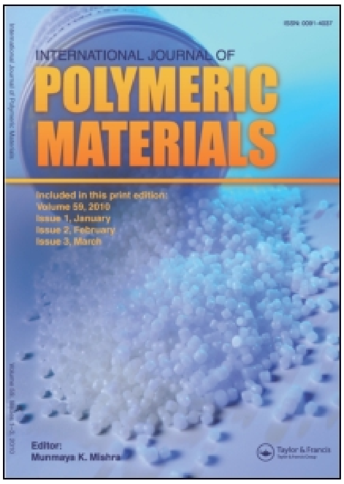

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1D, 2D and 3D Knitted Composite Reinforcements

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1D, 2D and 3D Knitted Composite Reinforcements

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Knitted fabric properties are extremely variable. It allows to use them for many different purposes. One of the possibilities is the reinforcement of so called textile composites, which have already been widely used and very probably are going to be spread much more yet in the future. What are the possibilities of such knitted fabrics construction, including double layer and three dimensional products *etc.*, is briefly described in this article.

Keywords: Knitted composite reinforcements; double layer knitted fabrics; fabrics break elongation; technical textiles; multiaxial fabrics; spatial knitted products

1. INTRODUCTION

Very probably, next century will be characterised as a century of new materials. Textile based composites may play an important role, because enable to use well the properties of income material.

Some of the advantages of knitted or alike products are these:

(a) Great variability of knitted fabric properties (extremely high or low extensibility, thick, thin fabric or net *etc.*).
(b) Possibility of double or multi-layer fabric construction.
(c) Possibility of linear (one dimensional, 1D), flat (2D) and space (3-D) products creation, in some cases without loss of textile material.

2. VARIABILITY OF KNITTED FABRIC DEFORMATIONAL PROPERTIES

From the point of view of possibility to change its dimensions, the knitted fabric is extremely variable. To compare with woven fabric it can be very extensible. It can be explained by more complicated guiding of the yarn through the fabric with many changes of its axes direction. The changes of the knitted fabric dimensions can be so enabled only by reshaping of the yarn. An example of the double faced weft knitted structure, which extensibility in the courses direction use to be several hundred percents, is introduced in the Figure 1 [2].

On the contrary, the knitted fabric which is very stable and with very small elongation till break can be constructed. Two of many examples of so called multi-axial fabrics can be seen in the Figure 2. Knitted structure with the straight yarns in 4 directions a, and woven

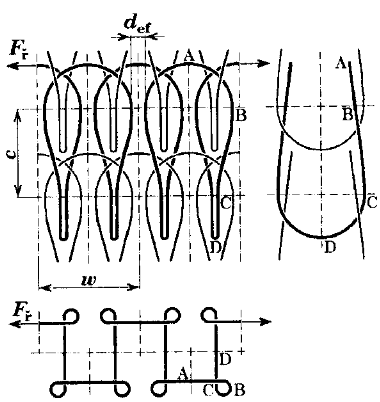

FIGURE 1 Structure of double faced weft knitted structure.

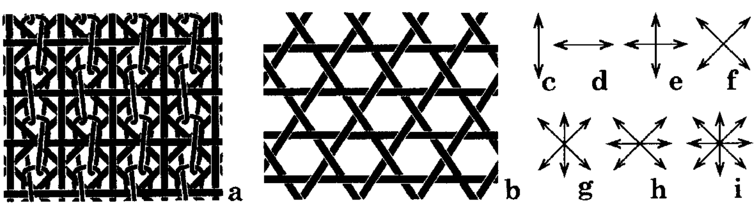

FIGURE 2 Multi-axial knitted and woven fabrics.

3-axial structure b. The disadvantage of woven example is formation of clusters of the binding points.

