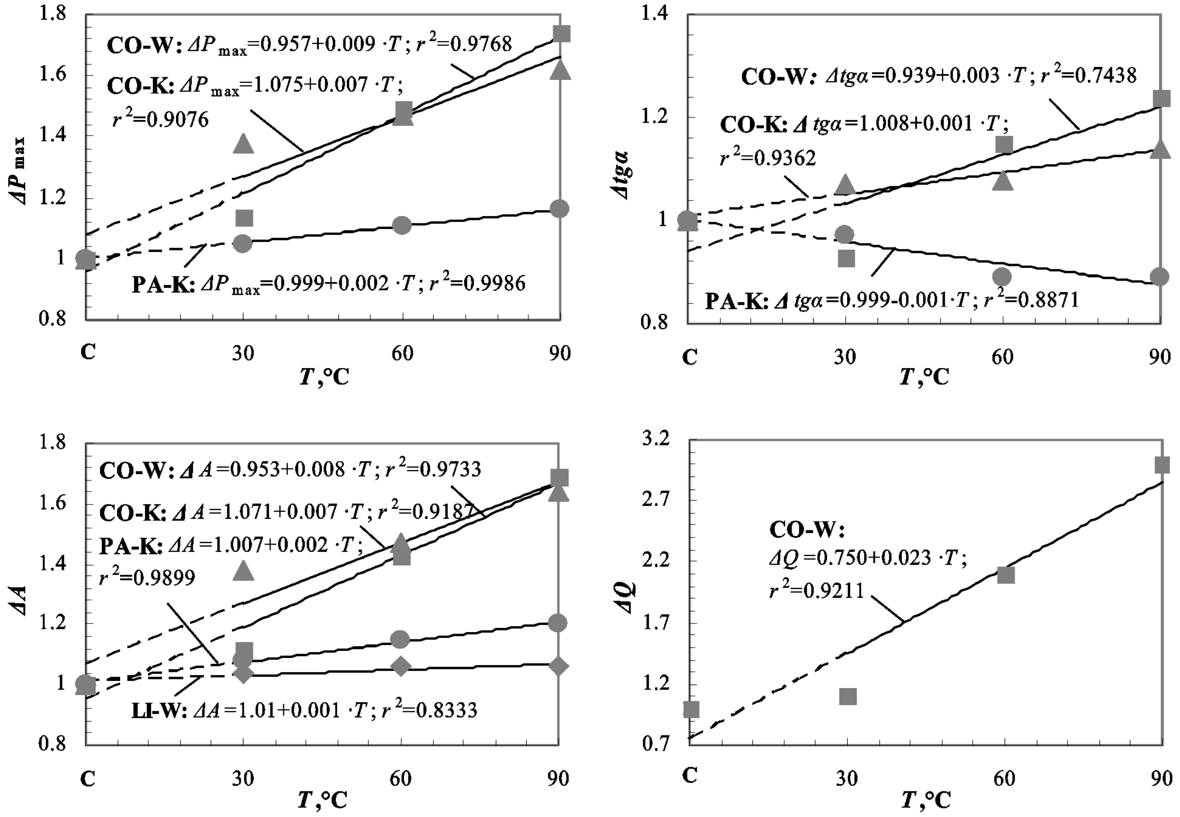

Fig.2 The dependences between the main hand parameters P_{max}, $tg\alpha$, A and Q and washing temperature (C - control (unwashed) specimen)

