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New Employment of Integrating Structure Factor for Investigation of Fabric Forming

Abstract
In this article, new possibilities for employing the integrating fabric structure factor φ proposed by Vytautas Milašius are presented. The integrating structure factor φ in separate dents of the reed is proposed for estimating the fabric structure. In order to investigate this proposal, high-tightened fabric with irregular hopsack weave made from two types of yarns in warps with irregular placement was analysed. Because of the sufficient difference of the fabric tightness in the separate dent of the reed, the high breaking of ends in one dent of the reed (with the high factor φ) and loose ends and warp floats in another (with a low factor φ) can arise at the same time. It was determined that 3-4% is an acceptable difference between φ values in the separate reed dents.

Key words: *woven fabrics, integrating structure factor, reed dent, weave factor, weaving resistance.*

Introduction

Designing the woven fabrics and parameters of their technology and investigating their properties always presents the problem of how to generalise the fabric structure features by one integrating factor. The need for such a factor is so evident that interest in it has been ongoing since the end of the nineteenth century [1]. Peirce [2] particularly precisely specified the significance of the integrating fabric structure factor: "... it gives a very suitable basis of comparison for any experimental investigation, not only of cover but also of hardness, crimp, permeability and transparency, limits of picking, etc., in which fabrics of similar cover factors show similarity." At this time, possibilities for employing the integrating fabric structure factor proposed by V. Milašius [3] to solve various problems (for example, air permeability [4], fabric cross-section parameters unevenness [5]) are being analysed. The main aim of this article is to introduce the new possibilities of this factor by use of the factor φ to estimate the fabric structure, not for the whole fabric, but also in separate dents of the reed. This method refers to Brierley's [6] theory of maximum setting. Irrespective of the fabric structure factor, it is always calculated by comparing a certain mathematical expression of the given fabric structure's parameters with the maximum value of a so-called standard fabric. The method suggested by Milašius [3] refers (as does Brierley's method) to the comparison of the given fabric setting with the standard 'square' (balanced) structure maximum-setting 'wire' fabric (i.e. with a yarn packing density equal to 1) woven by a plain weave. The representation of this new integrating fabric structure factor is as follows:

$$\varphi = \sqrt{\frac{12}{\pi}}\,\frac{1}{P_1}\sqrt{\frac{T_{average}}{\rho}}\;S_2^{\frac{1}{1+2/3\sqrt{T_1/T_2}}}\;S_1^{\frac{2/3\sqrt{T_1/T_2}}{1+2/3\sqrt{T_1/T_2}}} \quad (1)$$

where:

P_1 - the weave factor calculated according to the propositions made in [3],

$T_{average}$ - the average of the linear density of threads [tex], calculated as

$$T_{average} = \frac{T_1 S_1 + T_2 S_2}{S_1 + S_2}$$

T_1, T_2 - the linear density of warp and weft, respectively,

S_1, S_2 - the setting of warp and weft [dm^{-1}], respectively, and

ρ - the overall density of raw materials of the threads.

The two main differences from Brierley's proposals are as follows: firstly, only a *g* factor value equal to 2/3 is used (which above all is independent of the type of the weave), and secondly a new weave factor P, calculated directly from the weave matrix, is used. Earlier [7] excellent correlation between P_1 and F^m was shown (F - the average of weave float, m - the empirical coefficient by Brierley), as well as between P_1 and the experimental weave factor [8]. The integrating factor of cloth structure (the fabric firmness factor φ) calculated in this way has none of the shortcomings enumerated by some authors when estimating similar factors. First, various different weaves are well estimated. This positive property is inherited from Brierley's weave factor F^m which correlates very well with the proposed weave factor P_1, but it lacks the subjectivity which Brierley's factor possesses because it can be calculated straight from the weave 2D matrix. On the other hand, the fabric firmness factor φ possesses all the characteristic peculiarities for such factors: it not only integrates the parameters of fabric structure, but it can also define properties of weaving resistance and weaveability, i.e. to estimate technological properties of loom and warp threads. The arrival of sophisticated fabrics with extremely irregular structure (high different linear density of the one-system threads, high different density of the warp in the fabric width, etc.) influences the requirement to evaluate the fabric structure in its various individual parts. The novelty of this proposal is the evaluation of fabric structure in its smallest part, namely in the separate reed dent. In this case, the outside threads of the neighbouring dents must be estimated by calculating the weave factor P_1.

