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Effect of Raw Material on Changes in the Weft Setting of Fabric

Abstract
This article analyses the dependence of changes in the weft setting of fabric on the integrated fabric structure factor φ, for woven fabrics of different raw materials. Similar research of the above changes after taking a fabric out of a loom and of the "stabilization in time" a fabric structure has not been conducted so far, despite the importance of trying to precisely evaluate the fabric structure at different stages of its manufacture. Five fabrics of different raw materials were analysed with respect to changes in their weft setting after taking the fabric out of loom and the "stabilization in time" of its structure. It was found that the above changes are regular in comparison with fabrics of different raw material.

Key words: *weavability, weft setting, integrated fabric structure factor φ, raw material.*

Introduction

Any fabric appears to be sophisticated material with a structure that has an impact on its properties [1]. There are seven basic parameters of a fabric structure: warp and weft raw material, the warp and weft linear density, the warp and weft setting and fabric weave [1 - 3]. All these parameters are evaluated by the integrated fabric structure factors. Different researchers have proposed different kinds of evaluation of all these parameters [4, 5]. According to the ways and methods of their evaluation, two groups of integrated factors are identified: those based on Peirce's theories and those based on Brierley's [6]. These groups differ in their physical meaning. Peirce's group of integrated fabric structure factors show the cover of the fabric surface using threads, whereas Brierley's group of factors present the weavability of the fabric expressed by the ratio of the setting of a given fabric to the maximum setting of a standard fabric. This article employs the integrated fabric structure factor φ, proposed by V. Milašius, which belongs to Brierley's group of fabric structure factors and are related to fabric weavability. This factor can be calculated according to the formula:

$$\varphi = \sqrt{\frac{2}{\pi}}\frac{1}{P_1}\sqrt{\frac{T_{av}}{\rho}}\,S_2^{\frac{1}{1+2/3\sqrt{T_1/T_2}}}\,S_1^{\frac{2/3\sqrt{T_1/T_2}}{1+2/3\sqrt{T_1/T_2}}}$$

where:
T_1 – warp linear density,
T_2 – weft linear density,
T_{av} – average woven fabric thread linear density,
P_1 – Milašius' weave factor,
ρ – raw material density,
S_1 – woven fabric warp setting,
S_2 – woven fabric weft setting.

Brierley standard fabric is dense at the maximum, square in the structure, plain weave and wire thread [7]. The fabric structure factor φ is related to the fabric's weavability, which appears to be one of most important technological properties of fabric, and the possibilities for its processing on a weaving loom are dependent on it [8]. The maximum factor φ is obtained when weaving fabrics at maximum weft settings. Kumpikaitė and V. Milašius [9] established that the weaving of fabrics under similar conditions, i.e. at maximum weft settings, a fabric of similar structural stiffness is produced, and the maximum integrated fabric structure factor φ is attained. The maximum factor φ as well as the fabric's weavability depend solely on the raw material and the construction of the loom [7, 9].

During previous researches on the tendencies and regularities of structural changes in fabric after taking it out of a loom, no stabilised structure was found. Therefore, the aim of this article is to define regularities in changes in the fabric weft setting when the weavability of fabrics with different raw material has changed.

Materials and methods

To identify the effect of raw material on changes in the weft setting, five fabrics of different raw materials were woven. Their structural parameters are introduced in ***Table 1***.

To examine the effect of fabric structure on changes in the weft setting, the fabrics were woven when φ was equal to 40, 45, 50, 55, 60, 65. The fabrics were also woven at a maximum weft setting. Maximum weft settings were achieved by gradually increasing the weft setting of the fabrics until the reed could no longer normally beat-up weft and cloth fell started to recede from its actual position. These maximum weft settings were obtained experimentally, whereas other weft settings were firstly calculated, taking into account the necessary value of factor φ. Afterwards fabrics were woven in this theoretically established weft setting.

After weaving the fabrics and removing them from the weaving loom, the weft setting was defined on the basis of the international standard ISO 7211-2:1984 [10]. After four weeks, the weft settings were identified once again, assuming that the structure of grey fabric after this period is already stable.