The straight yarns provides the structure with extremely high strength and low elongation at break, what make them to be very useful as composites reinforcement. The survey of the main possible directions of the yarns in the fabric is introduced in the Figure 2c–i. Nevertheless, the influence of the elongation at break is not so simple. Some share of the elastic and plastic deformation of reinforcement can improve the tenacity of the composite and its notch strength. This effect can be reached by suitable fibers, not necessarily only by the flat textile structure.

3. 1-D PRODUCTS CONSTRUCTION

Longitudinal textiles can be produced by different technologies. As far as they are aimed to bear the tensile stress only and stay flexible, the technology to twisted ropes or cables can be used. More complicated profile, suitable for bearing the bending moment as well, can be reached by "tailor" technology, as in shown in the Figure 3a [2]. The well known profiles T, I, U, L are introduced.

The braiding technology enables to produce even quite complicated profiles. To remember the base of this structure, the most simple

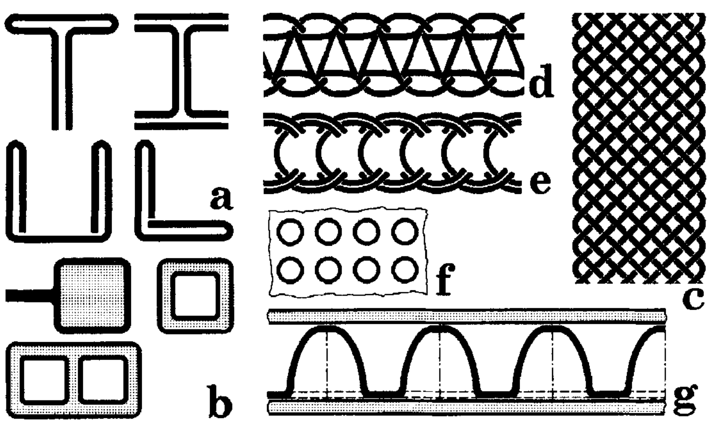

FIGURE 3 Examples of 1-D and 2-D composites reinforcements.

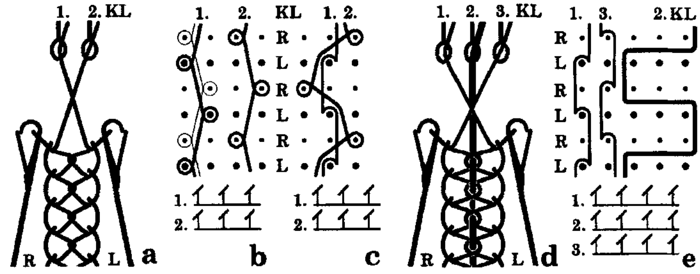

FIGURE 4 Examples of warp double layer (distanced) fabrics.

possibility, used often as a ribbon bookmark, is in the Figure 3c. It resembles a little plain woven structure, but it is composed of one system of yarns only. Modern braiding machines incorporate CAM system and provide possibility of very complicated interlocking of the yarns. Each yarn carrier, called mallet (lacer bone), can within one panel follow optional route and complicated spatial product can be reached. Some examples are in the Figure 3b.

From the point of view of bending rigidity, the I profile is the best if the bending moment acts in one direction or tube in the case of random bending moment direction.

4. 2-D PRODUCTS CONSTRUCTION

For 2-D composites the bending load can be supposed to be the most important. For efficiency of its construction it is important to concentrate the most of the mass on the surface of the product and light inner parts of it. As well as at metal constructions, the resistance against bending load depends on the second moment of area and for efficiency it is necessary to have as small space of the cross-sections as possible. Inner parts of the composite bear only small normal tension σ_N which depends on the tangential tension σ_T and curvature and can be calculated by $\sigma_N = (\sigma_T)/r$, where r is the radius of the product neutral axis. As r is at composites very great, the mass of inner components of the reinforcement could be reduced. Examples of such knitted structures are shown in the Figure 3d (based on the warp knitted structure) and e (weft knitted structure).

