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3D-Knitted Shoe-Upper on a Large Circular Knitting Machine Including Directly Knitted Sling Structures for the Support of Shoelaces

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Abstract

In the past, 3D-knitting was only possible on flat knitting machines. With the new developed ITA-3D-Knit Technology knitting of 3D-textiles becomes possible on large circular knitting machines. In previous publications the application of the ITA-3D-Knit Technology was shown for sports-bras or similar sports clothing. The main reason for the usage of 3D-fabrics is the reduction of cut & sew processes after the knitting process. With the development of 3D-knitting for large circular knitting machines it is possible to accelerate the production process by using the high productivity of the circular knitting machines. The following paper presents the development of a 3D-knitted shoe-upper to enable the production on large circular knitting machines. In order to compete with flat knitted shoe uppers a directly knitted sling structure was developed to further reduce the necessary finishing process steps.

Keywords: Circular weft knitting; 3D; Shoe-upper; ITA-3D-Knit; Knitted slings; Large circular knitting machines

Introduction

Fast fashion and the recent trend towards individualised products ensure, that the production processes used have to be adapted. For individualised production it is not possible any more to produce large batches. The products must be adapted to the customer requirements and should be deliverable within days to allow a continuous change of products. With the current usage of large circular knitting machines, the production of individualised products is only possible with cut and sew processes. To reduce the expense in cut and sew processes the production of 3D-knitted products can be an effective approach [1,2]. 3D knitted fabrics are already familiar from flat knitting machines. Knee bandages or sports bras, for example, are manufactured there as three-dimensional products in which the cut & sew steps can be omitted. Loop transfer and shifting of the needle beds allow a flexible design of 3D-geometries. In contrast to the high degree of flexibility and diverse form formation on flat knitting machines, productivity is lower than on large circular knitting machines. In order to further promote the widespread use of 3D knitted fabrics, it is either necessary to make flat knitting technology more productive or to make large circular knitting technology more flexible [1,3-5].

At the Institut für Textiltechnik (ITA) of RWTH Aachen University the ITA-3D-Knit Technology was developed to allow the production of 3D-knitted fabrics on large circular knitting machines thus making circular knitting more flexible. Without any machine modifications or loss in productivity the new technology enables 3D-knitting on large circular knitting machines. As it is generally the case with 3D knitting, the prerequisite for this application is individual needle control, which means that only jacquard machines can be used [1,3,4]. To enable the production of 3D-knitted fabrics a new knitting pattern was developed. With this pattern it is possible to implement the reduction of the surface, which is typically made by confection during the cut & sew process. This “sewing-like” knitting pattern can be arranged in the product to get the desired three-dimensional form. The knitting pattern consists of floats and stitches that alternate horizontally over the area to be reduced. Due to the continuous stitch wales of floats, the corresponding needles are not moved across the area and thus hold the knitted fabric in this position. The other needles continue to form loops but produce these on the back of the knitted fabric. In this way, the continuous movement of the circular knitting machines can be maintained, and the effective surface area can be reduced despite this [1] (Figure 1).

Development of 3D-shaped shoe-uppers

In order to further develop the ITA-3D-Knit Technology and to demonstrate the possibilities with new prototypes, a sports

shoe-upper was developed at ITA as a 3D knitted fabric. For the development of a 3D-shaped shoe upper on large circular knitting machines it was necessary to abstract the shape of the shoe and bring it into a knittable machine file. This moulding was made by dissecting the 3D form into a two-dimensional surface. In order to place the sewing-like pattern in the right places, this impression had to be adapted iteratively. An automatic im-pression using CAD data is currently being researched at the ITA and promises a significant acceleration of the development process.