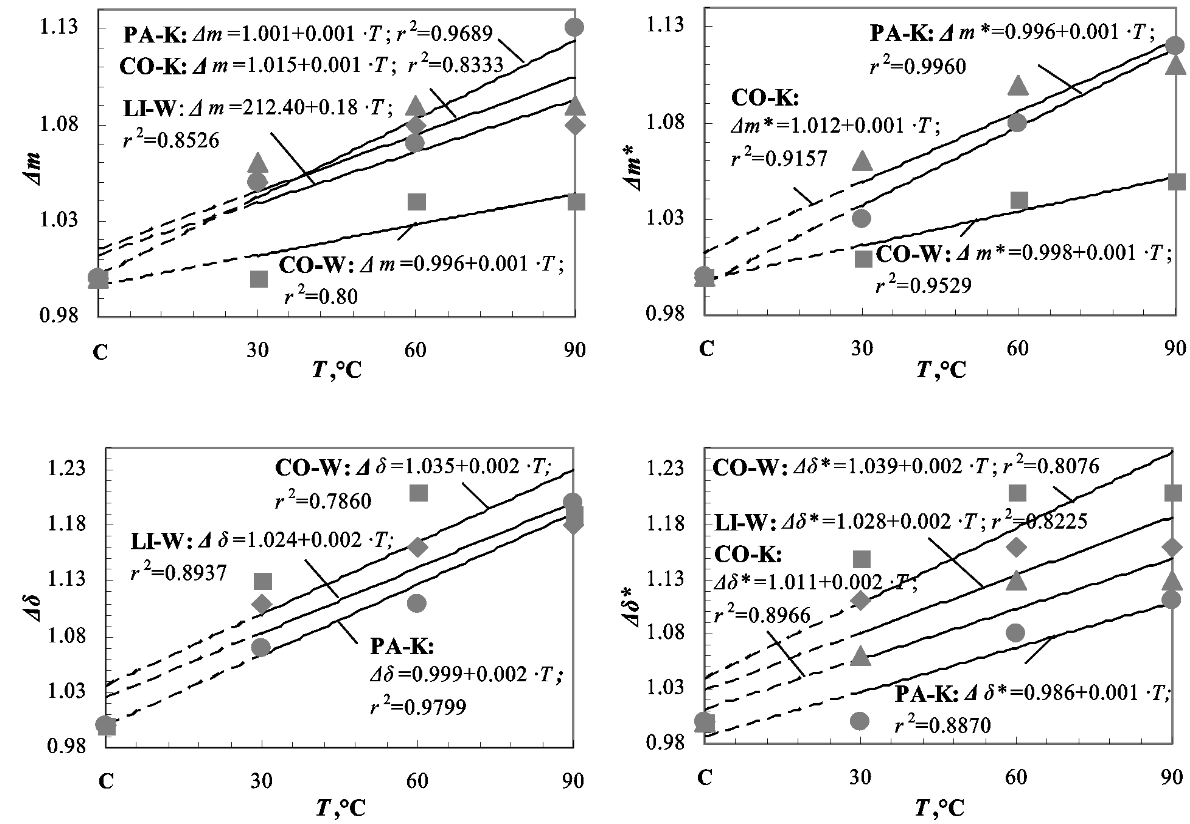

Fig.3 The influence of washing temperature on the changes of specimen mass (m) and thickness (δ) (Δm and $\Delta\delta$ – after washing; Δm* or $\Delta\delta$* – after washing and softening with the softener)

cause of the some peculiarities of their structure and deformation properties. The fabric softness takes the main value during the evaluation of textile hand. Knitted materials usually are softer than woven fabrics. So, in the case of knitted materials the extraction (pulling) parameters characterizing textile hand for knitted materials are better than ones of woven fabrics (Tab. 2). The dynamic friction coefficient μ_D is higher in the case of glass stand (G) compared to one of organic glass (OG). The measurements of the electrostatic charge have shown that the linen LI-W and polyester PES-W woven fabrics are charged low positively and all other fabrics are charged low negatively.

The high changes of the main fabric characteristics were determined after the fabric washing or rinsing with the solution containing the cationic softener. The main pulling parameters P_{max}, $tg\alpha$ and A increase after the increase of washing temperature which influences the increase of fabric thickness. The rinsing with the softener „Lenor“ contrariwise influences the changes of hand parameters. For these cases three main parameters decreased and became similar to these ones of control (unwashed) specimens. LI-W fabric stands in the exceptional position, i.e. the hand parameters of this fabric remain almost unchanged even after its washing or rinsing. The parameters P_{max} and $tg\alpha$ in the all cases are lower compared to these ones of control specimens and are very similar to the each other with their absolute values. These tendencies can be explained by the swilling out of finishing materials or the negative conditions for the joining of the molecules of chemical softener to the surface of fabric which is charged positively.

There were observed that almost in the all cases the rinsing with the liquid softener “Lenor” influences the decrease of the main hand parameters P_{max}, $tg\alpha$, A and Q below the limit of 1, i.e. this shows that the fabric hand becomes better.

From the Fig.2 and 3 can be shown that the washing temperature linearly correlates with the majority of the measured mechanical parameters. The exceptional position for the earlier described correlation takes LI-W fabric.

