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Experimental Quantification of the Intra-Tow Resin Storage Evolution during RTM Injection

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Abstract : Short cycle time Resin Transfer Molding (RTM) applications appear to be of great interest for the mass production of automotive or aeronautical lightweight structural parts. During the RTM process, the two components of a resin are mixed on-line and injected into the cavity of a mold where a fibrous preform has been placed. Injection and polymerization occur simultaneously in the preform inducing evolutions of temperature, degree of cure and viscosity that furthermore affect flow and curing. In order to adjust the processing conditions to reduce the cycle time, it is, therefore, essential to understand and quantify the physical mechanisms occurring in the part during injection. In a previous study, a dual-scale simulation tool has been developed to help determining the optimum injection parameters. This tool allows tracking finely the repartition of the resin and the evolution of its properties during reactive injections with on-line mixing. Tows and channels of the fibrous material are considered separately to deal with the consequences of the dual-scale morphology of the continuous fiber textiles. The simulation tool reproduces the unsaturated area at the flow front, generated by the tow/channel difference of permeability. Resin “storage” in the tows after saturation is also taken into account as it may significantly affect the repartition and evolution of the temperature, degree of cure and viscosity in the part during reactive injections. The aim of the current study is, thanks to experiments, to understand and quantify the “storage” evolution in the tows to adjust and validate the numerical tool. The presented study is based on four experimental repeats conducted on three different types of textiles: a unidirectional Non Crimp Fabric (NCF), a triaxial NCF and a satin weave. Model fluids, dyes and image analysis, are used to study quantitatively, the resin flow in the saturated area of the samples. Also, textiles characteristics affecting the resin “storage” evolution in the tows are analyzed. Finally, fully coupled on-line mixing reactive injections are conducted to validate the numerical model.

Keywords : experimental, on-line mixing, high-speed RTM process, dual-scale flow
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