The significance of the time-dependent behaviour of fibrous materials in resin infusion processes

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ABSTRACT

The objective of this study was to investigate the effect of time-dependent deformation of fibrous materials on the resin infusion manufacturing processes.

A series of compression tests was carried out on a number of fibrous materials as used in resin infusion processes (continuous filament mats, chopped strand mats, unidirectional fabrics), and the time-dependent response of these materials was demonstrated (significant stress relaxation and hysteresis).

A 5-parameter rheological model of the fibrous material(s) was constructed, consisting of non-linear elastic and non-linear viscous components. The parameters were obtained from limiting-case (very rapid and very slow) compression tests, and the model was fitted to the experimental data.

The viscoelastic model was incorporated into Finite Element (FE) simulations apart from the viscoelastic component, the governing equations used were the standard ones based on mass conservation and Darcy's law. The equations were solved using implicit solution techniques based on nodal saturation levels. The dependence of fibre permeability on volume fraction was found experimentally and this data was included in the FE model.

Simulations were run using viscoelastic fibrous deformation and again with standard non-linear elastic behaviour (with no fibrous viscous effects). It was shown, for example, with Vacuum Assisted Resin Transfer Moulding (VARTM), that the height of the part during infusion and the fill-times for complete infusion were significantly affected by the time-dependent response of the fibres.

The results of the investigation show that the time-dependent behaviour of fibrous materials affects the resin infusion manufacturing processes, and often needs to be taken into consideration when predicting critical features of the process such as fill times.