Properties of elastic fabrics with treated and untreated Co/PBT yarns in weft direction

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Abstract. Studies in the field of elasticised woven fabrics made of Co/ PBT yarns indicate great potential of PBT use in woven fabrics. Weaving experiments demonstrate that elasticity of Co/PBT fabrics gained after treatment depends not only on woven fabric settings but also on on-loom settings. Therefore, it is difficult to predict precisely the degree of shrinkage of the Co/PBT fabric after treatment. Six samples of woven fabrics were produced, three samples with the pre-treated core spun Co/PBT weft, each in a different weave. Other three samples were woven with untreated core spun Co/PBT weft, in the same weaves and afterwards the samples were treated. The results indicated big differences between samples with pre-treated Co/PBT yarns in weft direction and samples treated after weaving.

1. Introduction

The theme of elastic fabrics is well researched topic, however the general use of elastic fabric in everyday life dictates further search for new, and better products. The usual production of elastic woven fabric is performed by weaving with elastic yarns, which affects the production process, the final product price and applicable properties. Studies in the field of elasticised woven fabrics made of Co/ PBT yarns indicate great potential of PBT use in woven and knitted fabrics. PBT (polybutylene terephthalate) is a textured polyester filament yarn with chemical structure that enable permanent elastic properties (stretch and recovery), which are achieved by the finishing processes. [1, 2]

Previous studies of elastic woven fabric containing PBT yarns were carried out on finished fabrics (treated in a boiling water at 100 °C for 30 min.), wherein the fabrics obtained elastic properties. By weaving point of view, this is an ideal solution, since the process of weaving is undemanding compared to weaving with elastic yarns. Properties of finished Co/PBT woven fabrics are of great dependence on constructional parameters. [3, 4, 5]

During the finishing process of Co/PBT fabric PBT filaments gain elastic properties, at the same time occurs shrinkage and swelling of cotton fibers. Shrinkage of Co/PBT yarns in the loose state differs from shrinkage in the clamped state (meaning yarns in fabric structure), which is affected by many factors, particularly by the weave and thread density. A larger number of interlacing points in the structure means more friction surfaces that inhibit the contraction of fibers/threads in the fabric.
Weaving experiments demonstrate that elasticity of Co/PBT fabrics gained after finishing depends not only on woven fabric settings (the share of PBT component in the yarn; the yarn structure and already mentioned fabrics settings) but also on on-loom settings (thread tension, speed, weft insertion technology, etc.). Therefore, it is difficult to predict precisely the degree of shrinkage of the Co/PBT fabric after finishing. By producing woven samples out of treated and untreated Co/PBT yarns, all with the same production parameters, we tried to demonstrate the influence of fabrics setting and sequence of treatment process (finishing) onto the fabric properties.

2. Experimental part

2.1. Sample preparation

All woven samples were produced on the sample loom Minifaber, on the same warp and with the same on-loom setting (Table 1).

| Sample designation | Weft Yarn | Weave | Treatment |
|---------------------|-----------|-------|-----------|
| Co/PBT – UN1        | Co/PBT core spun yarn | plain | Fabrics treated in boiling water |
| Co/PBT – UN2        | 40 tex with PBT core yarn | Twill 1/3 Z |
| Co/PBT – UN3        | 83 dtex | Twill 1/5 Z |
| Co/PBT – TR1        | Co/PBT core spun yarn | plain | Co/PBT yarn treated in boiling water before weaving |
| Co/PBT – TR2        | 40 tex with PBT core yarn | Twill 1/3 Z |
| Co/PBT – TR3        | 83 dtex | Twill 1/5 Z |

2.2. Methods used

After weaving and thermal treatment, basic properties of yarns and woven fabrics were analyzed:

- dimensional change (shrinkage) of Co/PBT yarn after treatment,
- number of threads per unit length - warp and weft density, SIST EN 1049-2,
- warp and weft crimp percentage in woven fabric, ISO 7211-3:1984,
- mass per unit area, SIST EN 12127,
- thickness, ISO 5084:1996,
- dimensional changes of treated fabrics, ISO 3759:2011,
- air permeability (Air-Tronic, Mesdan), ISO 9237:1995.
Dimensional changes (shrinkage) of samples in warp and weft directions were assessed according to the standard before and after thermal treatment. Dimensional changes of Co/PBT yarn after treatment were assessed by measuring the yarn length before and after treatment in boiling water. During treatment in boiling water for 30 minutes, in loose condition, the Co/PBT yarn shrunk by 36,5 %, which consequently resulted in a change of yarn fineness.

Pictures of samples were obtained using the stereo microscope 65.560 NOVEX with the digital camera CMEX 5000, magnification 6.5 x 0.65 (Fig. 1).

![Figure 1: Pictures of samples before and after treatment](image-url)
The fabric structure affected changes (thickness and weight) that occur after treatment dramatically. The longer the floats (in twill 1/5 Z) the higher contraction after treatment, thus increased weight more than 60% and increased thickness for 169.6% of sample Co/PBT-UN3. There is a noticeable difference between samples made of pre-treated Co/PBT yarns and samples treated after weaving. The differences in thickness and weight values of Co/PBT-TR samples derived only from floating length and thus ability of thread contraction.

