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Investigation of Unevenness of Some Fabric Cross-Section Parameters

Abstract

Woven fabric, as other textile materials, has a specific three-dimensional structure; fabric thickness to all intents and purposes is low in comparison with its length and width. On the other hand, the various changes in the plane projection of fabric yarns, and the unevenness of yarn cross-section parameters are apparent. These examples illustrate that even very small changes in yarn cross-section parameters have very considerable influence on fabric properties, as presented and analysed in this article. It is determined that the fabric structure parameters (weave and settings of the threads) as well as weaving technology parameters (by the shrinkage of grey fabric) influence the unevenness of fabric cross-section parameters. The intention of this article is to demonstrate that at first sight the trivial variation of thread cross-section parameter (in the case presented in this article, it is about 10%) has in some cases substantial influence on fabric properties (for example, on air permeability).

Key words: *fabric cross-section, thread projection, air permeability.*

Introduction

Woven fabric, as other textile materials, has a specific three-dimensional structure (to all intents and purposes fabric thickness is almost negligible in comparison with its length and width). For this reason the main factors in the fabric's structure define its properties, considering the fabric as only a two-dimensional structure, such as linear densities of threads, setting, weave. To some degree this stands to reason, because the fabric plane characteristics are the most influential characteristics on its end-use properties and others as well. Furthermore, measuring the fabric's plane characteristics is much easier than measuring its cross-section parameters, for which the quite expensive microtome cut method is necessary. Moreover, considerable variation in the values of cross-section parameters measured using this method is observed; thus a large, expensive and time-consuming experiment is necessary. This all decides that only two-dimensional fabric characteristics are used for its estimation at this time. The third dimension is estimated only indirectly by the linear densities of yarns, their crimp etc. On the other hand, we may propose calculating the values of the fabric cross-section parameters using its setting data as well as some data of indirect measure - value of fabric thickness, value of horizontal axis of thread cross-section, values of crimp [1]. During this period of computation technique, when the personal computer and scanner have become the tools of everyday use for researchers, measuring the thread plane projection (i.e., the value of the horizontal axis of the thread cross-section) has become very cheap, quick and simple. The question arises of whether the visual picture reflects the real value of the horizontal axis of the thread cross-section. The experimental data available show that the difference between the value of the thread projection and the value of the horizontal axis, which is measured from the fabric cross-section, is inappreciable [1]. After assuming that the shape of thread cross-section is a lens [1], it is possible to calculate other parameters of the fabric cross-section. Of course the next question arises of whether these investigations are a talking point for practical use, because the values of cross-section parameters are very small. Can the tiny little changes of these parameters have a considerable influence on the fabric's properties? The problem of accidental variation in the yarns' cross-section parameters is not the subject of this article. The various regular changes in plane projection of fabric yarns and the unevenness of the yarns' cross-section parameters emerged for this reason, and the examples illustrate that even very small changes to the yarn's cross-section parameters considerably influence the fabric properties, which is demonstrated and analysed in this article.

Method of Investigation

The measurements were carried out using a PC with a scanner. The resolution of the equipment used allows the parameters of fabric structure to be measured with an accuracy of ± 0.01 mm. The measurement process is easy, time-saving, and cheap. Additionally, it is convenient for estimating the variation of the thread parameters in the fabric plane. Naturally, this method allows the measurement of only one thread's cross-section projection, i.e., in the plane of the fabric. However, other thread projections, e.g. the value of the vertical axis of its projection, can be evaluated theoretically assuming that the yarns' cross-section shape in the fabric is known, for example, a lens.

Experimental Results and Discussions

As stated above, it is accepted that the lens simulates the cross-section of threads. This shape of cross-section is characteristic of fabrics made from multifilament yarns [2]. While investigating the fabric woven from multifilament polyester yarns, it was found that the cross-section of the ends in the fabric was uneven. Weft threads show practically no change. Three main kinds of yarn unevenness were defined:

1) change in the yarns' cross-section parameters in the repeat for special kinds of weave,
2) change in the yarns' cross-section parameters for high-setting plain weave fabrics,
3) regular change in the yarns' cross-section parameters in the width of the fabric.

The first case - reshaping the yarns' cross-section at different points of the weave - is especially characteristic of multifilament weave fabrics. The example is presented in Figure 1. The

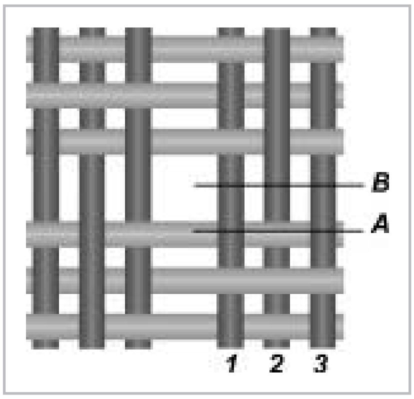

Figure 1. Scheme of the mock leno weave fabric.

