

## Control of Fabric End Use Properties Based on the Principle of Restricted Pulling Through a Nozzle

Diana GRINEVIČIŪTĖ<sup>1\*</sup>, Gailutė KAZAKEVIČIŪTĖ<sup>1</sup>, Aušra ABRAITIENĖ<sup>1</sup>,  
Dainora TRUNCYTĖ<sup>2</sup>, Matas GUTAUSKAS<sup>2</sup>

<sup>1</sup>Lithuanian Textile Institute, Demokratu 53, LT-58584 Kaunas, Lithuania

<sup>2</sup>Department of Clothing and Polymer Products Technology, Kaunas University of Technology, Studentu 56, LT-51424 Kaunas, Lithuania

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In this work, investigation of hand parameters' extent of polyester and blended cotton/bamboo fabrics was performed. It was established that tenuous specific differences, which depend on fabric end finish, could be determined using KTU-Griff-Tester. It was revealed that bamboo fiber interblended into cotton fabric basically changed the scale of main hand parameters as well as their extent that was influenced by fabric washing and chemical treatment processes. As in other cases, the most sensitive hand parameter, i.e. complex hand rate  $Q$ , was established. If compared to analogous parameters of control specimens, its extent (with alternating finishing conditions) as often as not reached 5 times.

**Keywords:** materials science, textile, cotton, bamboo, hand, chemical softening.

### INTRODUCTION

Emergence of new fibrous materials and changing technological processes in their manufacture lead to a new relevant materials science problem related that is to control of mechanical parameters of new materials. In the majority of cases, conventional methods, which define determination of strength and other standardized parameters, do not allow detecting significant differences between separate fabrics after different finishing, washing, softening and other processes that vary for several times during garment wear period.

Research of the recent years has shown that one of the most sensitive and most perspective control methods of textile garments' end use properties may be punching (extraction) of a disc-shaped specimen through a nozzle [1 – 7]. It was established that applying the method and the adequate device created at KTU, it is possible to determine fabric hand parameters' extent after different wear care processes [8 – 12].

The aim of this work was to determine the influence of bamboo fiber on fabric hand parameters' scale as well as their extent, influenced by fabric washing and chemical softening.

### MATERIALS AND METHODS

Selected objects of investigation included thin lining polyester fabric (P-X and P-Y) and several groups of cotton, bamboo and blended cotton/bamboo fabrics for special purposes (Table 1).

Determination of fabric hand parameters was performed using KTU-Griff-Tester and applying earlier developed and published methodology [8 – 10]. Four hand parameters were identified from the extraction curve  $H-P$ :  $P_{max}$  – maximal extraction force,  $tg\alpha$  – initial slope angle,  $A$  – pulling work. The primary hand parameters were

expressed by one numeric value – the complex hand parameter  $Q$  – area of a polygon in a polar chart.

Part of the investigated objects was soaked in industrial softeners: non-ionogenic “Viskosil PSN” (“BOME”) and cationogenic “Belfasin SI” (“COGNIS”). Textile fabrics' treatment was performed periodically using 5 % of softener from fabric weight, modulus 1 : 50, temperature 40 °C, duration – 20 min. After treatment, fabrics were squeezed and dried in a horizontal position. In comparison, fabrics of the same structure were soaked in pure water in the same conditions, then squeezed and dried. Number of specimens in each group varied from 5 to 8.

### RESULTS AND DISCUSSIONS

Analysis of polyester lining fabrics showed that initial parameters of P-X and P-Y fabrics, which were produced in the same technical conditions by different companies X and Y, were identical (Table 1).

Hand parameters of these fabrics were also similar (Table 2). However, some differences appeared in peak areas of fabric extraction curves (Fig. 1). The peak point  $P_{max}$  of fabric P-X curve  $H-P$  has a shape of knife-edge followed by an instant decrease of extraction force  $P$ . Part of the peak of fabric's P-Y curve  $H-P$ , however, is obtuse, with multiplex zigzag oscillation. This means that fabrics' behaviour during the extraction process is slightly different, i.e. they fold differently between limiting plates [12]. Current observation seems to be related to the peculiarities of technological finishing, which determine fabrics' surface parameters. This comparison of  $H-P$  curves' peaks may be effective when analyzing subtle differences in textile finishing.

Interesting scientific results were obtained when investigating hand parameters of cotton fabrics interblended with bamboo fiber.

In case of raw fabric (plain weave), increase of bamboo fiber quantity in the fabric led to decrease of the main hand parameters  $tg\alpha$  and  $Q$  (that characterize fabric softness)

\*Corresponding author. Tel.: +370-37-313432; fax.: +370-37-314423.  
E-mail address: [asta.sileikaite@stud.ktu.lt](mailto:asta.sileikaite@stud.ktu.lt) (A. Šileikaite)

(Table 3). When cotton was totally substituted by bamboo, decrease of  $tg\alpha$  reached 0.74, and  $Q = 0.91$  (parameters of the initial specimens were equal to 1.0). Due to fabric shrinkage, values of  $P_{max}$  and  $A$  parameters tend to vary.

