UNCERTAINTY IN MEASUREMENT OF PERMEABILITY TENSOR OF POROUS FIBROUS PREFORM USED FOR THE LIQUID COMPOSITE MOLDING

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Liquid composite molding is one of the popular methods of composite manufacturing. It is based on resin impregnation process of a dry fibrous preform. Numerical simulations of impregnation process are generally based on Darcy's Law stating that liquid velocity is proportional to the permeability tensor of the fibrous preform. The permeability tensor has in-plane and through-thickness components.

In-plane components of permeability tensor can be determined by the radial flow method using registration of the test liquid expansion through a circular opening in a mold [1-3]. Generally, it is assumed that the propagating liquid front has a planar shape and is perpendicular to the mold surfaces and, thereby, the radial method possesses no uncertainty caused by flow rate changes near the mold surface – the so-called race-tracking effect. However, complex shape of the propagating front, if present, might introduce an error in the permeability tensor components obtained with the radial flow analysis method. To determine the real flow front shape in the thickness of the preform, we developed an experimental technique (Figure 1).

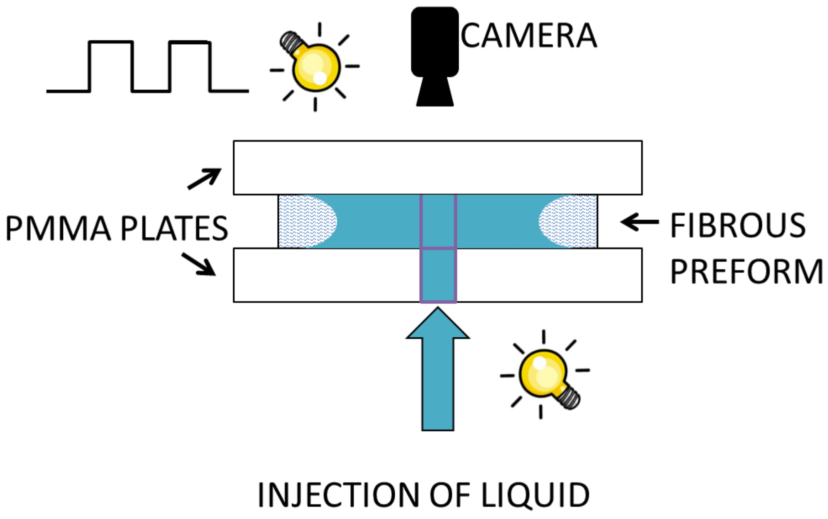

Figure 1: *A schematic drawing of the experimental set-up designed to study the liquid front propagation in a fibrous preform during the impregnation process.*

The technique is based on the simultaneous analysis of the light reflected from a preform and transmitted through it during its impregnation. To do that an investigated glass fiber preform was clamped uniformly between two transparent PMMA plates. The bottom plate has a circular opening through which the test liquid (silicon oil) was injected under constant pressure. During the impregnation process, the preform was illuminated by light sources placed below and above to obtain the transmitted and reflected light intensity distribution maps, respectively. The top illumination blinked with a frequency of 25 Hz. As a result, it was possible to record the reflected and transmitted light by one camera placed above the mold.

From the intensity distribution maps of reflected and transmitted lights, a series of cross-sections of the liquid front was extracted and analyzed (Figure 2A and 2B, respectively). As it can be seen in the Figure 2C, the transitional zone near the liquid front is broader for the transmitted light than for reflected one. It indicates that liquid front does not have a planar shape in the studied process. To determine the functional form of the liquid front, we fit the intensity of reflected light in the transitional zone by analytic models (Figure 2C). Results of our work allow to correct the components of the experimentally measured in-plane permeability tensor of a material, accounting for the race-tracking effect.

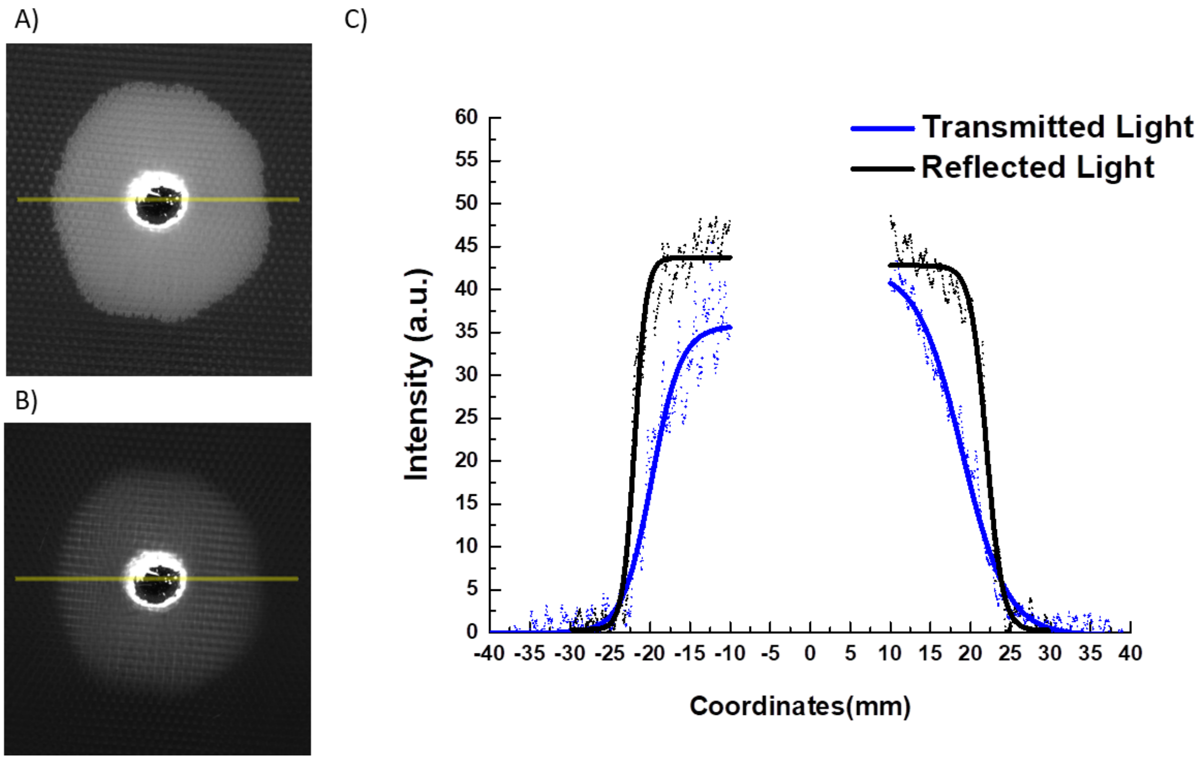

Figure 2: *Images of the fibrous preform in reflected (A) and transmitted (B) light during the impregnation process. (C) The intensity of transmitted and reflected light along the lines shown in A and B images.*

References

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