1 Introduction

Liquid Composite Moulding (LCM) processes are a range of closed-moulding techniques used in the production of composite components. LCM processes can be classified by the mould type and resin injection methodology; however all include insertion of a dry fibrous reinforcement in a mould, and infiltration of the reinforcement with a liquid resin. As a result, two important characteristics of the reinforcement affecting these processes are permeability and resistance to compaction.

Significant research has been undertaken by various groups into the permeability of reinforcement fabrics used in LCM processes [1-5]. The compaction response of reinforcements has received less attention, however knowledge and understanding of the compaction response of a material is required in order to accurately predict LCM processes [5,6]. This is particularly important when considering flexible and semi-flexible mould tools [7].

Research into both characteristics has typically concentrated on accurate characterisation. Typically the time invested into characterisation of materials has been a secondary consideration. As a result, full characterisation of a material can take considerable time and operator effort. Furthermore, while many parameters influencing the material characteristics (such as repeatability, number of layers, nesting, saturating flow effects etc) have been studied, few studies exist considering multiple effects on one reinforcing material.

2 Motivation

As industrial demands for high-volume, high-quality composite components increase, the demands and benefits of LCM process simulation also increase. The baseline for any reliable simulation is a set of reliable input parameters; in the case of LCM processes these are principally the permeability and compaction response. The characterisation of reinforcements is often outsourced to academic institutions, and is considerably time consuming – characterising the permeability of a single fabric alone can take several dozen tests. This is a considerable constraint, particularly as new fabrics are constantly developed and must be characterised each time, and adversely affects the ability of LCM simulation to meet the required timeframe for industry.

This paper will present the first stage in a wider project with the aim of introducing a methodology for rapid and efficient characterisation of materials. The goal of such a methodology is to reduce lead times between final component design and entering production, as well as reducing overall production cycle times and setup costs. The paper will present the first step in the development of a standalone characterisation facility, which will allow in-house characterisation of materials by industry - significantly reducing costs and improving flexibility through the removal of reliance on third parties for crucial material data.

2.1 Benefits

Efficient characterisation methods will be of significant benefit for improving the time- and cost-saving benefits associated with undertaking simulations to develop manufacturing process parameters, tool designs etc. In addition, fast characterisation methods will allow improved off-roll reinforcement evaluation during production, in turn allowing improved quality control or live adjustment of processing parameters to suit the available material.
3 Experimental Studies

3.1 Equipment

A 2-dimensional in-plane permeability facility has been developed at the Lehrstuhl für Carbon Composites to complement the existing 1-dimensional rectilinear facilities (Fig. 1). The in-plane facility will use image capture to allow measurement of anisotropic reinforcements, and is an evolution of the system developed at the Centre for Advanced Composite Materials at the University of Auckland. The facility will be mounted in a testing frame, which will allow measurement of the compaction response and permeability in a single facility.

Fig. 1. 2D permeability testing facility.

3.2 Details of Studies

The principal focus of this paper will be in-depth studies of permeability and compaction response of two fabric textiles. Parameters studied will include the influence of the number of layers in a preform, nesting, saturating effects, repeatability and in-plane shear. Experimental studies will be undertaken to compare 1D rectilinear measurement techniques with 2D radial filling techniques. The results of the experimental studies will be compared to existing studies presented in the literature to provide a large set of data in order to identify the key influences on the material characteristics. This work will then be used to propose efficient characterisation techniques, which will be studied in further detail in later work.

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References


