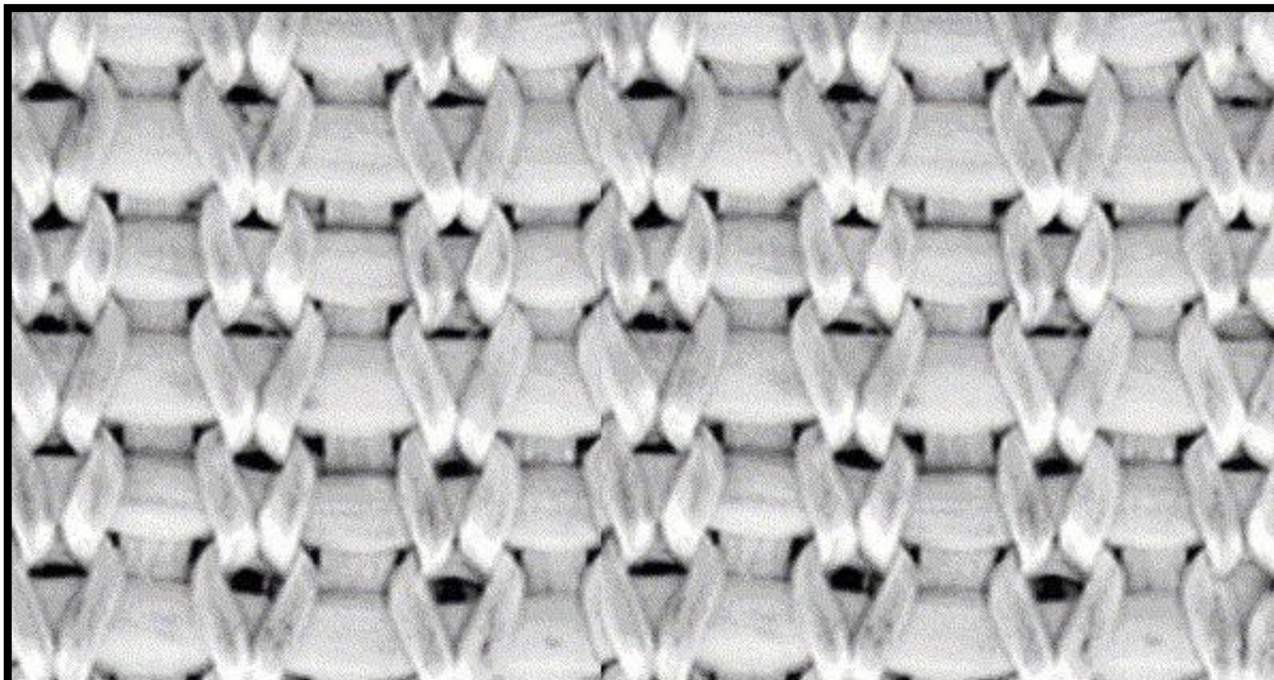
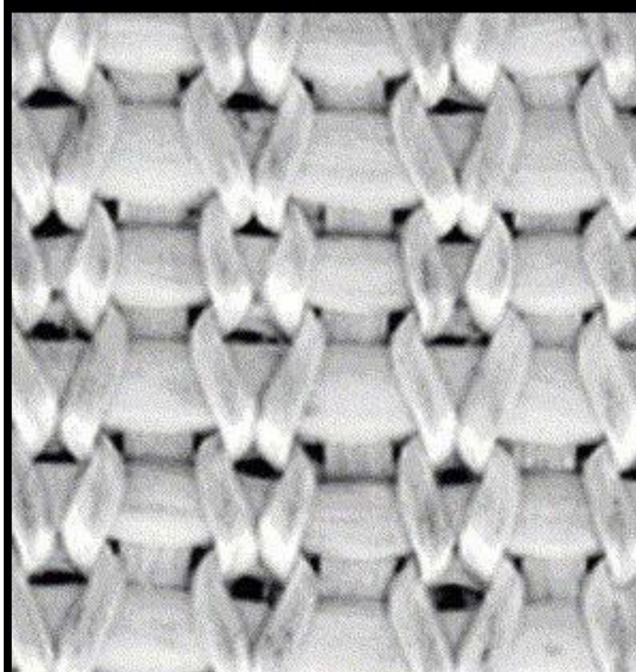


Fashionable preforms from Biaxial Weft knits



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The Advanced composite manufacturing process increases the demand of the shape of preforms from the biaxial knits in a fashionable way. One possible way for producing such preform materials is that via flat knitting technology. For most applications it is necessary to incorporate straight load bearing yarns into the fabric structure to account for the mechanical properties demanded for the composite part. The focus has been on combining the advantages of flat knitting with the various possibilities of two- and three-dimensional fully fashioned knitting. The aim is to achieve the manufacture of fully fashioned fabrics with straight load bearing yarns on flat knitting machines.