Experimental Investigations

In this paper, a new possibility for the factor φ to illustrate fabrics with extremely irregular structures is described. As noted earlier [3], the factor φ can estimate the technological properties of

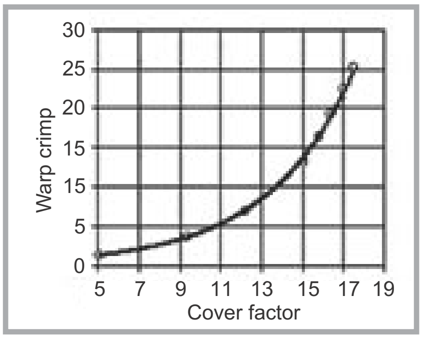

Figure 1. *Dependence of the warp crimp on the fabric cover factor according to Pollitt [7].*

a loom because the limiting value of the factor φ is one of the loom performances which is specific for any kind of loom. The conditions of weaving high-tightened fabrics are mostly at the limit of possibility for the specific type of the loom. The parameters of adjusting the loom have very low tolerances in this case. For simple structures with one type of yarn in warps and wefts and with simple weave, the integrating structure factor φ from the whole fabric can be used. In the case of weaving high-tightened fabric from more types of warp yarns and with irregular weave, some of the problems stated below may arise.

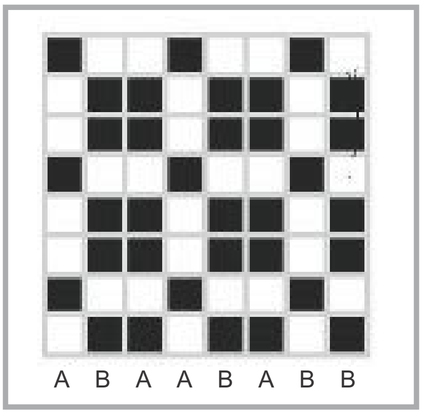

Figure 2. *Weave and placement of the ends, linear density $T_B=1.5T_A$.*

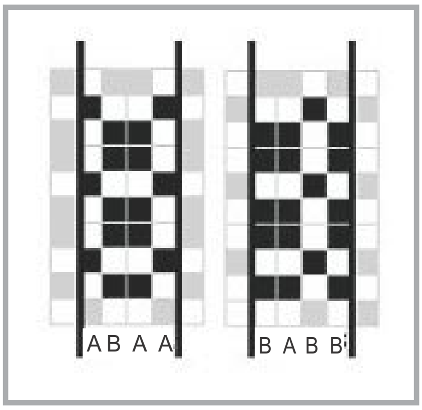

Figure 3. *Denting and weave of basic version.*

Pollitt's investigations [9] show the close exponential relation between the warp crimp and the cover factor (Figure 1). Because of the sufficient difference of firmness (which is one of the groups of integrating fabric structure factors, together with the fabric cover factor) in the separate dent of the reed, the high breaking of ends in one dent of the reed (with a high value of the factor φ, and thus having an abnormally high value of ends crimp), and loose ends and warp floats in another (with the low factor φ) can arise at the same time. Opposite tendencies in adjusting warp tension are predicted: on one hand, because of high breaking it should be reduced; on the other hand, at the same time it should be increased because of warp floats. It follows that the conditions of small parts of fabric forming become very important. In the paper, the smallest part of the fabric which it is possible to control is determined by the number of ends drafted into the reed. The high-tightened fabric investigated is made in irregular hopsack weave from two types of yarns in warps with irregular placement. In Figure 2, the weave and sequence of displacements of the warps of the fabric produced are presented. The integrating factor φ calculated for the fabric equals 68.3%. This value can be achieved on some types of looms [3]. The basic version of the fabric (Figure 3) was drafted with four ends in the dent. The black squares mark the interlacing of warps in the dent of the analysed reed, and the light grey squares mark the interlacing of warps placed in the next dent of the reed adjacent to the just-mentioned one. On this basis, the average linear density of warps in the first dent of the reed (Figure 3) is 112.5 tex, and the warp density in the reed is 128 dm^{-1}. In this dent of the reed, there are four free fields of the third group and four free fields of the fifth group [6]. From here, P_1=1.13 and φ=66.6%. In the second dent of the reed, the average linear density of yarns is 137.5 tex, the density in the reed is 128 dm^{-1}, P_1=1.13 and φ=70.0%. So, the difference between the values of φ was 3.4%.

While weaving this fabric with an unbalanced value of φ, increased breakage of the ends and an increase in the number of warp floats were observed. After adjusting the drafting into the reed by placing the last end at the beginning of the repeat, we can achieve the same value of φ=68.3% in all the dents of the reed (version A, Figure 4a). The run of this fabric version weaving was correct enough, but in both these versions the dent of the reed does not separate the pairs of the warps with the same interlacing, which means they may sometimes turn around themselves, thereby decreasing the quality of the fabric.