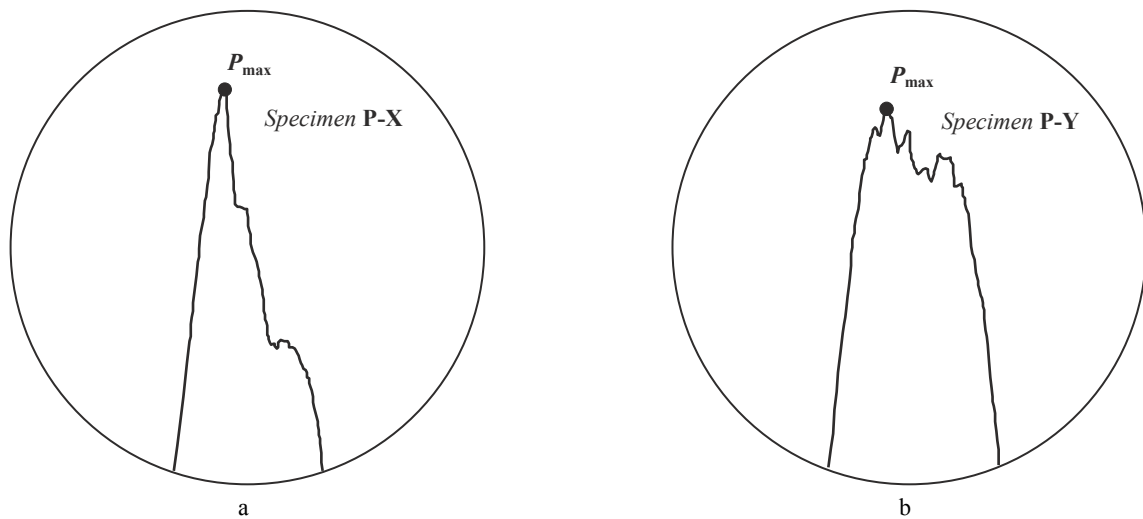
After treatment, fabrics become uniform according to their thickness and other characteristics. In this case it was

also noticed that the increase of bamboo fiber quantity in blended cotton/bamboo fabric (twill weave) from 0 % to 55 %, led to decrease of hand parameters (improvement) as well:  $tg\alpha$  – up to 0.84,  $A$  – up to 0.85,  $Q$  – up to 0.73. Only the parameter  $P_{max}$  slightly increased. When bamboo quantity composed 55 %,  $P_{max}$  decreased to 0.82.

**Table 1.** Objects of investigation

| Fabric           | Composition              | Weave | Density (Warp/Weft), cm <sup>-1</sup> | Area density, g/m <sup>2</sup> | Thickness, mm |
|------------------|--------------------------|-------|---------------------------------------|--------------------------------|---------------|
| Lining fabrics   |                          |       |                                       |                                |               |
| P-X              | PES 100 %                | Plain | 46/22                                 | 60                             | 0.11          |
| P-Y              | PES 100 %                | Plain | 46/22                                 | 60                             | 0.11          |
| Raw fabrics      |                          |       |                                       |                                |               |
| C-1              | Cotton 100 %             | Plain | 24/19.4                               | 144                            | 0.37          |
| CB-1             | Cotton 55%, bamboo 45 %  | Plain | 24/19.4                               | 141                            | 0.34          |
| B-1              | Bamboo 100 %             | Plain | 24/19.4                               | 142                            | 0.33          |
| Finished fabrics |                          |       |                                       |                                |               |
| C-2              | Cotton 100%              | Twill | 36/19                                 | 241                            | 0.47          |
| CB-21            | Cotton 85 %, bamboo 15 % | Twill | 36/19                                 | 241                            | 0.49          |
| CB-22            | Cotton 75 %, bamboo 25 % | Twill | 36/19                                 | 241                            | 0.49          |
| CB-23            | Cotton 65 %, bamboo 35 % | Twill | 36/19                                 | 244                            | 0.48          |
| CB-24            | Cotton 45 %, bamboo 55 % | Twill | 36/19                                 | 238                            | 0.48          |

Note: P – polyester; C – cotton; B – bamboo; CB – cotton + bamboo.



