Characterisation of random long fibre composites and prediction of the local stiffness properties

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ABSTRACT

The use of glass fibre reinforced polypropylene composites in engineering applications increases more and more these last years. Especially, long glass fibre polypropylene (LGFPP) composites offer specific advantages over classical laminates such as higher production rates at lower costs, improved thermal and mechanical properties. However during injection moulding of the part fibre breakage is occurring, leading to a distribution of fibre lengths inside the material. Moreover a change in orientation of the fibres also takes place during injection process, leading to micro-structural variations that affect the overall mechanical properties of the composite. Hence, the final properties of LGFPP composite are highly dependent on the processing conditions of the part, therefore the effect of fibre length on the mechanical properties of injection moulded LGFPP composites must be combined with the effect of fibre orientation changes because the two competing effects would determine the final mechanical properties of these composite materials. First, microstructural characterisation of LGFPP was performed, using the resin burnout technique to get the fibre length distribution and optical microscopy method (applied to a polished cross-section) to obtain the fibre orientation distribution. In parallel a software based on Mori and Tanaka method coupled with a Monte-Carlo simulation was developed to predict local mechanical properties of LGFPP composites taking into account the real microstructure in the part.

The longitudinal Young's modulus of unidirectional composite materials increases with the fibre length until a certain limit value of the fibre length (3 – 4 mm) where the modulus becomes constant and equal to the modulus of UD glass polypropylene composite laminate. This study confirms that the Young's and shear moduli increase with the fibre content in the composite material. The comparison of the results of the Mori and Tanaka model with other models from the literature or finite element models reveals a good agreement between the results for unidirectional composite materials. The stiffness properties decrease for LGFPP composites with strongly oriented fibres.

The length and orientation of the fibres play an important role on the final elastic properties of LGFPP composites. In the future, the model will be extended to include non-linear matrix behaviour and damage development in the fibres and the fibre/matrix interface.