Table1. *Parameters of the fabrics.*

Version	First dent				Second dent				Third dent				Fourth dent				$φ_{max}$ - $φ_{min}$
	S	T	P	φ	S	T	P	φ	S	T	P	φ	S	T	P	φ	
B	96	116.7	1.134	60.0	160	130	1.130	75.7									15.7
C	144	116.7	1.134	70.1	144	133.3	1.129	73.1	96	125	1.132	60.9					12.2
D	144	116.7	1.133	70.1	96	150	1.132	63.0	144	116.7	1.129	70.4					7.4
E	128	125	1.124	68.8	128	125	1.139	67.9	128	125	1.132	68.3	128	125	1.132	68.3	0.9

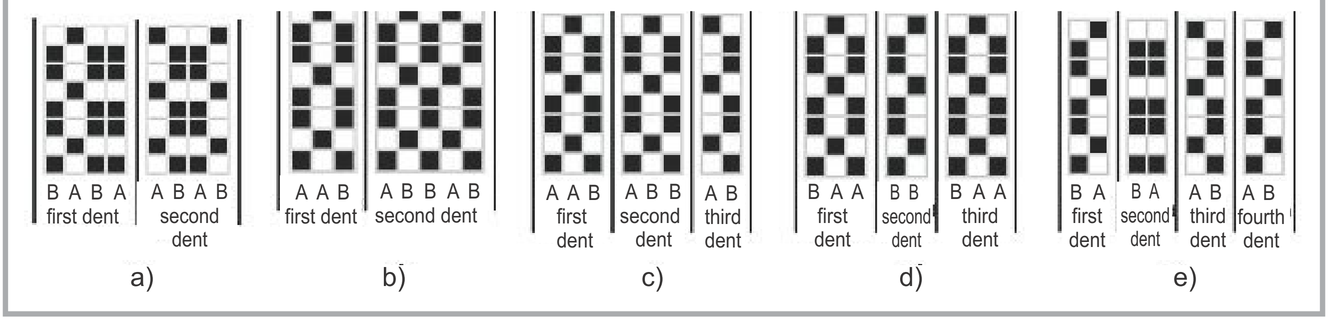

Figure 4. *Denting and weave of fabrics: a - version A, b - version B, c - version C, d - version D, e - version E.*

The following versions are presented for the investigation of conditions of fabric forming, separating pairs of warps and keeping the value of φ in the dents of the reed as equal as possible. As mentioned above, the difference of highest and lowest value of φ in the dent of the reed might mostly be important for weaving high-tightened fabrics (Table 1). In this Table, the data is given for the corresponding reed dent: S - the setting of warp (dm^{-1}), T - the linear density of warp (tex), P - the weave factor, and φ - the integrated fabric structure factor.

Weaving version B (Figure 4b) with such an unbalanced value of φ was completely impossible. Replacing warp No 1 with No 8 will only reduce the difference to 12.3%. A new drafting 3-3-2 (version C, Figure 4c) presented results which were almost the same as version B. On the basis of weaving experience producing this fabric, the difference of φ was too high to produce a fabric of acceptable quality. After changing ends and a new drafting (version D, Figure 4d) weaving conditions became better, as did the fabric quality, but it still was not acceptable. The difference in values of φ in version E (Figure 4e) is only 0.9%. This manner of fabric setting was most successful, yielding the best quality of the fabric and the most acceptable weavability. On the basis of the last experiment, we came to the conclusion that acceptable weavability and quality of the fabric could be achieved by minimising the difference of φ values to a sufficient level. It is worth mentioning that the firmness factor of the whole fabric was the same in all the cases.

Using the results of earlier investigations [10], it is possible to calculate the weaving resistance when producing the above-mentioned fabrics. The results are presented in Figure 5. One can see from Figure 5 that a small difference in the factor φ (for example 4%) makes a marked difference in weaving resistance (more than 20%). As noted above, only versions A and E give satisfactory results. All the other versions (B, C, and D) give abnormally large numbers of end breaking and warp floats. Earlier, Peirce [2], Seyam and El-Shiekh [11] showed that there is a close relation between weaving resistance and warp crimp. This completely conforms to the results of Pollitt's earlier-mentioned investigations [9]. On the basis of all these above-mentioned investigations, the conclusion can be drawn that an enlarged difference between integrating fabric structure factors in separate reed dents causes an increased difference between weaving resistance in small parts of the fabric, as well as between the end crimps, and thus the breaking of the ends (in some dents) and the number of warp floats (in other dents) increase. So, the conclusion could be drawn that an acceptable difference between φ values in the separate reed dents is 3-4% (the blank area of the diagram).

