Experimental Investigation of the Compressibility and Permeability of Fabric Reinforcements

E.C. van de Ven, R. Loendersloot, R. Akkerman
University of Twente,The Netherlands

In Resin Transfer Moulding (RTM) a porous preplaced preform is impregnated by a resin in a closed mold. The flow in thickness direction of a preform is often regarded as negligible. This simplification is justifiable for products with a small thickness compared to the in-plane dimensions. The flow in the mould will be approximately a two-dimensional flow.
However, the increasing application of RTM for structural components has led to thicker components in which the flow through the thickness can not be neglected. Consequently, knowledge of the permeability in transverse direction K_z is receiving an increasing amount of attention.
Another field in which the permeability in transverse direction is needed, is the field of the infusion technologies. The resin is generally injected through a transport medium on top of the preform, after which the resin impregnates the fibres in transverse direction. A second aspect of the infusion technologies is the compression behaviour of the fabric. The compressibility and the permeability are interrelated[1], hence it is desirable to gain simultaneously knowledge on both.
The presented work comprises the development of a tool to measure both the transverse permeability and the compressibility during impregnation of the fabric. Measurements at a previously fixed compression (i.e. fibre volume fraction) are also possible. The design of the tool is largely based on standard tools[2]. The device is mounted in a tubular cavity. Each side of the tube is closed with a lid, such that a completely closed system is formed. Fixation and compression of the preform is achieved by a set of soldered copper pipes. The fluid is not obstructed by the pipes. See figure 1. PE rings molted on the preform prevent racetracking.

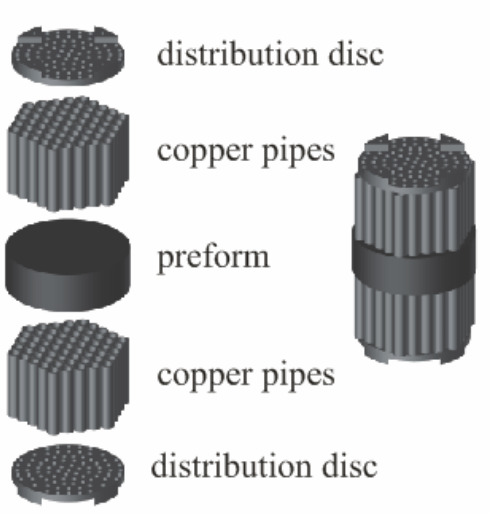

Figure 1 Exploded view of the internal parts of the cavity.

The tool is placed in a small press, such that the compression of the preform can be controlled and the compression force can be measured prior and during the impregnation of the fluid. Finally, the tool is equipped with an online viscosity meter of the injected fluid.
A number of experiments were performed using a 2/2 twill carbon fibre fabric type Ten Cate CD 202. The preform consisted of a stack of 30 layers (total thickness 10.5mm). The pressures at the entrance of the viscosity meter, at the entrance of the cavity and after the cavity were measured. The pressure drop between the entrance and the outlet of the cavity is a measure for the permeability. The mass flow is measured using a digital balance at the outlet of the cavity. Note that only the saturated permeability is measured.
The experiments show that the tool provides repeatable results. See figure 2.

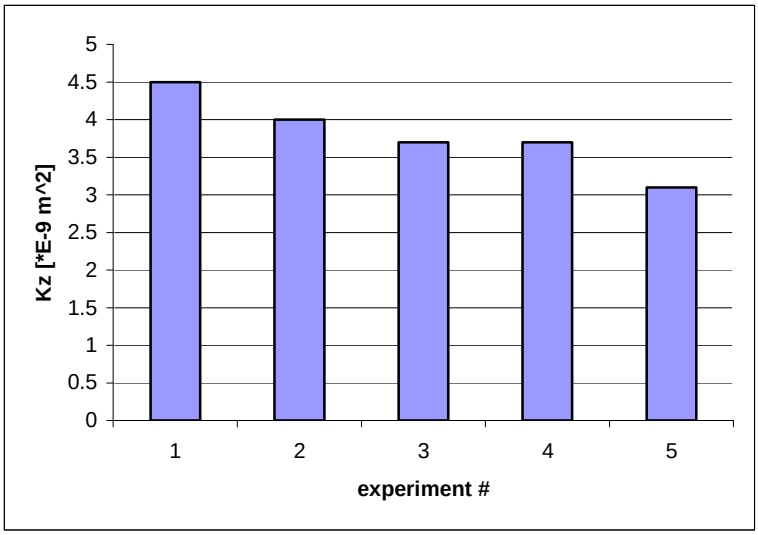

Figure 2 Measured K_z permeability in a 2/2 twill carbon fabric at 58% fiber volume fraction.

The variation in the measured permeabilities is well within bounds: qualitatively, the results are good. A comparison with other measurements, performed at two other institutes, indicates an acceptable accuracy in quantitative sense. One institute possesses an identical tool whereas the second institute performed K_z measurements with a tool with an alternative design. The influence of the different laboratories as well as the effect of a different design was evaluated.

References:

[1] **S. Bickerton and M.J. Butain and A.A. Somashekar**, The Viscoelastic Compression Behavior of Liquid Composite Molding Preforms, *composites Part A*, vol 34, pp 431-444 (2003).

[2] **S. Darpier and A. Pagot and A. Vautrin and P. Henrat**, Influence of the Stitching Density in the Transverse Permeability of Non-Crimped New Concept (NC@) Multiaxial Reinforcements: Measurements and Predictions}, *Composites Science and Technology*, vol. 62, pp 1979-1991 (2002)