Biaxial Reinforced Knitted Fabrics

Biaxial reinforced knitted fabrics are composed of weft and warp yarn layers which are held together by a stitch yarn system (Figure 1). Reinforcing yarns can be used within all yarn systems. The reinforcing yarn systems provide the necessary composite strength and stiffness, whereas the knitting structure allows the high drapeability of the preforms, as well as good impact behaviors of the composite. The Figure of the knitting needles and its cycles are clearly drawn below,

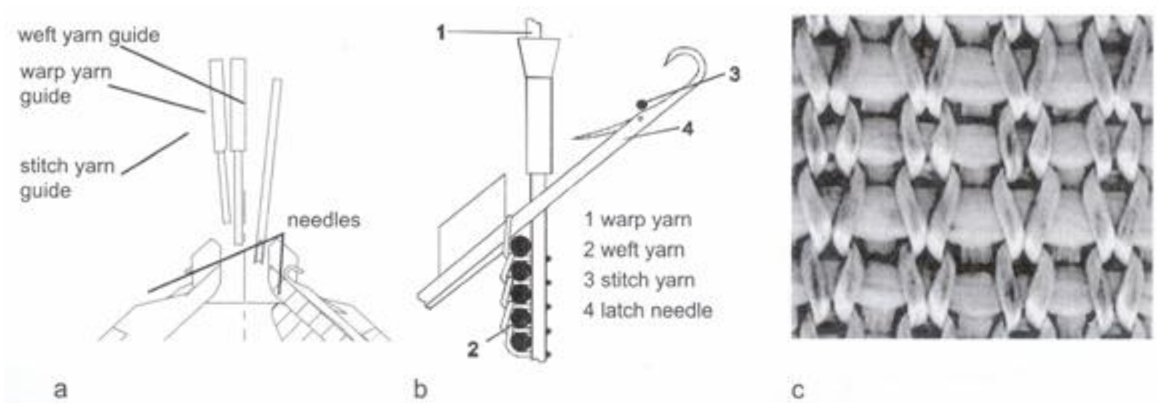

Figure 1: Working area of a biaxial flat knitting machine (a) and cross section (b) or top view (c) of a biaxial reinforced knitted fabric.

In combination with thermoplastic matrix materials, the preforms are suited for production via the thermo moulding method. The deformation of multilayer knitted fabrics during composite manufacturing is limited by the fabric's structure itself. At present the focus is on experimental investigations regarding the modification of a serial flat knitting machine with individual needle selection to allow the production of reinforced near -net shape preforms. The limited space in vicinity of the working area is illustrated in Figure 1, a.

The biaxial reinforced near -net shape preforms have been produced. Currently the required warp yarns are fed from the left and right sides of the machine. As a result of this, the fabric width is limited.

Shaping methods of biaxial knits

Various methods of fabric fashioning are known for flat knitting. One method of fashioning can be achieved by varying the number of stitches, i.e., by variation of the stitch length or the stitch pattern respectively. A different method is varying the number of stitches in the course direction as well as in the wale direction. In this method variation of the number of stitches in wale direction is particularly discussed. For producing fully fashioned biaxial reinforced fabrics by varying the number of stitches in the wale direction, partial courses have to be knitted. This means that in certain courses only selected needles are used for knitting. The remaining needles do not participate in stitch formation in a particular course, but the loops formed are kept in the needle head until employed for stitch formation again. This operation is called needle parking. The developed view of an optimized preform for a cuboid open on one side is shown in figure 2. The respective needles are parked in the area of the notches at the four corners of the cuboid, while the number of needles is varied according to the geometric requirements. After the completion of a corner, all needles participate again on stitch formation over the fabric width. Thus, none of the edges of the cuboid need to be subsequently sewn. In figure 2 a finished corner is illustrated on the right.

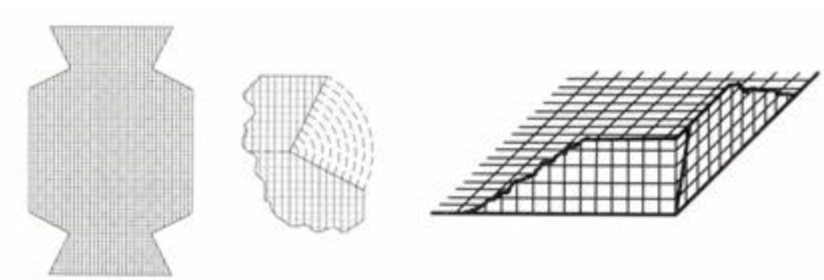

Figure 2: Production of a cuboid, open on one side, via needle parking method

Figure 3: Arrangement of the reinforcing yarns within the knitted preform

Regarding manufacture of the composite part, the arrangement of the reinforcement yarn has to be observed closely (Figure 3). On both side walls of the cuboid, the continuous warp yarns are turned round twice. The weft yarns are arranged continuously only within a respective side wall, and coincide at the reversing points. In Figure 3, the arrangement of weft and warp yarns is shown on the left. For greater clarity, the weft and warp yarn arrangement is shown separately on the centre and right (Figure 3).

