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## Manufacturing of textile preforms with an intelligent draping and gripping system

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### Abstract

In this paper, a novel pixel-based draping and gripping unit will be presented. To monitor and control the draping during the forming of a stack of semi-finished textiles, the pixels are equipped with integrated sensors. With these sensors, it is possible to adjust the tangential sliding and the normal holding force at each pixel. The sensor principle is based on the electrical conductivity of carbon fibers. Electrodes inside the gripping system allow a conclusion to the gripping force between the gripper and the carbon textile. Therefore, the gripping force can be adjusted to the special boundary conditions during the draping process.

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### 1. Introduction

The use of lightweight materials becomes more important for many areas. Reduction of weight has positive effects especially in electric mobility on driving range or the necessary battery size of the vehicle [1]. Adequate to this one increasingly tries to produce structural components of the vehicle out of light but still resistant materials like fiber-reinforced plastics and others to save weight. This will lead to a higher consumption of carbon fiber in the automotive industry within the next 20 years [2]. The use of lightweight materials in the field of the automotive industry must meet a set of requirements. This field demands high output figures, short process times, and cost-efficient processes [3]. These requirements are prohibitive through manual execution of necessary process steps. Nonetheless, many production processes for components made from fiber-reinforced plastics, like Resin-Transfer-Molding (RTM), are characterized by manually executed sub-processes [4]. However, this procedure has the potential to produce components in fast sequences through continuous automated sub-processes [5].

The first step to be able to infiltrate a component with the RTM-process is to create a preform. A preform is a dry but still

near-net-shaped semi-finished product whose fiber shows a resistant orientation [6]. To produce such a preform, frequently multiple layers of different textile pre-cut fiber are stacked to a layer structure, remodeled, and fixed to each other [7]. The building of a layer structure is accordingly handling-intensive. Likewise, this applies to remodeling of the fibers to the desired shape. This is also called to drape.

The basic idea of a drape gripper is the combining of both sub-processes handling and draping into one system. This would allow production of preforms, which will be infiltrated, quicker and therefore cheaper. A range of systems already exist that implement handling and draping simultaneously [8][9][10]. The unique selling point of the here presented drape gripper is the support of the drape and handling process through integrated sensors inside the gripper surface.

### 2. Requirements of a draping system

A system to handle and drape the semi-finished product's location must meet the requirements of both sub-processes, handling and draping. The preform's construction sequence through the draping gripper can be divided in the following sub steps and is illustrated in Fig. 1.

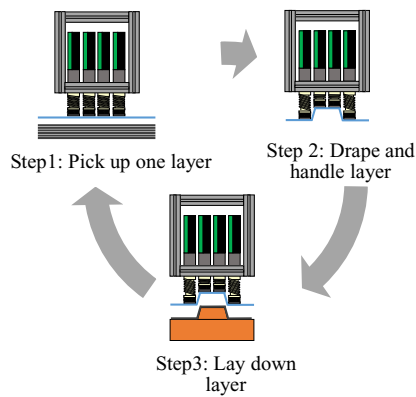


Fig. 1. Process steps of draping and handling in the manufacturing of preforms

First (Step 1), a single layer is taken out of stock. During Step 2 the movement of the layer from inventory to a platform occurs. At the same time the layer is formed from a two-dimensional state to a three-dimensional near-net-shape form. Last, the now remodeled layer is placed on a platform where other layers can already be located at. This sequence is repeated until all required layers are located on the platform. The preform is now completed and can be infiltrated. From this described process, different requirements follow for the drape gripper due to handling and draping. Handling covers the separation steps of taking a hold of, moving, and laying down the layer [11]. Out of these single steps, especially the intake of a single layer out of storage is a key challenge in automation of handling [12]. This step must also be accomplished in a way that the remaining layers are not affected in their orientation or placement [13]. No impermissible deformation or damage may occur while moving a layer [14]. Likewise, orientation and placement of the grabbed layer must be secured during movement [15]. The separation process, as well as the following movement, must be performed at a high level of reliability so that the course of the overall process is not disturbed.

Demands for the drape gripper also develop from draping. The system requires appropriate kinematics to illustrate the desired shape. Shifts occur in remodeling textiles when the layer is transformed from a two-dimensional into a three-dimensional state. Then again, textiles do not dispose of plastic properties. If a layer is fixed, shifts and non-plastic behavior bring structural deformation [16]. To avoid such errors, the textile must be able to level off while being transformed. Tangential shifts must be possible for the textile. Allowing tangential shifts creates a conflict with requirements of handling. It is demanded to grab the component during movement in a way that no alterations of position and orientation occur. This conflict can be resolved if the drape gripper can allow tangential shifts only in specific parts of the textile and holds every other part securely.

Realizations have shown that many conditions derive from requirements of handling and draping especially for gripping technology. On one hand, gripping technology must allow

reliable separation of single layers from big stocks. On the other hand, while reshaping, specific parts of the layer must be securely fixed, as well as other parts the textile must be able to shift. Also, at the same time during these processes, it is necessary to ensure that the textile is not detached from the drape gripper. If the system is supposed to be applicable to different layer shapes and three-dimensional geometries without modification, every gripper needs to be able to turn on or off the allowance or blocking of tangential shifts. A drape gripper's kinematics must also offer flexibility.

### 3. Implemented draping system

In accordance with the requirements detailed in the last chapter, wbk Institute of Production Science has developed a drape gripper within the research project HyPro (Fig. 2).



Fig. 2. Drape gripper with ten hexagonal pixels

It consists of ten separate controllable hexagonal pixels, while every pixel has a circumference radius of 44 mm. This regular division of the total area into hexagonal fields allows to cover different three-dimensional geometries. Each pixel disposes of a separate controllable z-axis. This allows to implement various three-dimensional shapes. As seen in Fig. 3, grip force to hold the layer is generated by a built-in Coanda-gripper in every pixel.

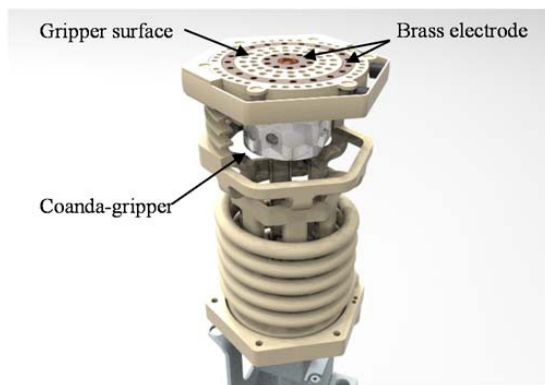


Fig. 3. Structure of a gripper pixel

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