THROUGH THICKNESS THERMOPLASTIC MELT IMPREGNATION: EFFECT OF FABRIC ARCHITECTURE ON COMPACTION AND PERMEABILITY UNDER HIGH PROCESSING PRESSURE

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Introduction

Liquid composite moulding (LCM) typically requires low viscosity resins to achieve reasonable processing times. However, by choosing through thickness direction, the impregnation with higher viscosity thermoplastic melt may become an attractive processing method on an injection moulding machine, as demonstrated in [1] for pultrusion. In this process, thermoplastic melt (10-50 Pas) is injected from the top in a gap above the dry preform, and then the fabric is impregnated through the thickness in a compression step. The aim of this work was to optimise the textile architecture of unidirectional glass fabrics to maintain a high permeability under high compaction pressure.

Experimental

The compaction behaviour and through thickness permeability of different UD glass fabrics are investigated with regards to the processing pressures between 10 and 50 bar that will act on the fabric, shown in Figure 1 right. A leno weave UD fabric (1280 g/m^2, 4800 tex) from FTA Albstadt GmbH (Albstadt, Germany) and a two warp system UD fabric (600 g/m^2, 1200 tex) from Tissa Glasweberei AG (Oberkulm, Switzerland) were used, shown in Figure 1 left.

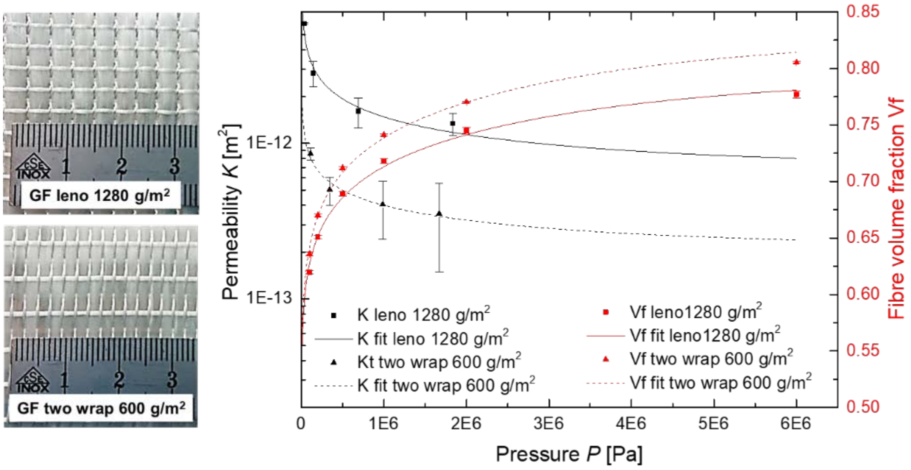

Figure 1: *left: Fabric architectures, right: Permeability with power law fit and fibre volume content with tanh fit.*

MicroCT is a useful tool for fabric characterisation and permeability prediction, as shown in [2] and [3]. MicroCT images of the leno UD fabric were recorded under increasing compaction pressure (Figure 2) and allow comparing the global compaction behaviour with the change in the meso- and microstructure.

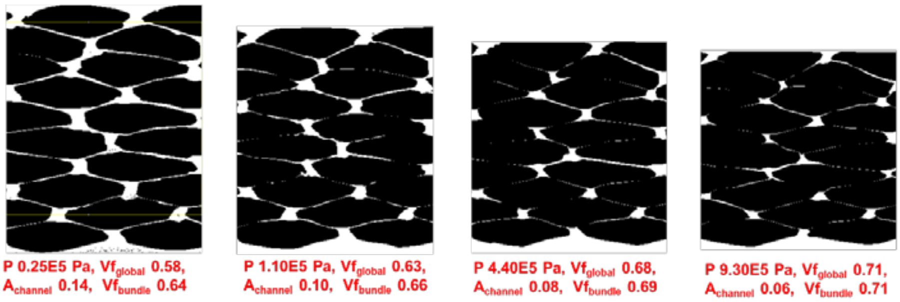

Figure 2: *Change of the global and bundle Vf and the area fraction of the channels with pressure from MicroCT images.*

Modelling

A dual scale model was implemented in Comsol. Boundary conditions are stationary flow with constant pressure, porous media flow (Darcy) in bundles and free flow (Stokes) in channels. Two bundle geometries according to MicroCT were tested: ellipse with a smallest channel diameter between two bundles and rhombus with constant diameter between two bundles, with the reality in between. The modelling results indicate that for the given fabric the minimum channel dimension (d) for a high permeability would be around 0.08 mm such that the permeability remains sufficiently high even under high compaction by promoting flow between the tows.

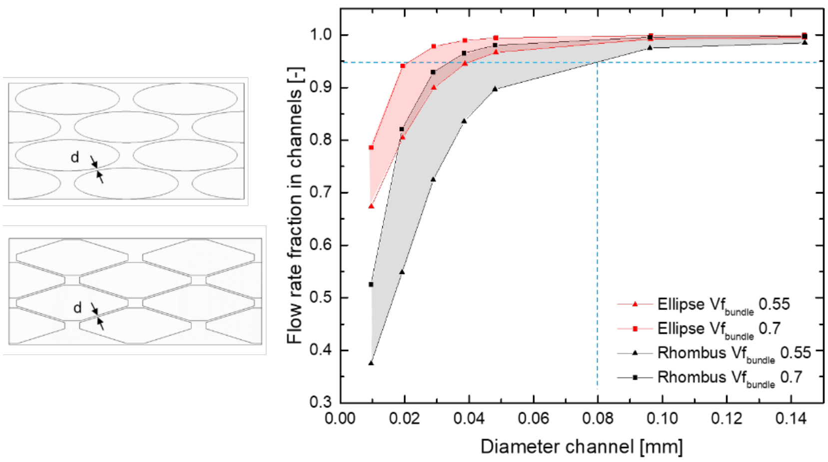

Figure 3: *left: Ellipse and Rhombus geometry, right: Flow rate fraction in channel, indicating min. d for high permeability.*

Conclusion

The results show that MicroCT together with modelling are useful tools for improving the fabric architecture concerning high permeability at high compaction. The minimum necessary diameter of the holding threads between the UD fabrics could be predicted and used for future materials.

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