STRAIN RATE AND TEMPERATURE DEPENDENCE OF HYBRID COMPOSITES UNDER COMPRESSIVE LOADING

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ABSTRACT

Discontinuous short fibre composites are becoming more attractive to the automotive industry due to their lower cost when compared to traditional continuous reinforced composites [1]. Short fibre composites have lower mechanical properties due to their 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 short fibre composites. Some studies have looked into hybridisation of composites [4], however, most of the literature available focuses on thermoset composites, and no studies have been carried out to look at the strain rate or temperature dependency of hybrid composites.

The materials selected for this investigation were carbon fibre reinforced polyether ether ketone (PEEK) thermoplastic composites supplied by Solvay. The first material was a short fibre composite in pellet format for injection moulding with an approximate 30% volume fraction of fibres with an approximate length of 0.15 mm. The second material was a UD pre-preg with an approximate 68% volume fraction of carbon fibres.

Manufacturing was carried out through a compression moulding process using a PEI Lab 450 press. The short fibre composite was consolidated into panel for testing. The hybrid material was produced through combining UD pre-preg layers with the short fibre composite panels through a second consolidation in the press, see Figure 1.

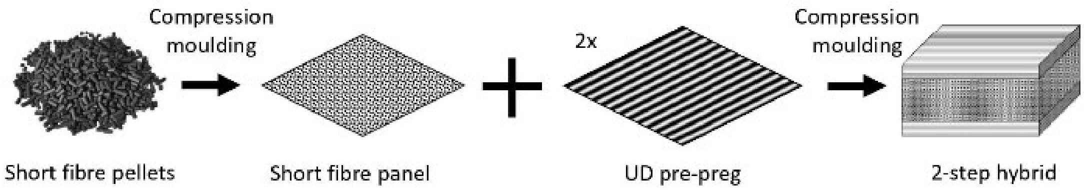

Figure 1: 2-step manufacturing process used to produce the hybrid composite comprising of short fibre injection mounding compound and UD pre-preg.

The long split Hopkinson pressure bar, located at the University of Oxford, was used to carry out high strain rate compressive testing up to a strain rate of $1350s^{-1}$. A hydraulic Zwick Z250 universal test machine was used for quasi-static testing. Environmental chambers were used in all tests to allow temperature variation between -50 and +85°C.

The rate dependency on compressive strength was observed for both the short fibre and hybrid materials. Figure 2 shows a significant rate dependence in the hybrid material with 55.0% increase in the average strength when comparing a strain rate of $1350s^{-1}$ to the quasi-static testing. A similar level of rate dependency was also observed in the short fibre composite.

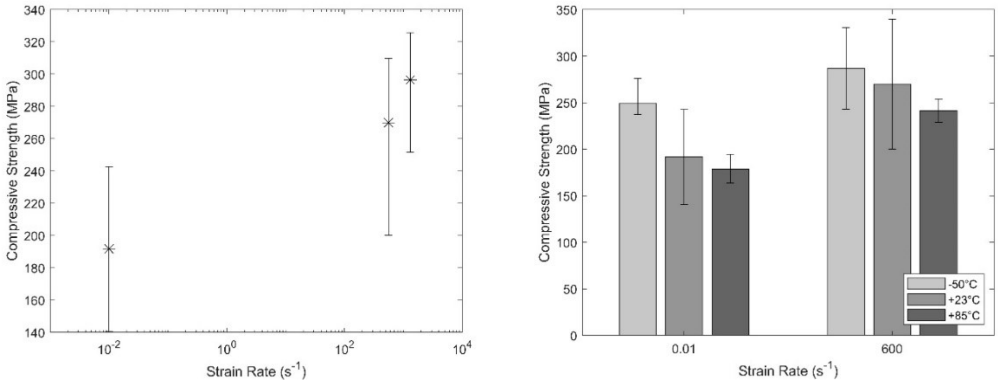

Figure 2: Compressive strength of the hybrid composite at strain rates between 0.01 and 1350s^{-1} (left). Compressive strength of the hybrid composite at strain rates of 0.01 and 600s-1 with temperature variation between -50 and +85°C (right).

The temperature dependence on compressive strength was observed in quasi-static testing and at a high strain rate of 600s^{-1} for both materials. As expected the lower temperature resulted in a more brittle specimen with a higher compressive strength, see Figure 2.

Fractography was used to observe the failure mechanisms of the materials resulting from temperature variation in quasi-static testing. Figure 3 shows the fracture surfaces of the short fibre composite tested at -50 and +85°C. At the lower temperature brittle failure was observed at the fibre matrix interface whilst at the higher temperature large areas of plastic deformation were observed in the matrix.

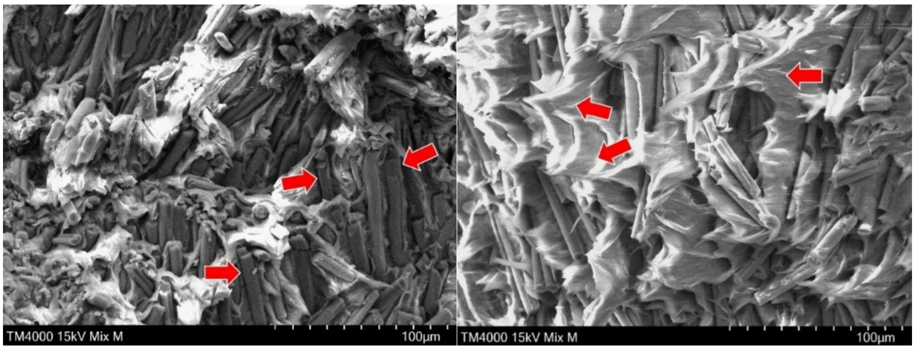

Figure 3: SEM image of fracture surface of short fibre composite tested in quasi-static compression at -50°C (left) and +85°C (right).

A large strain rate dependency was observed in both the short fibre and hybrid composites with a higher strain rate resulting in a higher compressive strength. A large temperature dependency was also observed with a lower temperature resulting in a higher compressive strength.

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