Embedding of locally functionalised textiles by injection moulding

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Abstract

The mechanical performance of fibre-reinforced polymer (FRP) components is often limited by abrupt transitions in reinforcement content and fibre orientation, for example between fibre-reinforced laminates and injection-moulded ribs or secondary features. These discontinuities result in local stress concentrations under mechanical loading and lead to premature failure in the transition region.
This work investigates a textile-based approach to create locally graded property transitions in FRP components by selectively reorienting fibre bundles from textile fabrics into the out-of-plane direction and integrating them into injection-moulded structures. The aim is to develop an injection-moulding process that preserves the maximum number of fibre bundles in an upright, out-of-plane orientation during mould filling, thereby creating a gradual reinforcement transition between the textile laminate and the injection-moulded subcomponent.

Different fabric types, numbers of reoriented fibre bundles and loop lengths are systematically evaluated. Since the raised fibres are exposed to melt flow, shear stresses and pressure during injection moulding, a reactive polymer system is applied by brushing and spraying to fix and stabilise the fibre loops. This fixation is intended to prevent displacement and deformation of the loops during subsequent injection moulding.

Numerical simulations of the melt flow are used to visualise the flow path and to evaluate the flow-induced conditions acting on the reoriented fibres, with particular attention to the influence of injection-moulding parameters on the fibres tendency to deform or become displaced. Finally, pull-off and bending tests are performed to compare the resulting graded FRP structures and to quantify the influence of the locally reoriented fibre bundles on mechanical performance and failure behaviour.

This work combines fibre reorientation, fixation, injection-moulding optimisation and numerical analysis for locally graded FRP structures with improved load transfer.
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