



Permeability Prediction of Non-Crimp Fabrics Based on a Geometric Model



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Resin Transfer Moulding (RTM) has proven to be a cost effective production method for nearnet shaped products with a high accuracy and a high reproducibility. It makes RTM suitable for the manufacture of complex shaped products. The applicability of non-crimp fabrics (NCFs) in RTM offers both lower cost and improved through-thickness properties with no significant drop in in-plane properties compared to woven fabrics, due to better crimp and drapeability properties.

Accurate flow simulations are an essential tool in finding the optimal process parameters, in particular for complex shaped structural components as applied in the aircraft industry. One of the most critical parameters in the mould filling simulations is the permeability of the fibre preform, which is in essence a geometric quantity. Geometrical changes, such as compaction and drape affect the permeability. This research aims to predict the permeability on a local level. The local permeability depends on the geometrical features of non-crimp fabrics and the influences of fabric deformation on these features.

The proposed geometric model is based on the distortions induced by the stitches penetrating the uni-directional fibre layers. Fibres are forced aside by the needle penetrating the individual layers during the production cycle. The fibres enclose the thread, which is left behind by the needle, forming a double wedge shaped distortion in the plane of the fibres in each layer. The distortions in each layer are oriented in the direction of the fibres and form flow channels, which determine the permeability of the fabric. Flow channels in the different fabric layers are connected to each other in overlapping regions, creating a network of flow channels. The distortions, referred to as Stitch Yarn Distortions (SYD), are defined in [1,2,3].

The dimensions of the Stitch Yarn Distortions depend on a number of variables, partly related to manufacturing parameters and partly to fabric and stitch yarn properties. It is not clear yet how these parameters affect the dimensions of the SYD. The width of the SYD is linked to the stitch yarn diameter assuming a linear relationship, where the proportionality constant is treated empirically.

Investigations on different types of fabrics revealed that the dimensions of the SYDs are distributed values. It is also shown that the dimensions as well as the distribution change under deformation of the fabric [2,3].

The distribution of the dimensions complicates the permeability prediction. As a consequence, the predicted permeability is an averaged value plus a distribution. Moreover, a SYD network, having a certain SYD size distribution, will have to be analysed, rather than a single SYD. This urges the development of fast solution algorithms for the fluid flow in this network. A multigrid solver is implemented for this purpose.

References

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