Development of structural low-cost hybrid composites

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Discontinuous short chopped fibre composites are becoming more attractive to the automotive industry due to their lower cost when compared to traditional continuous reinforced composites (1). Chopped fibre composites have lower mechanical properties due to the fibre length limiting the load transferred between the matrix and fibres (2), however, short fibres allow for greater material flow and therefore more complex geometries (3). Hybridisation is a method of increasing the mechanical performance of chopped fibre composites. Some studies have looked into hybridisation of composites (4), however, most of the literature available focuses on thermoset composites, and only few studies have reported results using thermoplastic matrix.

In this project hybridisation techniques were explored to produce a high performance, low cost, recyclable composite for automotive applications. Hybridisation was achieved through the combination of discontinuous injection moulding compound in pellet form with a fibre length of approximately 0.15mm, and uni-directional (UD) pre-preg manufactured via compression moulding. A single-step manufacturing process was used to produce the individual and hybrid carbon fibre reinforced PEEK composites. Panels of pure chopped fibre composite, pure UD composite and the hybrid material were manufactured to allow comparison of baseline materials to the hybrid. Void content and fibre volume fraction were analysed through resin burn-off highlighting differences in manufacture quality between materials. Characterisation was carried out through quasi-static tensile, compression and flexural tests. Results showed a large increase up to 440% in stiffness and 188% in strength in all tests in the 0° orientation with only a 21.5% increase in cost of raw materials. SEM images showed brittle failure of the chopped composite through fibre pull out with failure of the UD material through fibre break. Hybrid flexural samples showed pseudo-yielding as individual fibre failures resulted in small drops in stress. A constitutive model was developed and implemented as a VUMAT subroutine in the commercial software Abaqus/Explicit. The subroutine was able to predict the macro-mechanical response of the composite from the description of its micro-constituents including the void content.

References

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