ANALYSIS OF THE CAPILLARY DRIVEN WETTING BEHAVIOUR IN REINFORCING TEXTILE STRUCTURES

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Introduction

In the field of composite production, liquid composite moulding (LCM) processes have developed to become one of the main techniques for the manufacturing of structural composite parts. All variations of the existing LCM processes have in common that a porous textile structure is infiltrated by a liquid thermoset polymer. One of the key role during this process is a suitable pressure driven flow inside the textile to minimise the void content of the final composite part.

Impregnation and void formation

Impregnation defects like voids affect the mechanical properties of the final part and have a detrimental effect on fatigue life and material degradation like crack initiation and propagation [1-3]. The prevention of process induced air entrapment therefore becomes an important factor when reliability and maximum mechanical performance of the composite part must be ensured. This led to an increasing effort to investigate model-based approaches for process optimization [4-6].

Most engineering fabrics used as reinforcing structure of the composite contain a dual-scale architecture in terms of pore size: Macroscopic gaps exist between the fibre tows, rovings or yarns of e.g. weaves, non-crimp fabrics or braids, while interstitial microscopic pores appear inside these bundles between the single fibres or filaments. The pore size and shape significantly effects the permeability and fluid flow inside the porous medium. Figure 1 shows the two typical mechanisms in terms of unequal fluid flow velocities which can cause microscopic voids inside the fibre bundles or between them. These lead-lag profiles of the flow front are known as resin fingering or dual-scale fingering. Considering this dual-scale nature of the fibrous architecture, model-based approaches have been developed over the past years to describe the fluid propagation and void formation during the infiltration process.

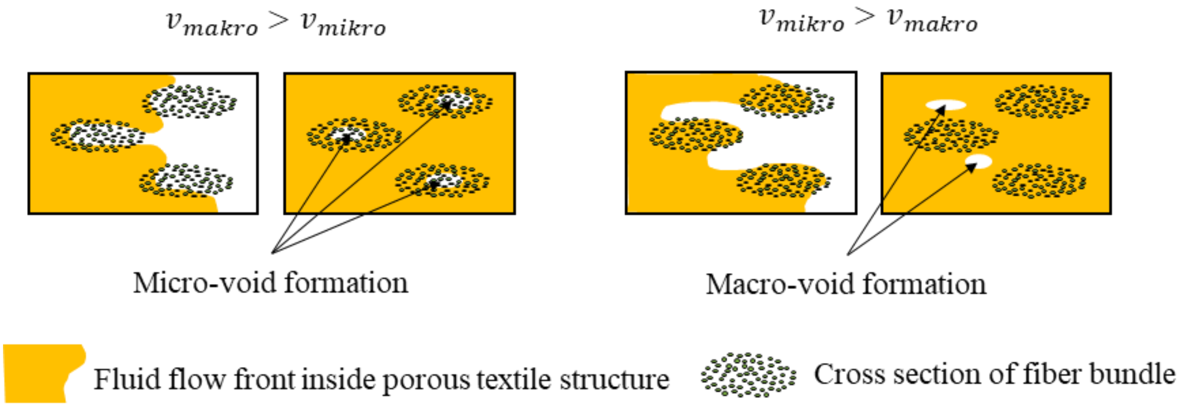

Figure 1: *Void formation mechanisms in dual-scale porous textile: advanced macroscopic flow through inter-tow pores (left), advanced microscopic flow through inter-tow pores (right).*

Spontaneous wetting phenomena investigations

In the present paper the analysis of the capillary effects acting during impregnation are focused. A test rig and experimental method is used for the evaluation of the governing process parameters which describe the spontaneous wetting phenomena inside different textile structures. With material models based on Washburn's equation and Darcy's law the dynamics of the capillary flow can be investigated [7,8]. Figure 2 shows the test set-up for a process-oriented characterization of engineering fabrics used in LCM processes in terms of their wicking behaviour with selected fluids. The detection of the capillary rise is implemented by fluid weight measurement and image processing. Based on the experimental results fluid characteristics, the wettability properties and dependency of fabric geometry are derived and refined.

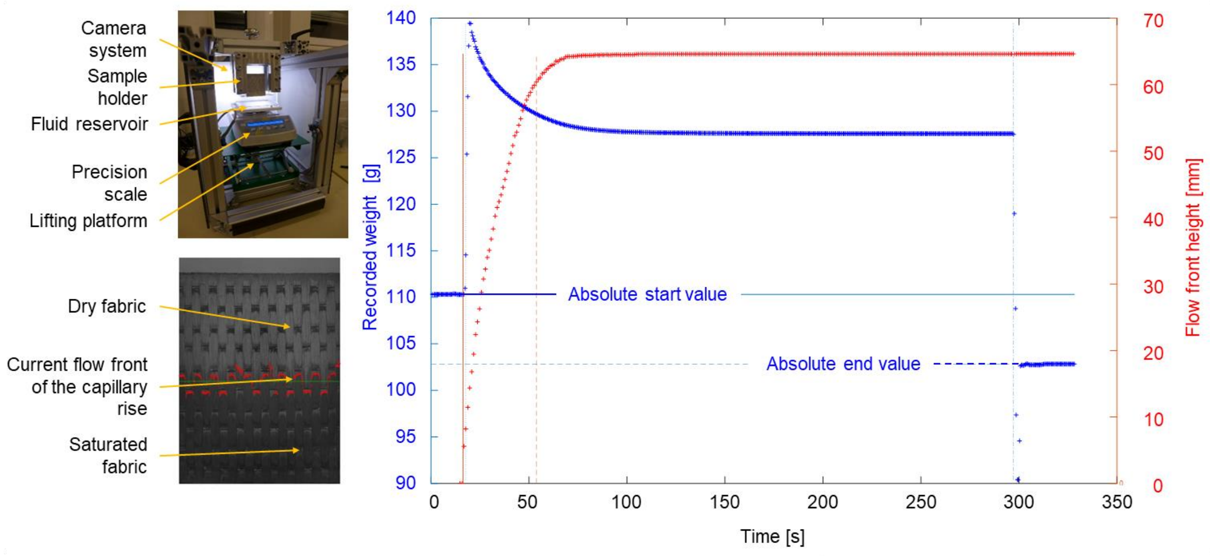

Figure 2: *Set-up for vertical wicking tests (left) and capillary rise detection by image processing (right).*

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