A first demonstration preform for an open cuboid manufactured on a flat knitting machine without an additional sewing process is represented in Figure 4. Thus the feasibility of three-dimensional preforms with biaxial reinforced can be demonstrated. The following materials are used in the respective yarn systems: stitching yarn - Twaron, 84 tex; warp yarn -glass, 2400 tex.

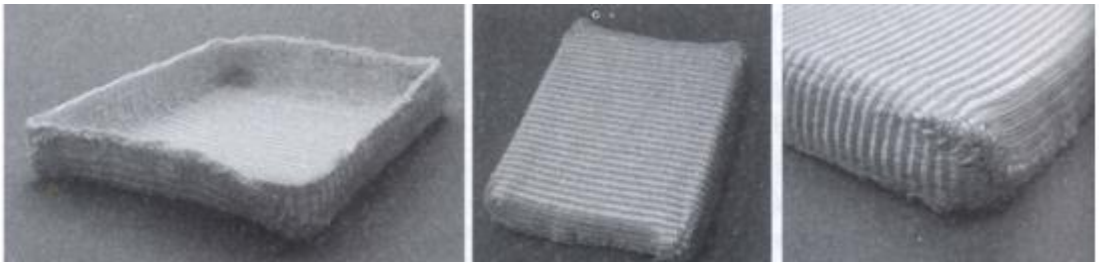

Figure 4: Open cuboid preform with biaxial reinforcement

The images illustrate the difficulties during perform production which arise from the stiff reinforcement material used. Because of the high warp and weft yarn density, the preform show high stiffness in both reinforcing directions and the high deformation resistance resulting from this. This means that the preform has the tendency to remain flat or return to a flat shape after deformation respectively. The purpose of introducing the controlled stitching yarn is to achieve a fashioned preform and to maintain the desired preform shape after production of the same. The warp yarn to weft yarn ratio for the cuboid preform has to be further optimized to achieve uniform stiffness and drapability in both reinforcing directions.

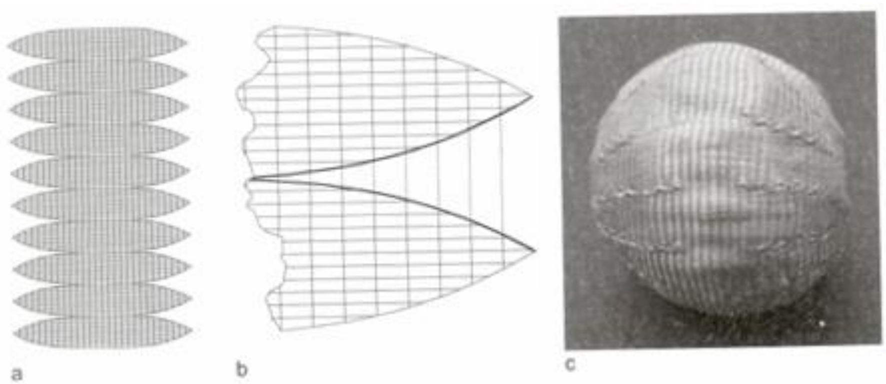

Figure 5: Developed view of a sphere comprised of shell elements and demonstration preform

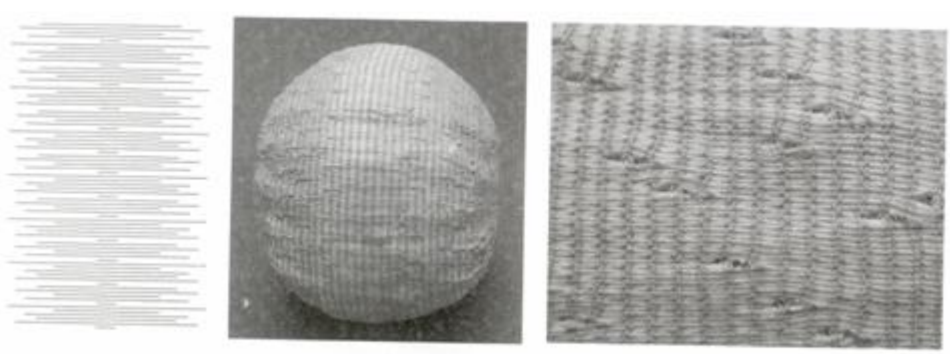

Figure 6: Stochastic distribution of knitted courses of different width within a biaxial reinforced sphere

A further example of fashioning by varying the number of stitches is presented in Figure 5. The biaxial reinforced sphere can either be described by an approximated developed view or by the use of shell elements respectively. The latter allow for a more exact modeling of the outer contour.

