

INFLUENCE OF TEXTILE ARCHITECTURE AND NESTING EFFECT ON THE SCATTER OF IN-PLANE PERMEABILITY RESULTS

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Abstract

For Liquid Composite Molding (LCM) processes, the accurate prediction of resin flow depends on reliable estimation of fibrous reinforcements permeability. However, literature reports significant variability in experimental permeability values depending on the human factor, the set-up configuration and the choice of the liquid nature, even for an identical porous medium [1]. Furthermore, several studies have investigated, for a define fabric stack, the impact of the nesting degree on the permeability scatter results [2]. The nesting effect refers to the interpenetration of tows between adjacent layers within a stack of fabric compressed in the mold. Studies report a real impact of the degree of nesting on the permeability scatter [2]. A previous work [3] from our research team reports a relatively low scatter on unsaturated permeability results of a quasi-unidirectional basalt fabric (about 5 to 10%), which is relatively low compared to the scatter observed in literature (about 10 to 20%) [1][4].

The aim of this study is to evaluate the robustness of our permeability setup, complying to the ISO 4410, and of our method by examining the impact of a controlled nesting on the scatter of unsaturated permeability values. However, it is evident that excessive degree of nesting will significantly affect the pore network between plies, thereby the morphology of the porous medium and as consequence, the permeability of the preform. Two architectures of fabric have been studied, a quasi-unidirectional fabric and a 2/2 twill. The test liquid is a silicone oil XIAMETER PMX200-100cSt, the pressure difference is set to 100 kPa and the target fiber volume fraction in the set-up is 54.8%.

For the quasi-unidirectional fabric, the effect of weft yarn placement between plies is investigated. As shown in Figure 1, two cases of draping are studied: a “minimum nesting” case by stacking the weft yarns along the same axis (Figure 1, case 1), and a “maximum nesting” case by shifting them by half a spacing (Figure 1, case 2).

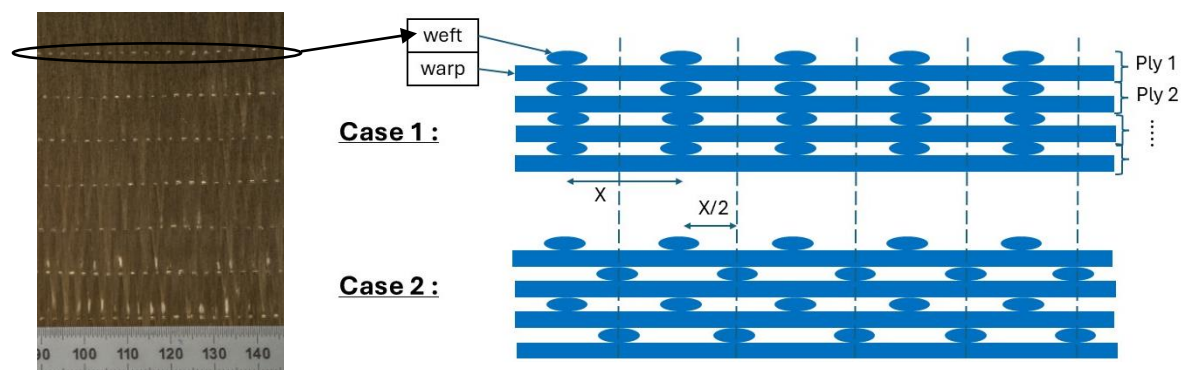


Figure 1. Nesting configuration - quasi-unidirectional

For the twill 2/2, the representative repeating pattern is presented in Figure 2. These dimensions represent a square of 5x5 mm². Consequently, due to the small repeating pattern size, the difficulty in handling the fabrics once cut while preventing tow loss, and the necessity to ensure a good repeatability in the placement of the fabrics relative to each other, only the case of ‘minimum nesting’ is investigated. It corresponds to an aligned superposition of the representative repeating pattern between layers. Indeed, due to the inherent difficulty in handling cut plies, this configuration will inevitably incorporate a certain degree of natural random nesting resulting from human factors: cutting, handling and positioning in the setup.

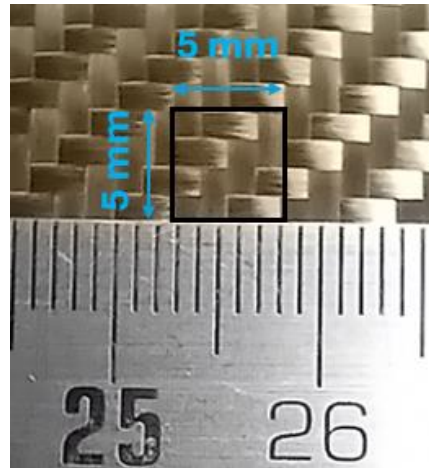


Figure 2. Representative repeating pattern of twill 2/2.

The scatters of the unsaturated permeability will thus be displayed and discussed. This study is part of the line of research established by previous works in literature [2] which underlines the importance of considering textile architecture and nesting phenomena when interpreting permeability data and developing predictive models for LCM processes. It contributes to a better understanding of the sources of experimental scatter in order to improve reproducibility in permeability experiments.

References

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