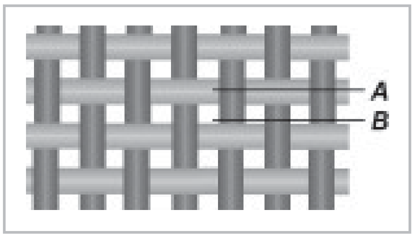

Figure 2. Scheme of the high-setting plain weave fabric.

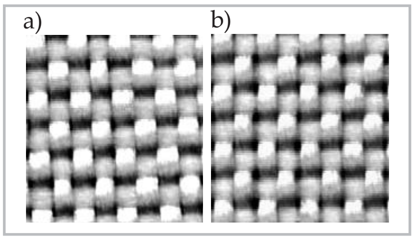

Figure 3. Image of fabric at 15 cm (a) and 60 cm (b) from its edge.

projections of warp threads 1 and 3 of the cross-section axis in the plane of fabric are variable. The value of this projection in the surroundings of line A (warp float points) is 0.40 mm, and that of the B (the points of warp interlacement) is 0.27 mm, i.e. considerably wider than the measuring accuracy (equal to 0.01 mm). This difference comes to 30%. The same tendency is noticed for the high setting plain weave fabric.

The value of projections of warp threads in the warp float point A (Figure 2, for the fabric woven from polyester 29.4 tex yarns and warp setting 320 dm^{-1} is equal to 0.35 mm) is 13% greater than the value of projection at the thread interlacement point B (equal to 0.31 mm). This unevenness can be eliminated by decreasing the setting of the warp threads. It is possible to anticipate that after decreasing the warp setting to 286 dm^{-1}, the unevenness of warp projection values can be eliminated, because the value of warp projection in float point A is equal to 0.35 mm. But in reality decreasing the warp setting increases the value of warp projection, because the neighbouring warp threads squeeze one another less. The evenness of warp projection values was obtained after merely decreasing the warp setting value to 260 dm^{-1}.

These two examples prove conclusively that the fabric's cross-section parameters vary significantly at different points. This assertion is very important, because in some cases the variation of the threads' cross-section influences the fabric's properties. The 160 cm-width fabric from multifilament polyester yarns for the aviation industry [3] can be analysed as an example. This fabric was chosen because of its specific employment; in this case, even a small-scale variation of the various properties is a very unacceptable phenomenon. While investigating the air permeability of this fabric, it was determined that this depends on the part of fabric from which the specimen was cut, either at the edge of fabric or at its centre. The image of this fabric at 15 cm and 60 cm from the edge of the fabric is presented in Figure 3.

From Figure 3 one can see that the value of projections of warp threads on the fabric plane at the edge of the fabric (a) is greater than its projection in the centre of the fabric (b). Therefore, further investigations were carried out to analyse the dependence of warp projections on the distance from the fabric's edge. The results of these investigations are presented in Figure 4.

From Figure 4, we observed that the high variation of projection is noted only in the part of fabric near the edge, up to 40 cm from both edges. The variation of projection in the central part is slight (within the limits of error). It must be noted that the maximum variation of the results of the individual experimental points is ±0.01 mm, and the coefficient of variation is not more than 4%.

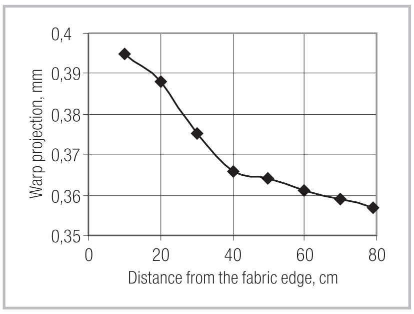

Figure 4. Dependence of warp projection on the distance from the fabric edge.

The part where the warp projection varies depends on the difference between the fabric's width after weaving and the width in the reed, i.e. on grey fabric shrinkage. If this shrinkage increases, the part of the fabric in which the warp projection varies increases too. As is known, grey fabric shrinkage depends on the fabric structure as well as on the parameters of weaving technology such as warp tension, heald-crossing time, reciprocal position of backrest and cloth support, and so on. Thus, the warp projection variation also depends on the parameters of weaving technology.