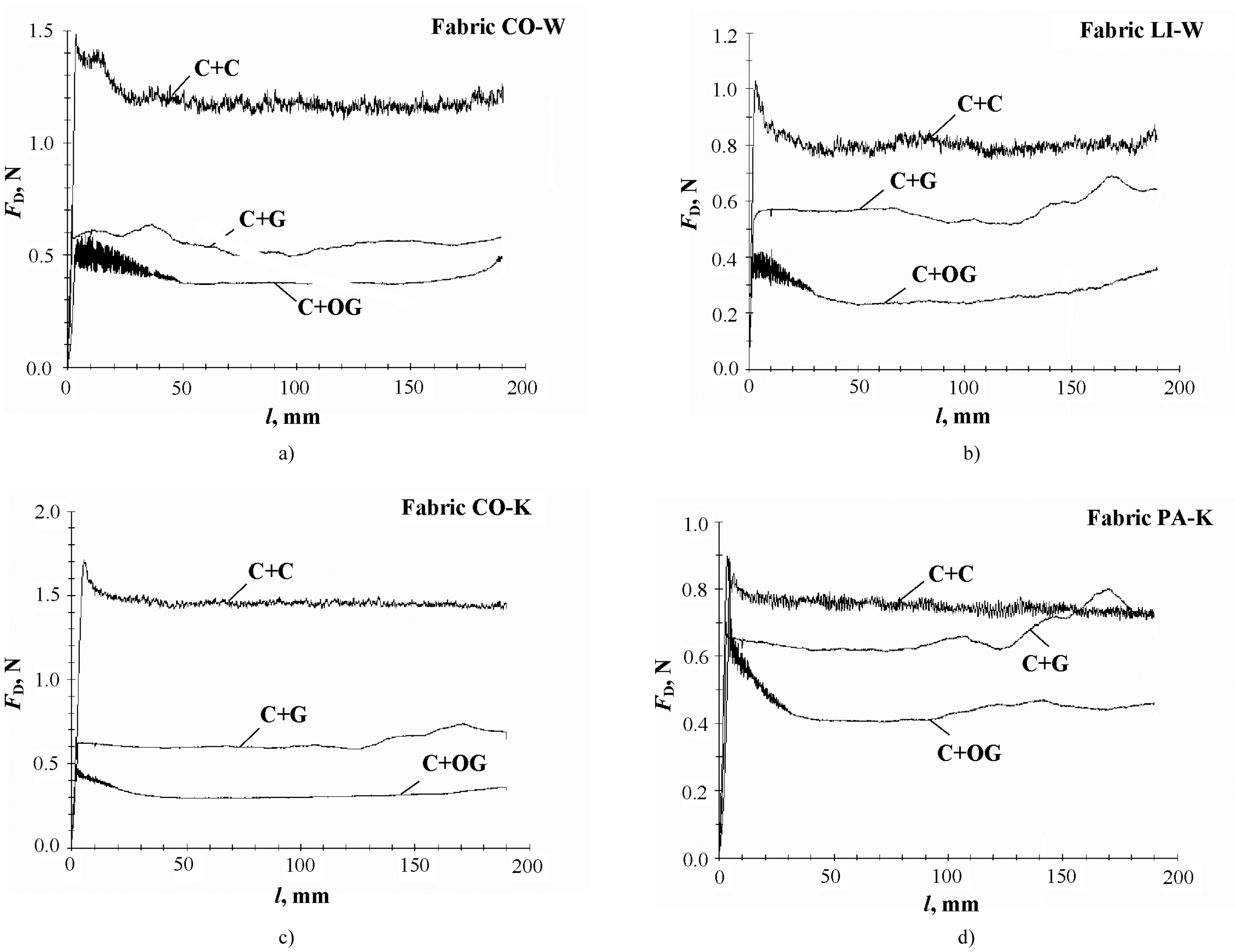

Fig.4 The friction curves of friction pair of the same control fabric (C+C); of woven (a, b) and knitted (c, d) fabrics during their sliding on the glass (C+G) and organic glass (OG) surfaces

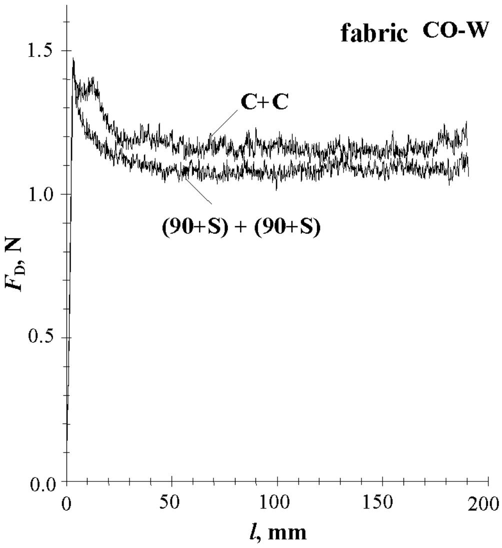

Fig.5 The friction curves in the pair of identical control woven fabric (C+C) before and after washing at the washing temperature 90 °C and after softening (90+S)

