KNITTED PREFORMS FOR COMPOSITES MATERIALS

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Abstract
Computer controlled weft flat knitting machines offer a great capability of manufacturing 3D structures, due to their technical features as: electronic needle selection, specific mechanisms and machine quick set-up. The design capability of CAD systems has also a significant contribution to the patterns variety. Knitted fabrics due to their inimitable properties can successfully meet the demands required by composite materials.

The first part of the paper presents an overview about knitted composite preforms, which are considered of a great importance because of their highest deformability and impact resistance compared to other textile based composites.

The second part aims to summarize the results upon technological conditions of producing spacer fabrics on CMS 530 E 6.2 weft flat knitting machine, Stoll, Germany. The study concerns the limits of stitch density and take-down values, for spacer fabrics with two outer layers and two connecting layers, as decisional parameters of fabric’s compactness.

Composites made from spacer fabrics have a great diversity, given by the design options of the outer layers structure, the way of connecting the layers (yarns or knits), structural parameters adjustments and consequently flexible properties.

Keywords: knitted preforms, weft spacer fabrics, technical application.

1. Introduction

Composite textiles refer to a range of textile surfaces that can be obtained by: weaving, braiding, knitting or nonwoven materials. When choosing the optimal variant of technology for composite preforms it must be taken into account both strengths and weaknesses of each preform.

The applicability of technical textiles in engineering has grown exponentially in the recent decades. These materials are known as technical textiles and they are used for: transport, geotextiles, civil engineering, road construction, aerospace, military, medical, sports equipment, protective clothing, etc. Composite materials with textile reinforcements represent the main domain of applicability of the technical textiles [1].

Knitted preforms have the advantage of a superior mass/resistance ratio, a low implementation time, a low amount of waste from the process of production, and a better control of the final shape and the quality of the product.

Advanced composite materials are based on textile materials with complex forms that are very different from the traditional materials, being used together with plastics, glass, films, and paper [2].

Knitted preforms as components of the sandwich structures can be used in domains which require product mass deduction, such as: buildings, aeronautics industry, machine industry, geotextiles, and protective equipment.

A sandwich fabric represents a three-dimensional construction compounded of two or many surfaces connected together through the connecting layers, see Fig. 1.

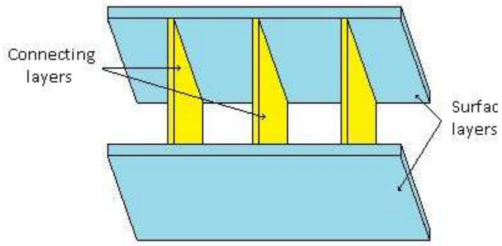
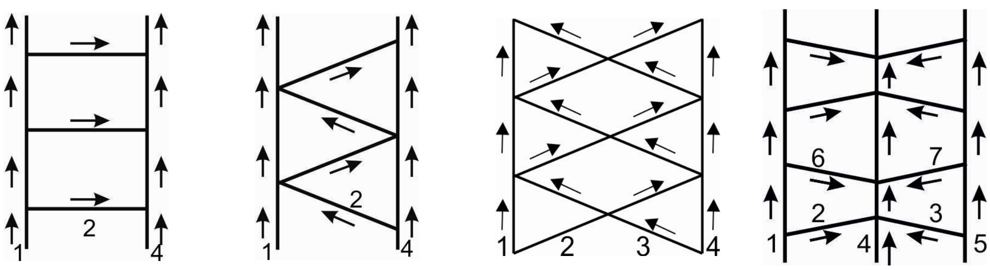


Figure 1. Principle of sandwich fabrics

The classic system of producing sandwich structures (weaving or knitting on circular knitting-machines) implies the connection of the layers by stitches. The disadvantage of these technologies is the limited distance from the two connected surfaces, due to the distance between needle beds [3].
The production of the preform requires the use of three-dimensional technology that can be made by the flat knitting machines controlled by microprocessor. These machines are based on the electronic selection of the needles at a certain level, systems of integrated cams for knitting and transfer, racking movement of the rear needle bed, main take-down mechanism, auxiliary take-down mechanism, knock-over sinkers and adaptable delivery mechanism. These characteristics offer the possibility to make technical fabrics with three-dimensional applications [4].
The paper aims to analyse the methods of producing knitted preforms based on sandwich structures. Secondary, the authors establish the technological limits of their production on the computer controlled flat knitting machines and suggest the technical solutions of varying them.

2. Sandwich structures

The principle of producing sandwich fabrics implies the knitting of two independent layers on the two needle beds and connecting layers will be knitted after finishing the knitting of the main layers. The connection between layers can be made either by yarns or by knitting or tucking, respectively. The recommended needle arrangement for knitting the bindings between surfaces is the 1:1 ratio.
In case of developing structures with connection by knitted layers, these can be one, two or more, according to the desired assembly cross section. The existing solutions [5], [6], deals with knitting or one or two layers, see Fig. 2.1. The option of one layer connection is based on the single needle bed knitting principle and single jersey structure. The two layers connection can be performed on two needle beds in patent or interlock structure.
According to the number of surface layers the developed spacer fabrics were defined as two surface layers and three surface layers, see Fig. 2.1 [5].