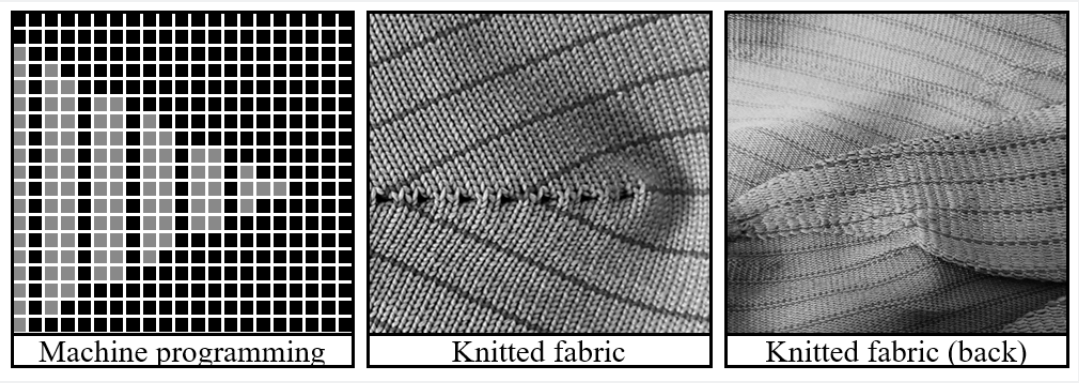

Figure 1: "Sewing-like" pattern of ITA-3D Knit Technology.

The resulting two-dimensional structure is then divided into surface areas and areas of reduction. The areas of reduction will be filled with the ITA-3D-Knit pattern. All other areas can be filled with the desired structure from the design specifications. In this case the knitted areas have been further divided into functional areas to achieve a higher air permeability on the upper side of the shoe and a higher strength on the heel of the shoe. Thus, a 3D-textile in the form of a shoe-upper was developed on large circular knitting machines. The knitting time of this shoe upper only takes less than 5 minutes, demonstrating the high productivity of circular knitting machines. The production of several shoe upper at once is also possible, depending on the machine diameter available. In contrast to 3D-textiles from flat knitting machines it is not possible yet to produce single piece products on large circular knitting machines. The shoe-uppers still have to be cut out of the knitted tube.

Development of sling structures

The implementation of holes in the knitted structure on RL-large circular knitting machines was only possible with opening systems or creating loose stitches. Both ways are not suitable for the usage as fixing elements for shoelaces or other structures. To compete with flat knitted 3D-textiles it is beneficial to create knitting patterns which allow the production of hole structures on large circular knitting machines. A modified version of the "sewing-like" pattern can be used to create holes in large circular knitted fabrics. For this purpose, the material reduction takes places in the whole product, creating a small sling at the desired position. This sling can be used to fasten the shoelaces (Figure 2).

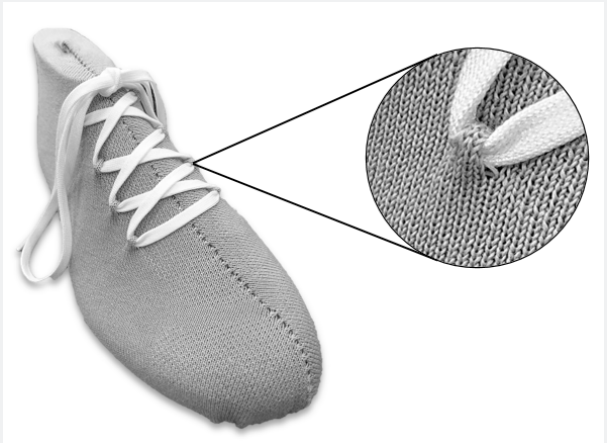

Figure 2: 3D-Shoe-upper with slings for shoelaces produced on large circular knitting machine.

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Conclusion and further outlook

Although ITA-3D Knit Technology enables the production of 3D knitted fabrics, it is not possible to achieve the same high flexibility of flat knitting machines. It is still necessary to cut the fabric out of the knitted tube and the reduced fabric is still on the backside, and therefore does not reduce the amount of material used. However, these restrictions can be economically compensated by the much higher productivity of the large circular knitting machines. Moreover, the further processing of 3D textiles has not yet reached the level of flat textiles. Due to the lack of a suitable washing and heat setting process, the aftertreatment is subject to strong fluctuations or has to be determined in extensive trials. In order to address this problem, the ITA is currently developing processes for the further processing of 3D textiles, which should be applicable independently of the production technology.

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