The analysis of the friction parameters have shown (Fig.4) that the shape of the friction curve and the values of friction parameters (μ and F_D) depend on the stand on which the specimen was sliding. The maximum values of the friction parameters were determined in the case of woven fabric sliding on the surface covered with the same woven fabric, i.e. for the friction pair (C+C). In the case of specimen sliding on the glass stand (C+G) the values of friction parameters are the medium in size and when the textile specimen slides on the organic glass stand (C+OG) the values of the parameters are the lowest. Two different glasses were the prototypes of the limiting plates of KTU-Griff-Tester. The case of glass stand has some peculiarities influenced by the accumulation of electrostatic charge which was changed during the sliding process causing the evident variation of dynamic friction force F_D. In the some cases the friction force F_D in the friction pair (C+G) was higher compared to that of the friction pair (C+C) (Fig.4).

The analysis of the friction parameters had shown also that the washing process (in the cases of all stands) influences the increase of friction coefficient μ_D and dynamic friction force F_D sometimes up to 13-16% (CO-W, LI-W, PA-K). Still the rinsing with the softener „Lenor“ was not being able to decrease the sliding parameters (Fig.5).

The parameters of woven fabric (CO-W) flexibility in weft and warp directions measured using conventional cantilever method had shown that the increase of the washing temperature influences the decrease of fabric flexibility while the fabric treatment with the softener slightly increases the flexibility of fabric (Fig.6).

The parameter Δc correlates with the majority of hand parameters. The highest correlation was determined between the parameters Δc_a and $\Delta tg\alpha$.

The electric charge of the textile fabric influences the some processes of fabric finishing, mostly the interaction between the fabric and molecules of cationic softener. The charts presented in Fig.7 show the influence of the softener "Lenor" on the hand parameters of acetate (CA-K) and polyester (PES-W) fabrics.

From the charts can be seen that the acetate fiber (CA-K) having negative charge intensively electrochemically reacts with the cations of the softener and the main hand parameters (P_{max}, tgα) become about two times better. The behaviour of the polyester fabric (PES-W) is quite otherwise and the hand parameters in this case remain almost unchanged compared to these ones of control specimens as the positive-

