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Towards Efficient Textile Characterisation: Industry-Focussed Permeability and Compaction Evaluation

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Introduction and Motivation

Liquid Composite Moulding (LCM) processes, such as RTM, resin infusion etc, are gaining in popularity due to the ability to produce high-quality components in a time-efficient manner. Simulation of the process is a key tool for process design. Permeability and compaction response of reinforcing materials are required inputs for such simulation.

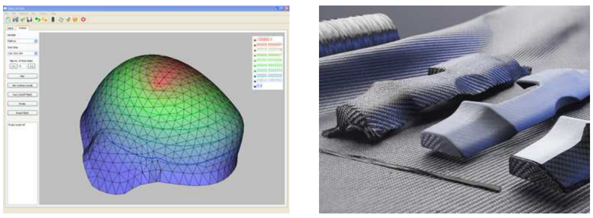

Figure 1. Flow and compaction stress simulation (left) and LCM manufacturing cycle, from preform to final component [1] (right).

Efficient Material Characterisation

Current characterization techniques requires numerous tests to get statistical confidence in the results. A European Union Marie Curie Actions International Incoming Fellowship focused on developing efficient material characterisation techniques. The aim of the project was to allow greater uptake of simulation by a wider portion of the composites industry and enhanced quality control measurements of textile reinforcements.

2D Permeability and Compaction Facility

To fully understand the parameters influencing permeability and compaction response, a number of test series are planned, covering a wider range of production parameters. The material used was a carbon fibre 540 g/m^2 ±45° non-crimp fabric (NCF).

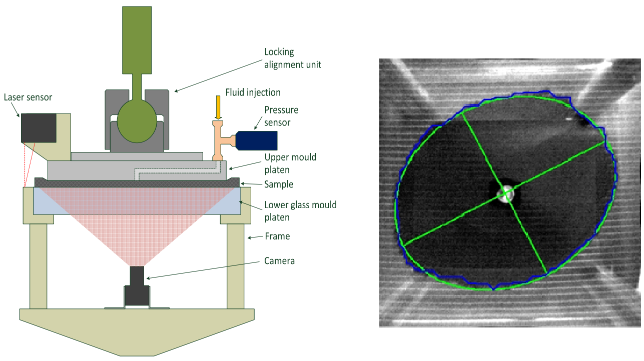

Figure 2. Permeability test bench (left) and example output showing flow front and fitted ellipse for the carbon fibre NCF material (right).

Results

Permeability

The results of the permeability study are presented in Figure 3. The trend of decreasing permeability with increasing fibre volume fraction (V_f) is as expected for both principal directions (K_{11} and K_{22}). An exponential curve fits the data well in both directions with low error (R^2 values greater than 0.985). The average permeability ratio (K_{11} / K_{22}) of 1.90 to 1.68 indicates an anisotropic material, despite the equal mass of fibres in each direction. This is likely due to differences in the stitching pattern [2].

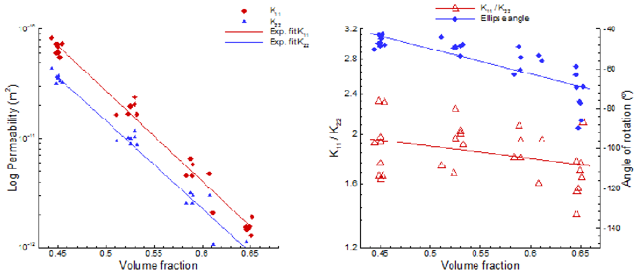

Figure 3. Permeability results and anisotropy ratio and ellipse rotation for NCF.

Compaction

Figure 4 presents the results of the baseline compaction response study for the NCF material. As expected, with increasing V_f compaction stress increases. With an increase in compaction speed (at constant V_f) an increase in peak compaction stress is evident. However this viscoelastic response is lower than noted in previous research on other reinforcements.

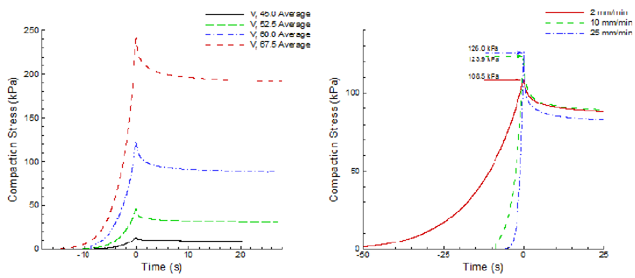

Figure 4. Compaction response of NCF as a function of V_f, compaction speed.

Simulation End-user Survey

A survey of industrial end-users of LCM simulation tools is underway. Current responses indicate a need to be flexible with developing efficient characterisation methods and facilities. Further detailed conclusions will be drawn once further responses have been obtained.

Combined with the results of the Fellowship, this will allow the development of a prototype efficient material characterisation facility. Such a facility will combine experimental and simulation based approaches to material characterisation, allowing a wide range of experimental parameters to be evaluated with minimal tests. However, current simulation approaches tend to focus on one material architecture, so a combined approach is required [2,3].

Acknowledgements

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