Experimental results and discussions

In the process of the research, attempts were made to establish how the weft setting in fabrics of different raw materials changes after removing them from the weaving loom and after stabilisation of

Table 1. *Primary data.*

Raw material	Weave	Warp and weft linear density, tex	Warp setting S_m, dm^{-1}	Yarn structure
Cotton	Plain	18.5 × 2	260	Plaid yarn
Wool	Crape	92.3	177	Spun yarn
PAN	Plain	347.0	63	Spun yarn
PP	Plain	166.7	59	Spun yarn
PES	Plain	29.4	284	Multi-thread

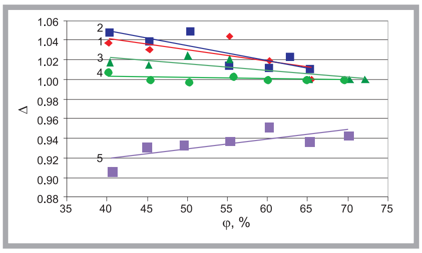

Figure 1. Dependence of alteration in the weft setting of fabric after removal from the weaving loom on the integrated fabric structure factor φ for woven fabrics of different raw material: 1 – PAN; 2 – PP; 3 – wool; 4 – PES; 5 – cotton.

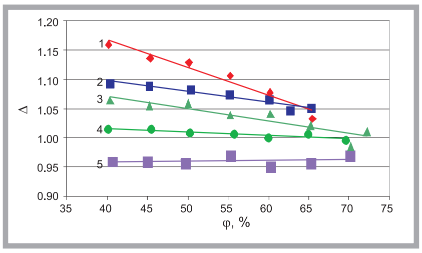

Figure 2. Dependences of alteration in the weft setting of fabrics after stabilisation of the fabric structure on the integrated fabric structure factor φ for woven fabrics of different raw material: 1 – PAN; 2 – PP; 3 – wool; 4 – PES; 5 – cotton.

the fabric structure. ***Figure 1*** introduces the dependences of changes (Δ) in the weft setting on factor φ for fabrics of different raw materials after removing them from the weaving loom in comparison with the weft setting on the weaving loom (during weaving). It becomes obvious that in many cases of fabric structure stiffening, when the integrated fabric structure factor φ increases, changes in the weft setting decrease, when comparing the weft setting of the weaving loom (during weaving) and right after removing the fabric from it. Δ was calculated according to the formula:

$$\Delta = \frac{S_{a2,3}}{S_{a1}}$$

where:

$S_{a2,3}$ – fabrics weft settings on integrated fabric structure factor φ (2 – after weaving loom; 3 – after stabilization of fabric structure)

S_{a1} – fabrics weft settings on integrated fabric structure factor φ (1 – in weaving loom).

The last point of all the lines presents the maximum weft setting, which was found experimentally. This is the reason that the lines do not finish at the same point. Other points of the lines were established theoretically, i.e. the weft settings were calculated according to the given factor φ and just after the fabrics were woven. Most varied weft settings were found for PP fabrics (from 1.011 to 1.049, which makes 3.8%), whereas changes in the weft setting of PES fabric were the fewest (from 0.998 to 1.007, which makes 0.9%), although it is not possible to maintain that alteration of the weft setting of the above fabric is permanent, as the experiment suggests. The settings of almost all the raw materials increase after removing them from the weaving loom, i.e. values of alteration in the weft setting are higher than 1. The line of cotton fabric is easily distinguishable, as values of the weft setting in these fabrics decrease after removing them from the weaving loom, whereas the settings increase when the value of factor φ becomes higher. This exclusive character of cotton fabrics could be explained by the fact that they were woven from plied yarn, whose behaviour after the weaving loom is different. The single threads in plied cotton yarns move mutually in relation to each other and became longer and less twisted when they are woven into the fabric. When the fabric becomes denser, the alteration of the weft setting approaches the primary weft setting of the weaving loom, which can be the reason for the different character of the cotton fabric line in ***Figure 1***.

Table 2 introduces equations and determination coefficients of the above lines. We presume that the determination coefficients are not high, i.e. defined dependences are not strong. In this case it was more important for the authors to focus on alteration tendencies in the parameters analysed rather than on the accuracy of dependences identified. The determination coefficient of PES fibre is the least, as any alteration in the weft setting of these fabrics is very insignificant.