After investigating some properties of this fabric, it was determined that its variation is very similar to the variation in values of warp projection. The dependencies of fabric air permeability and thickness on the distance from the fabric edge are presented in Figure 5 and Figure 6.

From Figure 5 and Figure 6, we see that the dependencies of air permeability and thickness on the distance from the fabric edge are noted only at the edges of the fabric, up to 40 cm from both edge. This means that they coincide with the dependence of warp projection on the distance from the fabric edge. The variation in these properties in the central part of the fabric is slight (within the limits of error). The maximum variation of the experiments is ±9 dm^3/m^2s for the air permeability and ±0.01 mm for the fabric thickness (both coefficients of variation are not more than 4%). It will be observed that the correlation between properties investigated and the warp projection is very high (R^2=0.979 for air permeability and R^2=0.879 for thickness). On the other hand, the distances between the warp axis (i.e. setting of the warp) remain the same, equal to 0.41±0.01 mm. As was mentioned above, the weft horizontal projection remains constant. It is thus possible to state that variation of warp projection in fabric plane has principal influence on the fabric properties investigated. Studying the fabrics of different settings, it was noted previously [4] that the fabric air permeability depends on the area of fabric pores and the area covered by individual threads. In summary, air permeability depends on the shape and value of "the inter-thread channels, which are dependent on the weave and structural parameters of the fabric" [5], between them on the threads' cross-section.

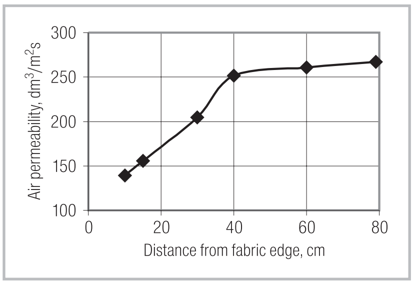

Figure 5. Dependence of air permeability on the distance from the fabric edge.

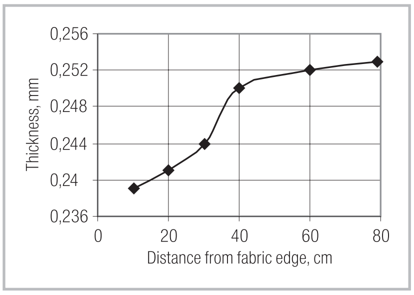

Figure 6. Dependence of fabric thickness on the distance from the fabric edge.

The same results were obtained while investigating other raw fabrics. For example, basket weave 2/2 fabric of 155 cm width made from polyamide 15.6 tex yarns and a fabric of 120 cm width made from polyester 29.4 tex yarns are both characterised by the same strong regular unevenness, as presented in Figure 4. It is important that S. Schlichter established the analogous unevenness of end stress on the loom [6].

Thus, the values of the yarn projections are not always constant; moreover, the regular unevenness changes also, it depends on fabric structure parameters and can distinctly influence the fabric's end-use properties.

Conclusions

Although fabric has a three-dimensional structure, the fabric's main factors are defined only by its plane properties - linear density of threads, setting, weave. The third dimension is estimated only indirectly by linear density of the threads and coefficients of crimp. It is possible to calculate the parameters of the fabric cross-section by using the data of the fabric setting and some measured values - thickness of fabric, value of horizontal axis of flattened thread, coefficients of crimp - which indirectly evaluate the parameters of the fabric cross-section. After considerable progress in computation technique, the measurement of the thread plane projection (i.e. the value of the horizontal axis of flattened thread cross-section e.g. in the form of a linse or ellipse) has become very cheap, quick and simple. After assuming the fabric cross-section's shape, it is possible to calculate its other parameters. The properties of the fabric depend on thread projections, which are one of the parameters of the fabric cross-section. It is thus very important to know that this parameter of the fabric cross-section is uneven. The designer can either eliminate this unevenness or forecast the variation in some fabric properties. It has been determined that both the fabric structure parameters (weave and settings of the threads) and the weaving technology parameters influence the unevenness of the fabric cross-section's parameters (e.g. by the shrinkage of grey fabric).

In this article, we do not propose how to eliminate the variation of the cross-section parameters and whether to do so always or not, because this variation does not always influence the fabric properties. The intention of this article is to demonstrate that at first sight the trivial variation of thread cross-section parameter (in the case presented in this article, it is about 10%) has in some cases substantial influence on the fabric's properties (for example, on air permeability). Especially when evaluating technical fabrics it is thus necessary to turn ones' attention to the parameters of the fabric's third dimension, the parameters of the cross-section, and especially to their variation.

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