Single layer Double layer

Knitting direction; 1,4,5 – surface layers; 2,3,6,7 – connecting layers

Figure 2.1 Sandwich structures with one or two connecting layers

The sandwich cross section can be engineered according to the connection points between layers (number and position). This way, the cells formed inside the assembly can be designed with vertical, horizontal or a diagonal orientation, see Fig. 2.2.

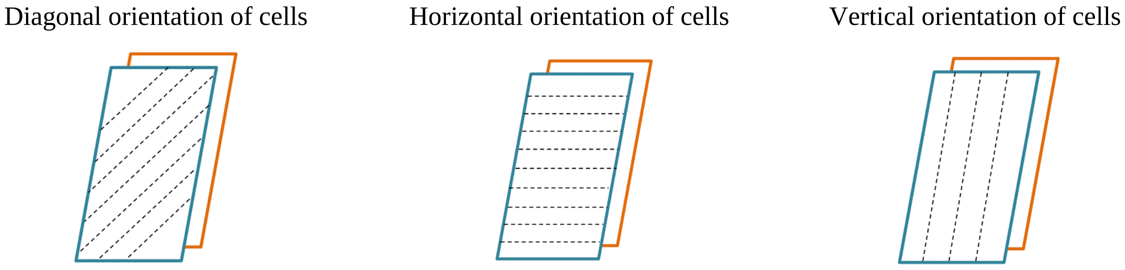


Figure 2.2 Options of cells position

These orientations can be used to produce some fabrics with technical purposes or different applications (liquid conduction, the intromission of some sensors, batteries, electric conductors) [6].

3. Technical solutions for spacer fabrics

The technical developments of the electronic flat knitting machines improved the possibilities of engineering knitted forms with various shapes. The fabric shaping can be performed by using the following methods: modifying the dimensions of the layers, alternating the working needles both on the row and wale direction and bind off technique.
The shape of the sandwich fabrics may vary according to the dimension of the connecting layer, incomplete rows knitting method, spatial narrowing.
Through the variation of the layers dimensions it is obtained a modification of the section cross section, see Fig. 3.1. By knitting on selected needles, and maintaining the loops on the needles which don't participate to the knitting temporary, one can achieve the incomplete rows, see Fig. 3.2. The spatial fully fashioning of the form is made by narrowing and widening with transfer stitches and needle beds racking [7], see Fig. 3.3.

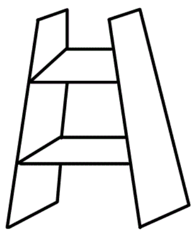


Figure 3.1 Modifying the layers dimensions

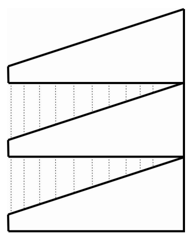


Figure 3.2 Incomplete rows knitting method

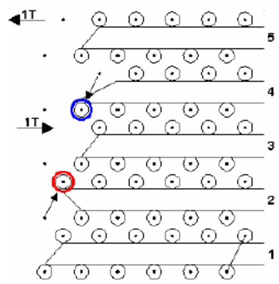


Figure 3.3 Spatial narrowing

4. The experimental part

When producing the spacer fabrics on the flat knitting machines, by connecting the outer layers with knitted layers, the degree of fabric compactness is low, due to the high distance between the needles which are participating to the knitting of one layer. The present work establishes the optimum technological parameters experimentally determined, in order to get the best fabric compactness. The fabrics were designed on M1 pattern station and they were produced on a Stoll CMS 530, E 6.2 electronic knitting machine. The fabrics are presented in Fig. 4.1, as principle.

