ABRASION RESISTANCE OF COTTON/FLAX FABRICS: 3D COMPUTER SIMULATIONS OF FABRIC WEAR GEOMETRY

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Abstract

Geometrical models constructed using WiseTex software are used to describe the abrasion resistance of flax/cotton two-layered fabrics. Good agreement with experimental observations is found.

Keywords

abrasion, geometrical models, woven fabrics

Introduction

Purely natural textile materials are in vogue nowadays. Two-component footwear fabrics, combining a cotton and a flax layer without a chemical bond, are a perfect example of the advantages which can be gained by using these materials. The flax sits in the outer, ‘heavy-duty’ layer, and the cotton inside, forming the hygienic liner of the textile footwear.

One of the important properties which determines the quality of a footwear fabric is its abrasive resistance. The paper presents an approach to modelling the change of the fabric geometry induced by abrasive wear. Our interest is focused on the change in the surface filling factor and the fabric thickness with the progressive wear of the fabric. The rate of this change indicates the rate of abrasion and allows qualitative assessment of the fabric’s resistance to wear.

A full quantitative model of abrasion must include a mechanical description of the wear process. The approach we use is purely geometrical. However, we show that this simplified model comprises the important generic features of wear, and can even be predictive to a certain extent.

The geometrical modelling is based on WiseTex textile modelling software [3,4], and the earlier version of this model, CETKA software [5,6].

Similar models have been presented also in [1,2] although concerned with different problems.

1. Materials

Three types of cotton-flax fabrics were used in this study (Figure 1). All the fabrics have the following common features:

- The same flax (92 tex in warp, 97 tex in weft) and cotton (155 tex) yarns are used.
- The weave has two layers.
- Flax yarns are used in the outer (face) layer of warp, and in both weft layers; cotton yarns form the inner (back) layer of warp.
- The flax yarns stay almost circular in the fabric, the cotton yarn is flattened (compression coefficient 0.6).

The models of the fabrics were created with WiseTex software. Figure 2 illustrates the qualitative adequacy of the models. The twill pattern on the face of the fabric is well represented by the computer-generated image. The roughness of the surface, important to the abrasive resistance, is also featured in the models. Upper flax warp yarns are well over the upper flax weft, creating a rough surface with ‘hills’ and ‘valleys’.
The comparison with the specified and measured fabric parameters (areal density, thickness, yarn crimp) shows good correspondence between the computed and experimental values. This allows the models to be used for the further study of the fabrics’ internal geometry and changes in wear.

2. Virtual ‘Microtoming’

To model the abrasion wear, the sections of the fabrics were created using the WiseTex tools (Figure 3). The sections were made parallel to the fabric surface at the depth step of 1% of the fabric thickness, and the relative area $S$ of the sectioned yarns (surface filling factor) was computed for each section. Figure 3 shows the dependence of $S$ on the position of the section.

At the beginning, the graphs for fabrics 1 and 3 coincide. The sections in this region include the yarns of the upper warp only, which are of the same weave pattern (plain) and of the same geometry for these fabrics. The basket weave in the face of fabric 2 creates a higher surface in the sections in this region.

When the section goes deeper in the sample, it starts to include warp cotton yarns of the bottom layer. The rate of the increase in $S$ is higher for fabric 1, because it has a plain weave for the bottom layer, as opposite to the weft-effect weaves of the fabrics 2 and 3.

A sharp minimum at the depth of 60% for samples 2 and 3 is explained by the transition of the sections from the top to the bottom weft yarns. For fabric 1 this effect is shaded by the presence of large sections of the plain-woven warp yarns.

For the depth of over 60%, the graph for fabric 1 goes lower than that for fabrics 2 and 3. This can be explained by the weft-effect of the back layer weaves of the former fabrics.

Using the computed data, the mass distribution of the fibrous material through the fabric thickness can be derived. We assume that:
- the density of the fibrous assemblies are the same in all the yarns;
- the volume of fibres between the two neighbouring sections is proportional to $S$.

With these two assumptions, the mass distribution curve would follow the $S$~$h$ curves of Figure 3.
3. Experiment in abrasive wear

An experimental study of the abrasive wear of the flax/cotton fabrics has been performed on the IM-3M rig. The load of 10 N and sand paper was used. After each 200 rotations the rig was stopped, the fibrous dust removed and the sample weighed. Using the mass distribution curves, the data of the mass loss of the samples was transformed into the dependency of the fabric thickness on the number of rotations of the abrasive disk (Figure 4).

A reasonable assumption of the criterion of a fabric's full disintegration would be the onset of the destruction of warp/weft yarns in all the layers. The geometric modelling predicts this onset to start at
the reduction of thickness of 35...40% (Figure 5), which is in good agreement with the experimental observations.

![Figure 5. Damage pattern of fabric 3, thickness reduction of 40%](image)

4. Conclusions

The geometrical WiseTex modelling of two-layered flax/cotton fabrics provides a tool for ‘virtual microtoming’ the fabrics. The dependencies of the area of fibrous material in a section on the section depth and the yarn damage pattern in the sections proved to be a useful instrument for assessing the resistance of the fabrics to abrasive wear, and for explaining the phenomena observed in the wear test with the abrasive disk.

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References