### Table 3. Thickness and mass per unit area of samples

| Sample designation | Thickness (mm) | Mass per unit area (g/m²) |
|--------------------|----------------|--------------------------|
|                    | Before treatment | After treatment | Difference (%) | Before treatment | After treatment | Difference (%) |
| Co/PBT – UN1       | 0,35            | 0,61               | 74,3           | 110,75          | 124,14         | 12,1           |
| Co/PBT – UN2       | 0,47            | 0,93               | 97,9           | 117,75          | 151,46         | 28,6           |
| Co/PBT – UN3       | 0,46            | 1,24               | 169,6          | 118             | 196,2          | 66,3           |
| Co/PBT – TR1       | 0,39            | /                 | 137,1          | /               | /              | /              |
| Co/PBT – TR2       | 0,53            | /                 | 145,5          | /               | /              | /              |
| Co/PBT – TR3       | 0,58            | /                 | 145,4          | /               | /              | /              |

### Table 4. Warp and weft yarns per unit length (density) and crimp of warp and weft yarns

| Sample designation | Warp/weft density (yarns/10 cm) | Warp/weft crimp (%) |
|--------------------|----------------------------------|---------------------|
|                    | Before treatment | After treatment | Difference (%) | Before treatment | After treatment | Difference (%) |
| Co/PBT – UN1       | 208/154           | 248/170           | 19,3/10,4      | 9,5/9,5          | 11/11,4         | 15,8/20        |
| Co/PBT – UN2       | 210/152           | 290/166           | 38,1/9,2       | 9,5/8,7          | 12,1/18,9       | 27,4/117,2     |
| Co/PBT – UN3       | 210/152           | 369/164           | 75,7/7,9       | 4,5/14,3         | 11,8/36         | 162,2/151,7    |
| Co/PBT – TR1       | 212/148           | /                 | 6,4/7,9        | /               | /              | /              |
| Co/PBT – TR2       | 220/150           | /                 | 3,6/7,3        | /               | /              | /              |
| Co/PBT – TR3       | 220/150           | /                 | 5/5,1          | /               | /              | /              |

After treatment, thread density of Co/PBT-UN1 sample was increased 19,3% in warpwise and 10% in weftwise, while these values of Co/PBT-UN2 sample in warp-and weftwise were increased 38% and 9% respectively, and values of Co/PBT-UN3 sample in warp-and weftwise were increased 75,7% and 8% respectively. When compared the warp density of Co/PBT-UN samples, the fabrics with longer weft floats had higher warp density. As it was expected, the opposite phenomenon was observed for warp and weft crimp percentage. After treatment, the samples with longer floats and increased warp density had higher weft crimp percentage (Co/PBT-UN3: increased for more than 150%).

The results shown in Table 4, revealed that all Co/PBT-TR samples had similar warp and weft density with minor deviation due to different weaves. The lowest weft crimp percentage was obtained from Co/PBT-TR3 fabric sample following by Co/PBT-TR2 and 1 fabric samples. These samples exhibited similar properties as those of conventional cotton fabrics.
Table 5. Air permeability (measurement conditions: 100 cm², 100 Pa) and dimensional changes

| Sample designation | Air permeability | Dimensional changes (shrinkage) of fabrics after treatment |
|--------------------|------------------|----------------------------------------------------------|
|                    | Before treatment (l/min) | After treatment (l/min) | Difference (%) | Warpwise (% | Weftwise (%) |
| Co/PBT – UN1       | 126,1             | 56,5             | -55,1           | -12,8       | -18,6       |
| Co/PBT – UN2       | 185,7             | 60,9             | -67,2           | -11,1       | -34,15      |
| Co/PBT – UN3       | 196,5             | 63               | -67,9           | -10,8       | -46,45      |
| Co/PBT – TR1       | 109,6             | /                | /               | /           | /           |
| Co/PBT – TR2       | 120,92            | /                | /               | /           | /           |
| Co/PBT – TR3       | 135,44            | /                | /               | /           | /           |

The air permeability values of the Co/PBT fabric samples before and after treatment as well as values of the Co/PBT samples made of pre-treated yarns were given in Table 5. After treatment, the values of air permeability of Co/PBT-UN samples were decreased for more than 50%, while these values of samples with pre-treated Co/PBT weft yarns demonstrated better air permeability properties (with more than 100 l/min). The results and pictures revealed that treatment of Co/PBT samples after weaving worsened the air permeability significantly, since the fabrics with longer floats had very dense surface (Figure 1).

After treatment, the dimensional changes of Co/PBT-UN samples had negative values in both directions, meaning shrinkage after treatment and thus denser surface structure. Shrinkage values were approximately 10%. The highest shrinkage value in warpwise was obtained from Co/PBT-UN3 sample. The results revealed that weave structure with longer floats had tendency to excessive dimensional changes.

3. Conclusion
The results indicated big difference between samples with pretreated Co/PBT yarns in weft direction and Co/PBT samples treated after weaving:

- the samples with Co/PBT in weft direction treated after weaving had higher weight and higher thickness, these values increased in dependence on the weave (length of floating threads),
- the differences in thickness and weight values of Co/PBT-TR samples were slightly higher comparing to untreated Co/PBT-UN samples and derived only from floating length and thus ability of thread contraction,
- after treatment, the thread density of Co/PBT-UN samples were increased and these affected higher warp and weft shrinkage, where it is obvious that samples with longer floats and increased warp density had higher crimp percentage weft wise.
- 3D fabric surface, achieved by treatment and thus shrinkage of Co/PBT-UN samples, were similar to crêpe fabrics and gave a sense of fabric soft touch. However, there were two disadvantages, the decreased values of air permeability and excessive dimensional changes in terms of change of width of the fabric.

4. References
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