The reversing points of the weft yarns coincide along the transition lines of the particular segments. This is unfavorable because these areas become the weak point of the composite part. Considering this fact, it was found that the knitted courses within a respective segment should be stochastically distributed (Figure 6). With that concentration of reversing, points of weft yarns can be avoided.

Preliminary Investigations Regarding the Influence of Process Parameters on Geometric Characteristic Values of the Knitted Fabric

Influence of Process Parameters

During industrial manufacturing of unreinforced flat knitted fabrics, dimensional fluctuation can occur because of changing yarn properties or bobbin characteristics respectively. The result may be garments of second selection or even rejects. Only small dimensional fluctuations or observed during the production of flat biaxial reinforced knitted fabrics while using high performance yarns in all yarn systems (low strain), because the stitch geometry is mainly determined by the weft and warp yarns. In contrast to this, larger dimensional fluctuation can occur during the production of fully fashioned three- dimensional biaxial reinforced knitted fabrics. Factors causing this are the preform geometry and the take-up conditions on the flat knitting machine.

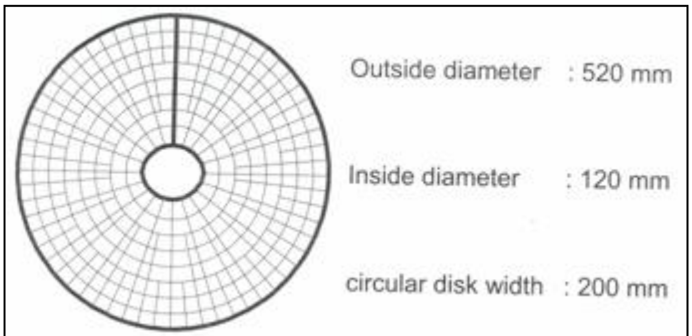

Figure 7: Spirally circular disk and dimension

The main take up designed as a multi roller take up is unsuitable for the production of fully fashioned three dimensional preforms because of low slippage and the constant take up force of the single take up rollers. Therefore, only the second take up mechanism and the presser foots can be used. The presser foots move both the stitches and the weft threads down, thus allowing knitting without external take up. The drawback of this method is that only very small distances between the stitches in the course direction can be obtained. The second take up mechanism employs two facing gear rollers and provides sufficient slippage. The dimensional fluctuations that occur during production of fully fashioned biaxial reinforced knitted fabrics are exemplarily examined. The selected preform is that of a biaxial reinforced knitted fabric. During production several machine parameters are varied. Reinforcing materials are identical to those used for the cuboid preforms.

In figure 6 the construction and dimensions of the spiral fabrics are outlined. For manufacturing the outer contour is simplified (Figure 7), i.e., the circular shape is approximately a polygon with 24 sides. Deviations of the actual preform shape from the approximated circular shape occur. Depending on the parameters such as stitch length and take up value (second take up), different geometrical characteristic values are determined. The stitch length (sinking depth) and weft yarn tension have a major influence upon this. Compared to conventional knitted fabrics, the contraction is decreased at reducing stitch lengths, because the stitching yarns tightly enclose the reinforcing yarns. In addition the warp yarns hamper the contraction of the fabric.

Knitted fabric produced without take up nearly has no contraction. The weft yarn density of these fabrics is higher than the density of fabrics produced using the second take up mechanism. Due to the high fabric tension, the weft yarn density decreases from inside to outside of the fabric. The reason for this is the higher number of stitches in course direction at the outer area of the fabric which leads to increased take up forces at the inside fabric area. In contrast the loops within the inside fabric area reduce the effect of take up in the outer fabric area. To achieve uniform weft yarn densities, the influences determined have to be taken into consideration during fabric design. The stitch length should be low within the inside fabric area, whereas as many stitches as theoretically necessary should be formed in the outer fabric area.

Conclusions

Advanced composite manufacturing processes employed in industry increasingly demand the use of preassembled near net shape preforms. Flat knitting technology is especially suited for the production of fully fashioned preforms owing to its high flexibility. It has become possible to develop near net shape biaxial reinforced multi layer weft knitted fabrics. The possibility for fashioning by varying the number of stitches in the wale direction makes this process especially suitable for composite preform production because fixed fabric edges are formed. The capability of this manufacturing method to achieve three dimensional preforms via needle parking method is exemplarily shown for an open cuboid and a spherical shell. Technological specifics as well as the fluctuations of geometric dimensions of a spiral fabric are exemplarily shown.

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