The product in a shape of thick plate can be produced as well by combined technology. Shaped knitted fabric can be use as a filling between two covering independent thin plates. Example of such construction is in the Figures 3f, g. As a filling can be used, for example, warp knitted structure suitably deformed and chemically fixed by resin (3-D textile composite).

Two particular possibilities of double layer (distanced) warp knitted products construction are shown in the Figure 4. They are based on knitting of two independent layers, on each needle bed of double bed warp knitting machine (for example raschel machine) one. Example a, b, c introduces connection of two parts by cross lay-in of the yarns (right guide bar on the left needle bed and on the contrary). To connect the face and the reverse of the structure, the crossing of both yarns creating binding points are necessary. Example d, e shows the possibility to connect the layers using another supplementary yarn (laid in by guide bar 2), which is hidden within the structure and can, if suitable, reduce the extensibility in the wales direction.

5. 3-D KNITTED PRODUCTS

An imitation of three dimensional knitted product can be easily derived from tubular knitting (or: knitted fabric) when two independent layers are only locally connected. Using warp knitting technology, it can be done by additional guide bar or by the change of the warp laying. Some examples can be seen in the Figure 5, the space where the face and the reverse is connected is marked by grey colour. First (a) describes the possibility how to produce the sacks which are ready for use by cutting the strip of the fabric without any sewing.

Textile product, which can replace concrete boarding, is in the Figure b (the concrete is pumped in the space between two layers of the fabric). Last example (c) shows suspension "pockets" that can for example serve as an noise and pollution insulation of the roads from buildings. The pockets are to be filled by soil mixed with the grass seeds, necessary maintenance is regular moistening. The pockets can be as well used for planting of the trees on the steep slopes *etc.*

From the point of view of 3-D fabric manufacturing, the weft knitting technology has an exceptional position. Spaced textile product can be created even from one reversibly laid yarn without any textile material losses. It enables to change the length of the added courses and such to vary in a great scale the number of the stitches in different wales and courses. The basic principle of it is well known from the construction of the heels of hosiery goods, see scheme of knitting in the Figure 6a. In another words, there is a wedge added to the tubular fabric.

When the shortening of the courses is done almost till zero value, the knee-joint of the pipe-line can be made, see the Figure 6b, b′ (scheme of knitting and appearance of the result). To receive more smooth change of the tube direction, several lower heels could be done, Figure 6c, c′. Out of a lot of other possibilities, the Figure 6d, d′ shows the box-shaped fabric. If there is any disadvantage of this technique it is necessity to use the weft knitting technology only, when the properties of the warp knitted or woven structures have a better properties for the textile reinforcements usage.

6. DISCUSSION

The contribution brings only brief survey of chosen possibilities of some technical textiles production. Only the list of such different textiles from the point of view of the use should cover several pages.

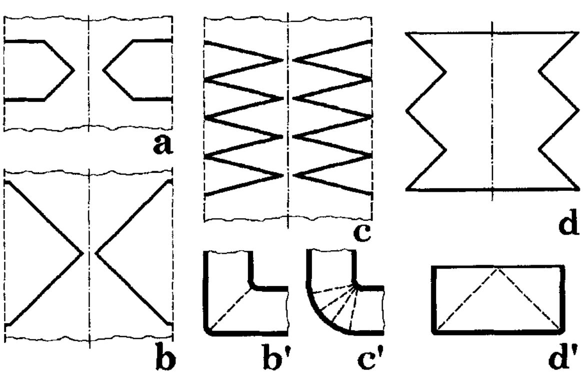

FIGURE 6 Examples of spatial knitted fabrics produced without waste.

Some technologies have already been introduced into practice, some others are waiting for development, invention or only for a good idea.

A raw of yet not solved problems there exists. From the point of view of knitted reinforcement structure and properties it is lack to suitable theory for calculation of the textile product and final composite properties, which could enable purposeful design or projecting of the fabrics with desirable appearance. On this field the theory could be much more important then it is in the fashion textiles.

Acknowledgements

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