Figure 2 introduces dependences of alteration in the weft setting on the integrated fabric structure factor φ, woven fabrics of different raw materials, comparing the weft settings of a weaving loom (during weaving) and after the fabric structure has settled. Apparently, the intensity of the alteration of lines is slightly higher compared to those previously discussed and presented in ***Figure 1***. Almost all the weft settings increased compared to those of the weaving loom, i.e. alteration in the weft setting is higher than 1. The line of cotton fabric is also exceptional as alteration in its weft setting is lower than 1, which means that the weft setting decreased compared to that of the weaving loom. The line of cotton fabric is almost parallel to the horizontal axis. Although the experiment was rather informative, it is not possible to maintain that alteration in the weft setting is stable. The most intensive alternation was found in the PAN fibre line – from 1.033 to 1.159, which makes 12.2%.

Table 3 introduces equations and determination coefficients of the above lines. Evidently, these are rather strong dependences, as the determination coefficients change from 0.8155 to 0.9503, i.e. they are rather high. The determination coefficient of cotton fibre remains low, as the line is almost parallel to the horizontal axis.

Figure 3 introduces dependences of the line alteration intensity *a* (this is the first regression coefficients of the line equ-

Table 2. *Equations and determination coefficients of dependences among fabrics after weaving loom.*

Graph	Raw material	Equation	Determination coefficient R^2
1	PAN	Δ = -0.0012φ + 1.0883	0.5096
2	PP	Δ = -0.0015φ + 1.1111	0.7090
3	Wool	Δ = -0.0007φ + 1.0503	0.6734
4	PES	Δ = -0.0001φ + 1.0075	0.1770
5	Cotton	Δ = 0.0012φ + 0.8695	0.5955

Table 3. *Equations and determination coefficients of dependences among fabrics after stabilization of fabric structure.*

Graph	Raw Material	Equation	Determination coefficient R^2
1	PAN	Δ = -0.0047φ + 1.3556	0.9503
2	PP	Δ = -0.0018φ + 1.1717	0.9225
3	Wool	Δ = -0.0021φ + 1.1542	0.8350
4	PES	Δ = -0.0006φ + 1.039	0.8155
5	Cotton	Δ = 0.0001φ + 0.9537	0.0415

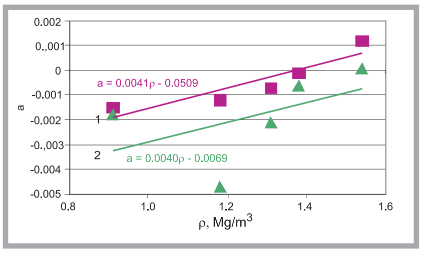

Figure 3. *Dependence of alteration level on the raw material density of the fabrics explored: 1 – after removal from the weaving loom; 2 – after stabilisation of the fabric structure.*

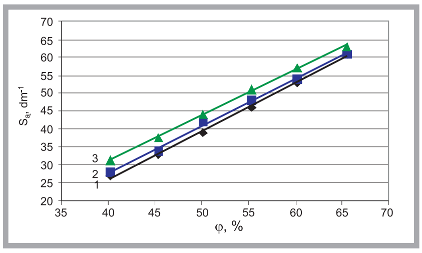

Figure 4. *Dependences of polyacrylnitrilic fabric weft settings S_a on the integrated fabric structure factor φ: 1 – in weaving loom/during weaving; 2 – after removal from the weaving loom; 3 – after stabilisation of the fabric structure.*

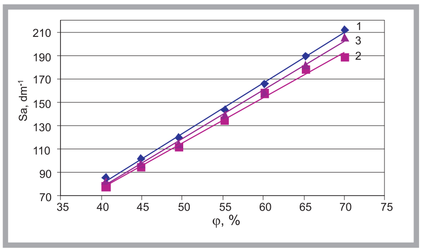

Figure 5. *Dependences of cotton fabric weft settings S_a on the integrated fabric structure factor φ: 1 – in weaving loom/during weaving; 2 – after removal from the weaving loom; 3 – after stabilisation of the fabric structure.*

ations from ***Tables 2*** and ***3***) on the raw material density ρ after the weaving loom and stabilisation of the fabric structure. The raw material densities of the fabrics analysed are given in ***Table 4***. Evidently, an increase in raw material density leads to an almost equal intensity of the alteration of graphs in both cases, as the lines are almost parallel to each other. The value of line regression coefficient *a* (from the ***Tables 2*** and ***3***) supports this, as it shows the angle tangent of its rise, i.e. the intensity of its rise, as we can see in ***Figures 1*** and ***2***. After stabilisation of the fabric structure, the rise angles of the graphs become smaller compared to those after the weaving loom. It should be emphasised that, unlike other fabrics, the points of PES fabrics do not differ from the group of other fibres, although the only fabrics of this material were woven from multi-thread yarn. Thus, it is possible to maintain that the dependences obtained fit both fabrics, woven from spun and multi-thread yarn.