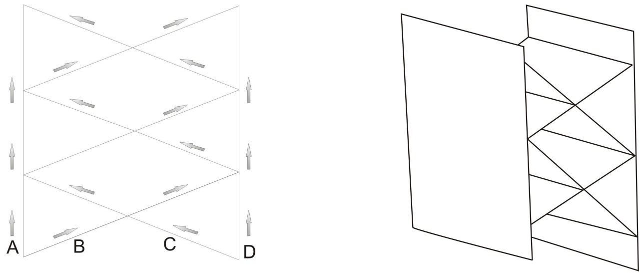


Figure 4.1. Principle of sandwich structure with two connecting layers

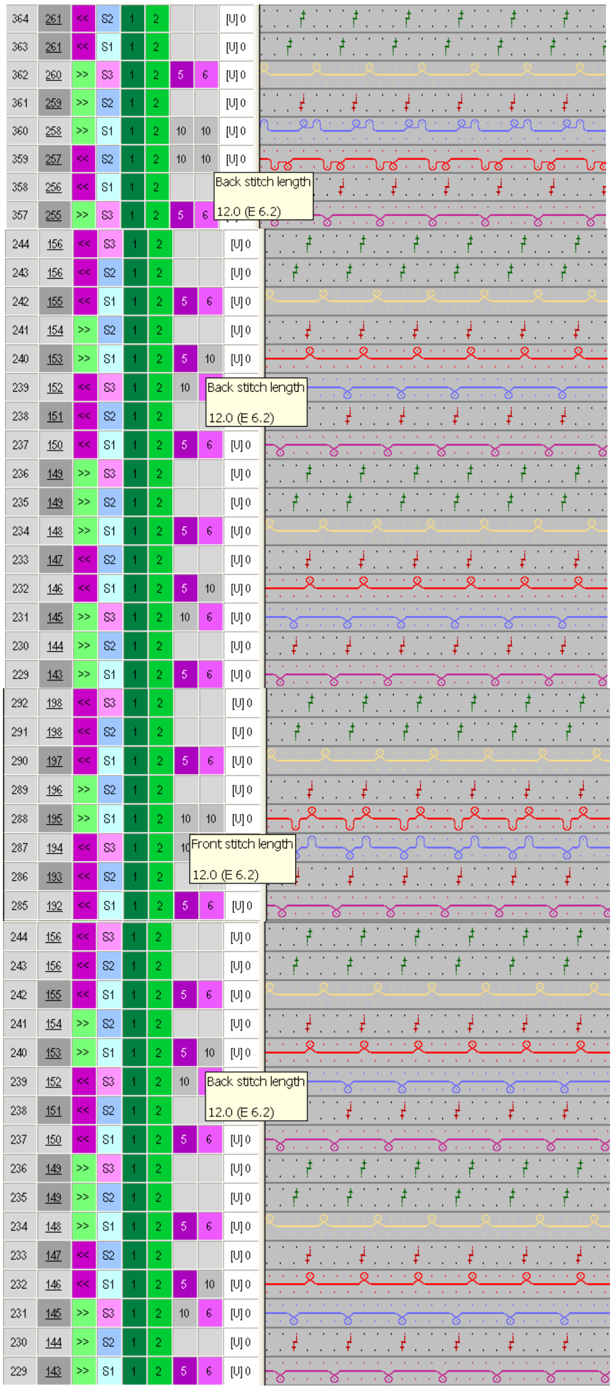
To achieve this objective it was chosen a sandwich structure with two connecting layers using a 50/50% PAN/Cotton yarn, Nm 30/2. The fabric was knitted with a 1:3 needles arrangement.

Figure 4.2 Sandwich structure with two connecting layers

The chosen values of stitch density were NP=12, NP=11, NP=10 and NP=9. These structures are based on a high number of transfer stages, and in order to avoid the cast off, a low value of carriage speed was employed (0.5÷0.7) m/s and the take-down force was chosen in the interval of WM=3÷3.5. The knitted fabric with NP=12 proves a low degree of tightness, which is increasing along with the reduction of the loop depth. The minimum value of the stitch depth can be used to obtain this structure with the yarns previously mentioned is of NP=9, lower values create yarns breaking. Between NP 12.0 and NP 10.0 the aspect of fabric doesn’t show significant changes, but from NP 10.0 and NP 9.0 the fabric compactness modifies essentially. The tightness is increased but the obtained aspect is not the best quality and appearance one, because the sinker loops excessively pull the yarn from the sinker loops of the neighbour stitches. A finishing process could improve the appearance or another option concerning the structure, so further trials should further done.

Figure 4.3. Sandwich structure with two binding layers

The knitting scheme used for the production of the sandwich fabric with two connecting layers is shown in Fig. 4.4.



The connection between the inside layers is made by tuck loops on the opposite layer.

The knitting of the two layers, with needle ratio 1:3.

The connection of the inside layers to the outside ones is made by tucking.

To obtain a sandwich fabric the work should be done in 1:3 relations, using two yarn carriers, one carrier for each thread. Two layers are knitted on the front bed and two on the rear bed. To individualize the layers it is made the successive transfer of the stitches.

Figure 4.4. Knitting scheme and the description of knitting process

5. Conclusions

Sandwich fabrics are three dimensional structures suitable for the production of 3D knitted preforms used for technical purposes. If high performance yarns are used, these composites provide improved mechanical properties compared to traditional materials. The use of flat knitting machines offers great possibilities of shaping for knitted preforms.

The dimensional spacer fabrics provide tortuous spaces which allow air, heat and moisture to be transferred through the fabric easily. These characteristics make them recommendable to use for medical purposes, pillows, matrices, shoes, tables for operations.

Technical solutions for fabric diversification are summarised below:

- Variations of the number of layers;
- Combinations between the outer fabrics, connecting layers on vertical and horizontal position;
- Engineering the thickness by modifying the length of connection layers;
- Developing different structure and opacity independently on each side;
- Using different materials for the two fabric sides and spacer threads;

To obtain a high degree of fabric compactness for this group of fabrics, on a machine with 6.2E, one can use Nm=30/2 yarns, knitted with a stitch depth of NP=9 and take-down force WM=3.5 or changing the thread with Nm=24/1, in combination with a stitch depth of NP=12.

The structural design of the sandwich structures is essential for the fabric properties engineering. Especially the cross section of the fabric is responsible for the channel shape and orientation, thus for the type of resulted cells. The properties of the fabric depend on the cross-section geometry, which is determined by joint points position between layers.

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