Finite element simulation of draping with non crimp fabrics

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Introduction

Liquid resin infused Non Crimp Fabric (NCF) based products provide lower production cost without a significant drop in in-plane performance compared to prepreg technology. A NCF is fabricated by stitching together non crimped unidirectional layers of fibres, which explains the high mechanical in plane performance.

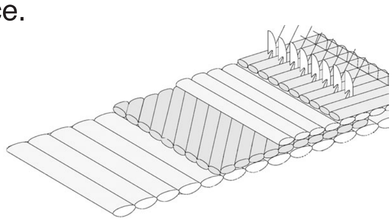

Figure 1 : A four layer non crimp fabric (Saertex).

As with most composite products, processability and performance are conflicting aspects in the development of NCF products. Easily drapeable and easily infusible NCFs often result in poor mechanical performance and vice versa.

Objective and methodology

The objective of this study is to develop a design tool that models both the production and the performance of NCF based composites. This design tool will allow to find an optimum between processability and performance. For components exhibiting double curvature, the process of draping the NCF on the mould plays a key role. The fibre distribution after draping dominates both the filling process and the mechanical performance of the finished part. A Finite Element (FE) model is being developed to simulate the draping process of NCFs on arbitrary geometries. The fibres can slide through the stitches, which is an unconventional type of textile deformation and requires a novel modelling approach.

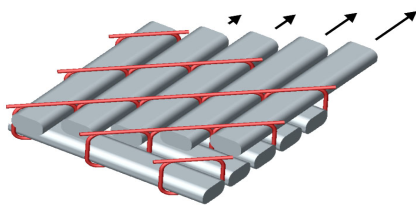

Figure 2 : Slip of the fibre bundles through the stitches.

Simulation and experiments

The mechanical behaviour of the multilayer NCF is implemented into a single membrane element. This enables efficient simulation of the NCF draping process. A fibre pull-out experiment is used to measure the required force to cause slip of the fibres. Figure 3 shows a close up of the experiment and the results of a FE simulation with a viscous slip model.

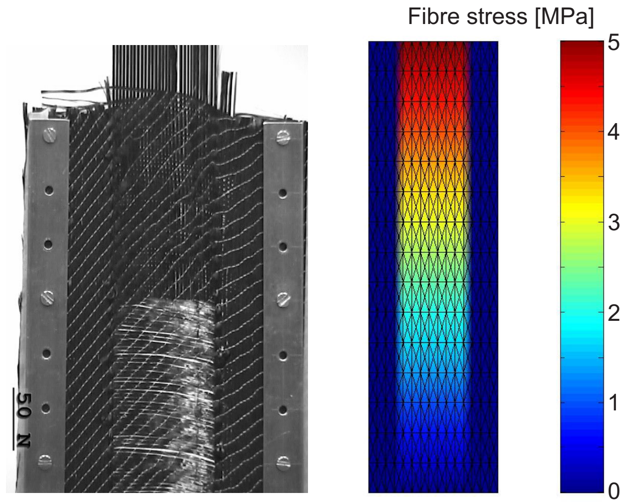

Figure 3 : Fibre pull-out experiment and a simulation with a viscous friction model.

The model includes further mechanical deformation mechanisms such as the stitch thread response and the response of the fabric to shear deformation. These responses are both modelled with a nonlinear stiffness and are fitted on experimental data.

Discussion

The current work shows that implementation of the sliding mechanism of the fibres is possible. The next step in the development of the design tool is the simulation of the draping process of a real product and validation against corresponding drape experiments.

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