## Abstract

Liquid Composite Moulding (LCM) has become an economic technique for the manufacture of advanced composite lightweight structures in many cases. Meanwhile the acronym LCM represents more than a dozen of varying process types, which all have the principle in common that a liquid monomer is firstly injected into a cavity filled with a reinforcing fibre preform and secondly it forms the part by chemically reacting to a solid polymer network. A distinctive feature of the LCM process variations is their applicability to the fabrication of a variety of different part sizes and shapes. Within this development numerical process simulation has become an important engineering tool for mould design and process control. Thereby the research focuses on the simulation of resin flow through a fibrous reinforcement, because this turned out to be the most critical process within the manufacture of composites by applying LCM-Technologies. With the software commercially available the mould-filling pattern can be simulated depending on the locations and number of inlet and outlet gates, resin rheology, injection rate and pressure, thermal effects and the physics of liquid flow through fibre preforms. Hereby the standard flow modelling bases on a proportional relationship between the flow rate and the applied pressure gradient, which is known as D´Arcy's law. The describing proportional factor is called the permeability. Its value depends on the considered flow direction because of a non-isotropic structural arrangement of the fibre reinforcement. It becomes clear that the permeability affects the injection process crucially and so the knowledge about it is indispensable for the realistic prediction of a filling pattern by flow simulation.

Due to the complexity of the inner structure of a textile reinforcement the resulting multiphase flow cannot be described adequately by an analytical model at the current stage of research, so that the permeabilities of planar textile reinforcements like woven or non-crimped fabrics is usually obtained from flow measurements. A variety of experimental set-ups were developed, which allow the tracking of the fluid flow through the textile reinforcement. The permeability is derived from the flow data by applying D´Arcy´s law. Most of these test-rigs allow the determination of the in-plane flow characteristics only, because they are dominant in the most classical processing techniques. But the simulation of these processes produces still significant errors, which result from neglecting the out-of-plane flow. Since new liquid composite moulding processes like SCRIMP™ or resin film infusion were developed, the knowledge of the permeability in thickness direction becomes as important as the in-plane characteristics so that researchers started to measure flow in thickness direction and developed flow models which include the principle permeability in thickness direction. The main arising difficulties are the measuring and the modelling for the calculation of the permeability from flow front data. The objective of this work is to overcome these problems by the development of a test-rig for the measure of the flow in thickness direction and by determining a transformation rule, which addresses the unsolved geometric boundary condition at the injection port.

After investigating the existing instrumentation for measuring flow in thickness direction a new sensor concept is developed on the basis of ultrasound transmission, which enables a steady collection of the actual position of a flow front. The applicability of this test-rig was tested within the measure of the flow through different woven and non-crimped fabrics. The permeability values, which were obtained from the flow data with the aid of the improved analytic model, were validated by two-dimensional radial flow experiments.