Figure 4 introduces dependences of polyacrylnitrilic fabric weft settings on the integrated fabric structure factor φ after identification of the weft settings of the weaving loom (during weaving), after it and after stabilisation of the fabric structure. Graph 1 represents the weft settings of the weaving loom (during weaving). Evidently, this graph is the lowest, which indicates the lowest weft settings. Graph 2 shows weft settings after the weaving loom. This graph is higher and highlights an increase of 2 - 8% after the weaving loom. Weft settings increased even higher (up to 3 - 16%) after stabilisation of the fabric structure (see ***Figure 4*** & graph 3). Therefore, it is possible to maintain that the structure of the polyacrylnitrilic fabric came loose after the weaving loom; accordingly, weft settings increased.

The dependences of weft settings in cotton fabric on the integrated fabric structure factor φ are presented in ***Figure 5***. It introduces three graphs, reflecting the weft settings of a weaving loom/during weaving, after it and after stabilisation of the fabric structure. Evidently, graph 1, representing the weft settings of a weaving loom (during weaving), is the highest; accordingly, the weft settings are the highest, whereas graph 2 is the lowest; accordingly, the weft settings after the weaving loom are the lowest. This means that the fabric expanded after removal from the weaving loom. After stabilisation of the fabric structure, the weft settings slightly increased again, approaching those in weaving loom (during weaving).

Summary

This article analyses the dependences of alteration in the weft settings of 5 different raw materials on the integrated fabric structure factor *φ* after removing the fabrics from the weaving loom and stabilisation of the fabric structure. It was discovered that alteration of the weft settings in polyacrylnitrilic, polypropylene, wool and polyester fabrics decreases with an increase in the stiffness of the fabric structure. The weft settings in these fabrics increased after they were removed from the weaving loom, when the fabric structure stabilised. The results for cotton fabric are significantly different as they are likely to be influenced by the different structure of cotton yarn (plaid yarn is employed in the fabric). With a change in raw material, after removing the fabric from the weaving loom and after stabilisation of the fabric structure, the intensity of alteration in the weft settings reaches a similar tendency, which could be described by a line equation. The dependences attained fit for spun yarn and multi-thread yarn, which is demonstrated by the results for PES fabrics, which do not differ from the results related to fabrics of another raw material.

Table 4. *Values of raw material densities of raw materials densities of used fabrics.*

Number	Raw material	Raw material density ρ, Mg/m3
1	PAN	1.18
2	PP	0.91
3	Wool	1.31
4	PES	1.38
5	Cotton	1.54

References

1. *Kumpikaitė E.; Fibres & Textiles in Eastern Europe, Vol. 15, No.1 (60), 2007, pp. 35-38.*
2. *Kumpikaitė, E.;Fibres & Textiles in Eastern Europe, Vol. 16, No. 3 (68), 2008, pp. 44-46.*
3. *Kumpikaitė, E., Milašius, V.; "Analysis of Interrelation between Fabric Structure Factors and Beat-up Parameters", Materials Science (Medžiagotyra), 2003, Part 9, No. 2, pp. 228-232.*
4. *Milašius V.; The Journal of the Textile Institute, 2000, 91, Part 2, No. 2, pp. 277-284.*
5. *Milašius A., Milašius V.; Fibres & Textiles in Eastern Europe, Vol. 13, No. 1(49), 2005, pp. 44-46.*
6. *Newton A.; The Journal of the Textile Institute, 1995, 86, pp. 232-240.*
7. *Galuszynski S., Ellis P.; The Journal of the Textile Institute, 1983, 80, No. 6, pp. 357-365.*
8. *Milašius V., Milašius R., Kumpikaitė E., Olšauskienė A.; Fibres & Textiles in Eastern Europe, Vol. 11, No. 2 (41), 2003, pp. 48-51.*
9. *Kumpikaitė, E., Milašius, V. Influence of Fabric Structure on Its Weavability, Materials Science (Medžiagotyra), 2003, Part 9, No. 4, pp. 395-400.*
10. *ISO 7211-2:1984. Textiles – Woven fabrics – Construction – Methods of analysis – Part 2: Determination of number of threads per unit length. 1998. pp. 11.*

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