INFLUENCE OF THE SURFACE MODIFICATION OF A BASALT FIBER ON THE IN-PLANE PERMEABILITY AT TWO SCALES: THE TOW AND THE FIBROUS PREFORM

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Keywords: Permeability, Liquid composite molding, Wettability. Basalt fiber.

Abstract

During liquid composite molding processes, the impregnation of the fibrous preform, composed of a double pore scale, is a crucial challenge [1]. As a matter of fact, a poor impregnation can lead to void formation (micro or macro voids), and those voids can affect the surface and interface quality as well as the mechanical properties of the final parts [2]. To avoid these defects, numerical simulation is an important tool for manufacturers to predict the impregnation of the fibrous preform during the process. Therefore, the experimental permeabilities of fibrous preforms are determinant input data for the models. Furthermore, the multiscale structure of the fibrous preform leads to a dual scale flow of the liquid (between the tows and inside the tows) [3]. Consequently, to conduct simulations as close as possible to the reality, permeability values at different scales (fibrous preform and tow) are required. Another aspect addressed in this work, often neglected in the literature, is the effect of the affinity between the fluid and the fiber (related to capillary pressure [4]) on the permeability values at both scales. According to the literature, the capillary pressure can modify the unsaturated permeability under certain conditions, such as process parameters and the fluid/fiber affinity [5].

The main aim of this study is to evaluate the impact of the surface modification of a basalt fabric on the in-plane permeability at two scales: the tow scale and the fibrous preform scale. Unsaturated (K_{unsat}) and saturated (K_{sat}) permeability experiments were performed at the fibrous preform scale whereas only saturated permeability experiments were performed at the tow scale (Figure 1). The basalt fabric was modified by thermal treatment in order to remove the sizing. The test liquids used for this study were water, a polyethylene glycol (PEG300) and a silicone oil (PMX200 – 100cS). First results showed, at the single fiber scale, that the thermal treatment modified significantly the surface energy of the basalt fiber by increasing the total surface energy, and especially the polar component [6]. At the fibrous preform scale with water, results showed an increase of the saturated and unsaturated in-plane permeability after thermal treatment (Table 1). The experiments with the polyethylene glycol and the silicone oil will also be addressed for the thermal treated fabric. These results, combined with results at the tow scale, will allow us to improve the understanding of considering the capillary effects in the unsaturated permeability and to include these values in simulation at higher scale [7].

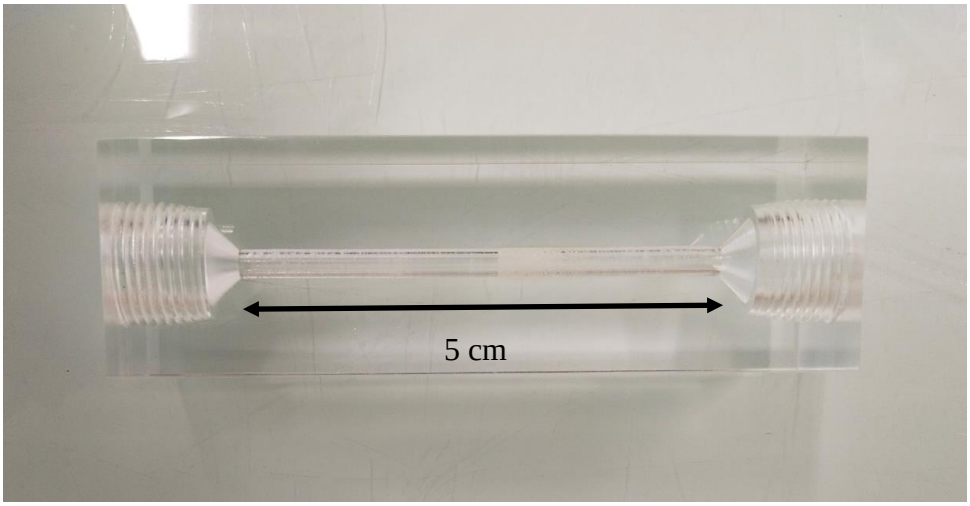

Figure 1. Permeability set-up at the tow scale

	"as received" fabric	**"thermally treated" fabric**
K_{unsat} (m^2)	1.11E-11 (± 5%)	1.87E-11 (± 5%)
K_{sat} (m^2)	1.12E-11 (± 5%)	1.89E-11 (± 5%)

Table 1. Permeability results at the fibrous preform scale with water (ΔP = 100 kPa, V_f = 54.8%)

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