**Fig. 1.** Illustration of the peak areas of polyester fabrics' P-X (a) and P-Y (b) extraction curves  $H-P$

**Table 2.** Hand parameters of P-X and P-Y fabrics

| Fabric | $P_{max}$ , N | $tg\alpha$ | $A$ , Ncm | $Q$    |
|--------|---------------|------------|-----------|--------|
| P-X    | 14.7±0.3      | 10.13±0.51 | 48.8±2.9  | 0.0172 |
| P-Y    | 14.4±0.3      | 10.33±0.32 | 53.0±3.1  | 0.0177 |

**Table 3.** Influence of fabric composition, weave and finishing on hand parameters

| Composition         | Weave | $P_{max}$ , N | $tg\alpha$ | $A$ , Ncm | $Q$    |
|---------------------|-------|---------------|------------|-----------|--------|
| Raw fabrics         |       |               |            |           |        |
| C – 100 %           | Plain | 9.9           | 10.43      | 36.7      | 0.0139 |
| C – 55 % + B – 45 % | Plain | 10.2          | 9.48       | 38.8      | 0.0137 |
| B – 100 %           | Plain | 10.7          | 7.67       | 38.7      | 0.0127 |
| Finished fabrics    |       |               |            |           |        |
| C – 100 %           | Twill | 96.6          | 66.35      | 301.2     | 0.2707 |
| C – 85 % + B – 15 % | Twill | 107.4         | 66.70      | 358.3     | 0.3211 |
| C – 75 % + B – 25 % | Twill | 110.2         | 66.80      | 353.9     | 0.3228 |
| C – 65 % + B – 35 % | Twill | 101.5         | 61.7       | 338.8     | 0.2907 |
| C – 45 % + B – 55 % | Twill | 78.8          | 55.6       | 255.3     | 0.1979 |

Note: C – cotton; B – bamboo.

**Table 4.** Relative change of fabrics' hand parameters after washing and chemical treatment, compared to initial specimens (which parameters were equal to 1.0)

| Process                                    | $\Delta P_{\max}$ | $\Delta t_{ga}$ | $\Delta A$ | $\Delta Q$ |
|--|-------------------|-----------------|------------|------------|
| Raw fabrics                                |                   |                 |            |            |
| Cotton – 100 %, plain weave                |                   |                 |            |            |
| Washing                                    | 1.10              | 0.79            | 1.04       | 0.96       |
| Softening "V"                              | 0.98              | 0.75            | 0.95       | 0.87       |
| Softening "B"                              | 0.96              | 0.75            | 0.89       | 0.86       |
| Bamboo – 100 %, plain weave                |                   |                 |            |            |
| Washing                                    | 0.81              | 0.75            | 0.76       | 0.80       |
| Softening "V"                              | 0.51              | 0.52            | 0.49       | 0.62       |
| Softening "B"                              | 0.41              | 0.51            | 0.40       | 0.54       |
| Finished fabrics                           |                   |                 |            |            |
| Cotton – 45 % + bamboo – 55 %, twill weave |                   |                 |            |            |
| Washing                                    | 0.93              | 0.78            | 0.92       | 0.80       |
| Softening "V"                              | 0.33              | 0.33            | 0.35       | 0.18       |
| Softening "B"                              | 0.37              | 0.36            | 0.39       | 0.21       |
| Cotton – 100 %, twill weave                |                   |                 |            |            |
| Washing                                    | 0.94              | 0.74            | 0.99       | 0.82       |
| Softening "V"                              | 0.49              | 0.46            | 0.53       | 0.30       |
| Softening "B"                              | 0.53              | 0.52            | 0.60       | 0.36       |

Note: "V" – softener "Viskozil PSN"; B – softener "Belfasin Si".

Analysis of blended cotton/bamboo fabrics' hand parameters extent after soaking (washing) and chemical softening revealed that fabrics' soaking in water (washing imitation) and in chemical softeners decreased (improved) hand parameters in all cases (Table 4). Only in rear instances parameters  $P_{\max}$  and  $A$  insignificantly increased (raw cotton fabric of plain weave).

Chemical softeners improved hand parameters of all fabrics, but in case of raw fabrics – only up to 0.75 – 0.96 of the level of initial specimens, and for finished fabrics – up to 0.21 – 0.36. The influence of both "V" and "B" softeners was very similar. The most significant improvement, which was dependent on chemical softening, was determined for blended fabric (C – 45 % + B – 55 %). Softener "V" decreased all hand parameters of this fabric from 1.0 to 0.35 – 0.18, which means that hand has been improved by 3 – 5 times. It should be noted that the influence of softener "V" was more significant on cotton fabrics, and the influence of softener "B" – on bamboo ones.

It should be also noted that in all cases the most sensitive hand parameter was complex rate  $Q$ . Its variation (having different finishing conditions) often reached 5 times, when compared to corresponding parameters of initial specimens.

## CONCLUSIONS

Analysis of specimen extraction through a nozzle curve  $H-P$  peak's zone may be useful for investigation of specific textile fabric attributes, related to finishing peculiarities.

Addition of bamboo fiber into cotton fabric improves its hand parameters. Increase of bamboo fiber quantity leads to more significant improvement of fabric hand.

Efficiency of chemical softeners "Viskozil PSN" and "Belfasin Si" is very similar when softening cotton – bamboo fiber fabrics. The most significant changes, caused by chemical softening, are inherent to blended fabric (C – 45 % + B – 55 %). Softener "Viskozil PSN" improved all hand parameters of this fabric from 3 to 5 times.

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