FACILITATING PROCESS SIMULATION THROUGH A SHARED PERMEABILITY RESOURCE

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Introduction

In the design and simulation phase for the manufacture of a component in liquid composite moulding, the permeability of the reinforcement fabric is a critical parameter for flow simulations. Sourcing reliable material data; however, can be a difficult and costly exercise, often involving materials characterisation testing. Furthermore, no current standard exists for fabric permeability characterisation, despite the efforts of the community in generating reference permeability data and previous attempts of generating a permeability database [1,2].

A shareable database collecting values currently available in literature was devised following discussions held at the FPCM-13 conference in Kyoto. The database aims to be a single resource of known and tested permeability values of reinforcements, allowing for more realistic simulations of flow injections. Users can therefore very quickly achieve flow estimations and make better decisions regarding material down selection at an earlier stage in the design process and at a lower cost.

Permeability Database

Permeability information from the currently-in-development database will be accessible through an online interface. Users will input the associated material type and architecture into the interface, and matching historical data from the database will be provided.

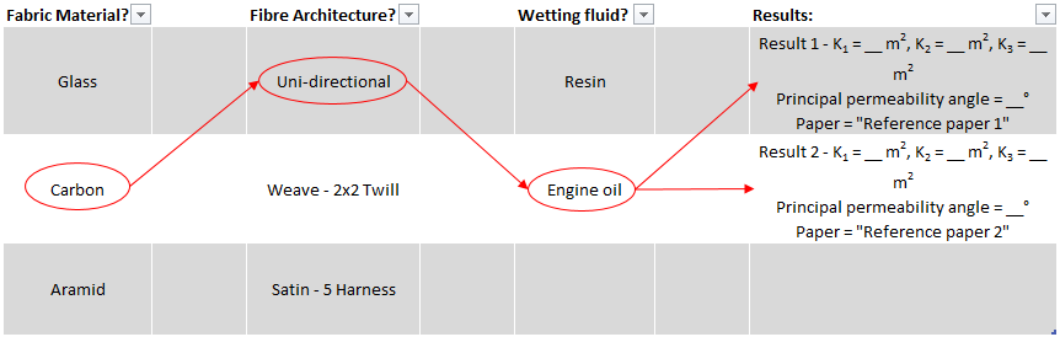

Figure 1: *Example of drop-down material selection*

Any matching historical results will show in-plane and/or through-thickness permeabilities of the fabric as appropriate, as well as a principal permeability angle of the material. Reference to the literature will also be provided, should the user require more information on the particular setup or experimental conditions and results. Users will be able to – and are encouraged to – contribute to the database with permeability results or experimental data for review. This encourages multi-organisational collaboration and opens up process simulation to a larger market.

Permeability Measurement

Generating data for the database involves measuring certain resin parameters at locations within a reference mould cavity during injection. Figure 2 shows an example of a flat panel injection rig setup where the flow front development is monitored via the instantaneous measurement of resin arrival at the sensors located on the mould surface. This setup has been used as a permeability measurement rig and is recommended as a viable solution. The array of sensors allows for sufficient flow monitoring and the mould tool can be implemented in a hydraulic press, replicating industrial processes.

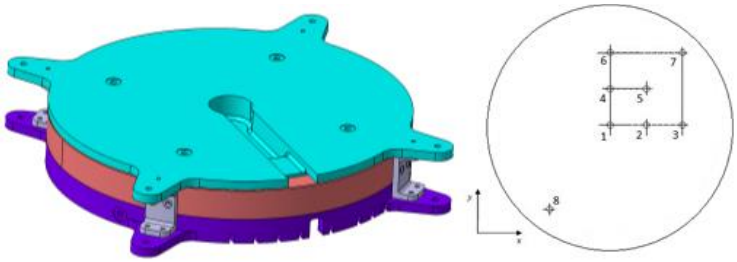

Figure 2: *Example of instrumented RTM mould (left) and lower mould sensor setup schematic (right)*

The monitoring of resin arrival, in conjunction with pressure measurements at the inlet and outlet gates, provides the necessary information for understanding the flow behaviour.

The use of industrial data logging setups for monitoring flow rate, inlet and outlet gate pressures and arrival times is common industrial practice in liquid composite moulding processes as well as current permeability characterisation procedures with differing setups [3, 4, 5, 6].

Resin arrival information can then be used to back-calculate the in-plane permeability of the associated reinforcement.

Automated Tool

An automated tool has been developed to back-calculate in-plane permeability values from arrival time or pressure sensor readings at known locations and other known parameters (injection pressure, fluid viscosity, fibre volume fraction) for a simplified injection geometry. Back-calculation follows the Weitzenböck/Shenoi/Wilson (WSW) approach [7]. The tool is in the form of an iterative Python script. The tool was initially formed around the mould tool and sensor array geometry of the tool shown in Figure 2, however the code could be amended allowing for alternative sensor setups. This eliminates human interference in the permeability calculation process and greatly reduces calculation time – which can ultimately lead to a quicker and more transparent population of the proposed permeability database.

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