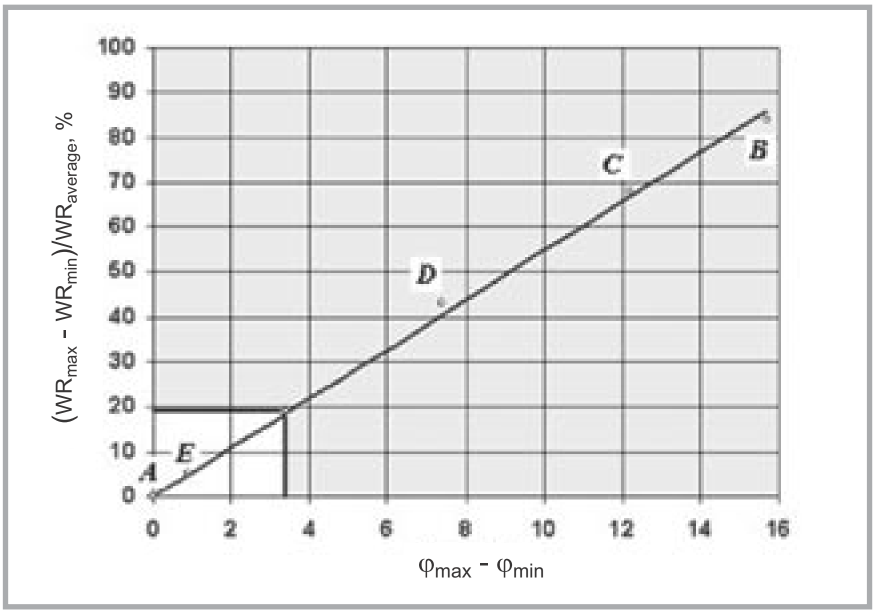

Figure 5. *Dependence of difference (calculated by [8]) between the values of the weaving resistance in separate dents (%) on φ_{max}-φ_{min}.*

Conclusions

Sophisticated fabric with an irregular extreme high-tightened structure (irregular hopsack weave, two types of yarns in warps, irregularly placed) was investigated. The integrating structure factor φ can be used for investigating the weavability and quality of this fabric. In this case, the integrating structure factor φ in the separate dents of the reed was proposed for estimating the fabric structure. Because of the sufficient difference of the fabric tightness in the separate dents of the reed, the high breaking of ends in one dent of the reed (with the high factor φ) and the loose ends and warp floats in another (with the low factor φ) can arise at the same time even though the integrating structure factor of the whole fabric is constant. It was determined that an acceptable difference between φ values in the separate reed dents is 3-4%.

References

1. *Thos. R. Ashenhurst, A Treatise on Textile Calculations and the Structure of Fabrics. 1884, Huddersfield, England.*
2. *F. T. Peirce, The Geometry of Cloth Structure. J. Text. Inst., 1937, 28, T 45-196.*
3. *V. Milašius, An Integrated Structure Factor for Woven Fabrics, Part II: Fabric-firmness Factor. J. Text. Inst., 2000, 91, Part 1, No. 2, 277-284.*
4. *R. Milašius, V. Milašius. Investigation of Unevenness of Some Fabric Cross-Section Parameters. Fibres & Textiles in Eastern Europe, 10, 2002, No.3, p. 47-49.*
5. *R. Milašius, V. Milašius, E. Kumpikaitė, A. Olšauskienė. Influence of Fabric Structure On Some Technological and End-Use Properties Fabrics. Fibres & Textiles in Eastern Europe, 11, 2003, No 2, p. 49-52.*
6. *S. Brierley, Theory and Practice of Cloth Setting, The Textile Manuf., 1931, 58, 3-4, 47-49, 130-132, 206-208, 244-246.*
7. *V. Milašius, On Evaluation of the Fabric Weaves, Izv. VUZ. Tekhnologija Tekstilnoj Promyshlennosti, 1983, No 4, 49-51 (in Russian).*
8. *V. Milašius, A. Milašius, R. Milašius, Comparison of Integrating Structure Factors of Woven Fabric, Materials Science, 2001, 7, No 1, 48-53.*
9. *J. Pollitt, The Geometry of Cloth Structure, J. Text. Inst., 1949, 40, P11-P2.*
10. *V. Milašius, An Integrated Structure Factor for Woven Fabrics, Part I: Estimation of the Weave. J. Text. Inst., 2000, 91, Part 1, No 2, 268-276.*
11. *Seyam, A. and Aly El-Shiekh, 1995. Mechanics of Woven Fabrics. Part V: Impact of Weavability Limit Parameters on Properties of Fabrics from Yarns with Thickness Variation. Text. Res. J., 65, 14-25.*

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