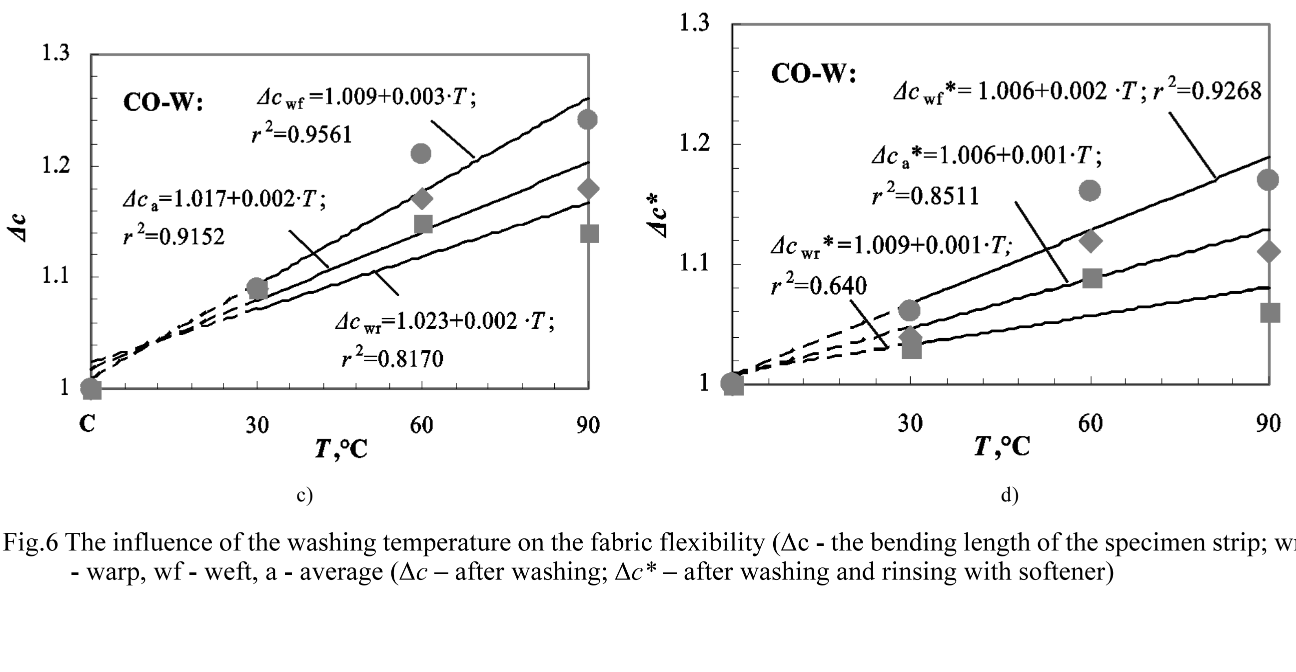

Fig.6 The influence of the washing temperature on the fabric flexibility (Δc - the bending length of the specimen strip; wr - warp, wf - weft, a - average (Δ*c* – after washing; Δ*c** – after washing and rinsing with softener)

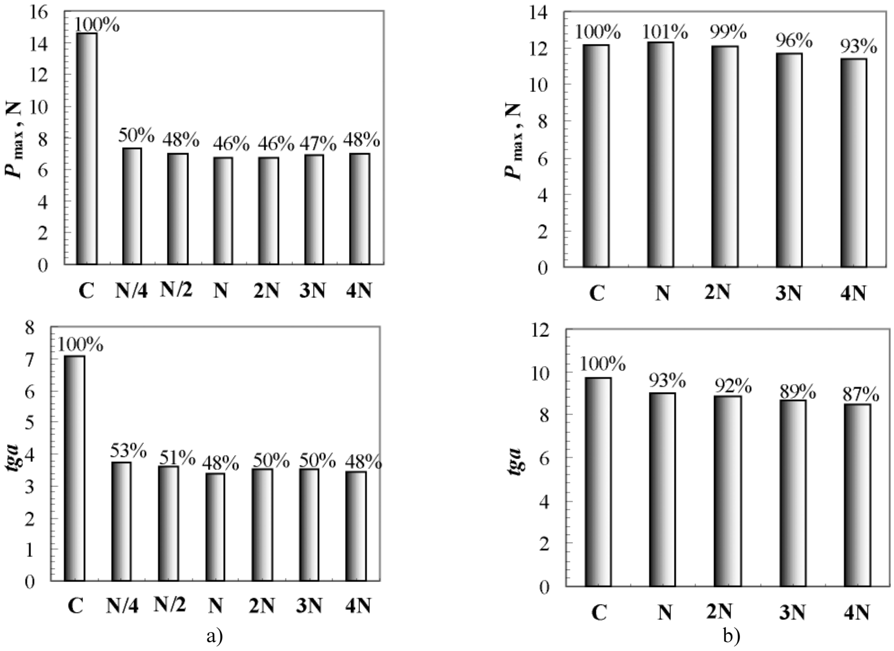

Fig.7 The influence of concentration *N* of cationic liquid softener "Lenor" on the hand parameters P_{max} and $tg\alpha$ determined using the KTU-Griff-Tester [5-8]: a) for acetate knitted fabric (CA-K) and b) polyester woven fabric (PES-W) (*N* – the concentration of liquid softener recommended by it's producer; C – hand parameters of control specimens)

ly charged surface of polyester fabric does not reacts with the cations of the softener. The results presented in Fig.7 show that in the case of polyester material the cationic softener can act as best as antistatic agent [11].

4. Conclusion

The increase of washing temperature increases the fabric resistance to pulling through the central hole (the hand parameters change for the worse, i.e. some of them even - up to 60-70 %). Linen fabric takes the exceptional position and its parameters P_{max}, $tg\alpha$ and Q slightly decreases compared to these ones of control specimens and later remain unchanged even if the washing temperature is changed.

Hand parameters and flexibility of fabrics rinsed with the softener „Lenor" were better compared to these ones of fabrics washed without the softeners and even in the most cases they were the higher compared to these ones of control (unwashed) fabrics.

The specific reaction of linen woven fabric (LI-W) to the softener could be influenced by the positively charged surface and the swilling out of finishing materials.

KTU-Griff-Tester is well-suitable instrumental device for determining the changes of mechanical properties of woven and knitted fabrics after their washing, softening and other gentle factors influencing during their exploitation and care period.

The kind of materials has been used for material finishing and the mechanical properties of the textile materials depend on the polarity of electrostatic charge accumulated on the surface of textile materials.

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