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Modeling of Void Formation in 3D Woven Fabric During Resin Transfer Moulding

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Abstract : Resin transfer molding (RTM) is increasingly used for manufacturing high-quality composite structures due to its additional advantages over prepregs of low-cost out-of-autoclave processing. However, to retain the advantages, it is critical to reduce the void content during the injection. Reinforcements commonly used in RTM, such as woven fabrics, have dual-scale porosity with mesoscale pores between the yarns and the micro-scale pores within the yarns. Due to the fabric geometry and the nature of the dual-scale flow, the flow front during injection creates a complicated fingering formation which leads to void formation. Analytical modeling of void formation for woven fabrics has been widely studied elsewhere. However, there is scope for improvement to the reduction in void formation in 3D fabrics wherein the in-plane yarn layers are confined by additional through-thickness binder yarns. In the present study, the structural morphology of the tortuous pore spaces in the 3D fabric has been studied and implemented using open-source software TexGen. An analytical model for the void and the fingering formation has been implemented based on an idealized unit cell model of the 3D fabric. Since the pore spaces between the yarns are free domains, the region is treated as flow-through connected channels, whereas intra-yarn flow has been modeled using Darcy's law with an additional term to account for capillary pressure. Later the void fraction has been characterised using the criterion of void formation by comparing the fill time for inter and intra yarn flow. Moreover, the dual-scale two-phase flow of resin with air has been simulated in the commercial CFD solver OpenFOAM/ANSYS to predict the probable location of voids and validate the analytical model. The use of an idealised unit cell model will give the insight to optimise the mesoscale geometry of the reinforcement and injection parameters to minimise the void content during the LCM process.

Keywords : 3D fiber, void formation, RTM, process modelling
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