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CHARACTERISATION OF BEARING ENERGY ABSORPTION OF THIN-PLY BASED DISCONTINUOUS COMPOSITE

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ABSTRACT

Discontinuous composites in the form of short fibre reinforced plastics have been widely used in automotive structures for some time due to their manufacturability and superior properties compared to neat plastics. In some cases, materials such as sheet moulding compound (SMC) or bulk moulding compound (BMC) are employed to replace non-critical structural metal parts to reduce weight. Recently, a new type of material called tape based discontinuous composite has been receiving a significant amount of attention. These materials offer better mechanical properties than traditional short fibre composites, but increased manufacturability and lower cost compared to traditional continuous fibre reinforced composites. In this study a thin-ply based carbon fibre reinforced polypropylene discontinuous composite is tested to characterise the bearing energy absorption capacity to assess its suitability for use in crash applications. Bearing failure behaviour in tensile testing including the effect of width to hole diameter ratio (*w/D*) on energy absorption is studied. The results show that the discontinuous composite material studied has higher specific bearing energy absorption capacity than traditional long-fibre reinforced continuous composites, while offering advantages of processability, and in the current case recyclability.

Spread tow tapes of TR50S 15k JJ carbon fibre were provided by Oxeon AB for making laminates. These tapes were 50 µm thick, which is much thinner than conventional carbon fibre tapes (130 µm). Thin tapes were used to reduce the potential out-of-plane misalignment due to overlap of tape pieces, and theoretically increase the strength of the material [1]. An automatic cutting machine was used to cut tape into pieces of 50 mm x 20 mm (length x width). Tape pieces were manually stacked in a quasi-isotropic layup with a 50 µm thick polypropylene film layer placed between each carbon fibre layer. The dry preform was then compression moulded at 230˚C with 6 MPa pressure to form consolidated laminates. The fibre volume fraction (*vf*) of the laminate was measured using resin burn off test and the *vf* was found to be 32% ± 2%.

The laminates were cut into specimens with varying *w/D* ratios, from 5 to 9. A hole of diameter 5 mm was drilled into each specimen. These specimens were tested according to ASTM D5961/D5961M -17 standard [2] using a double lap shear joint setup which was mounted onto a Shimadzu testing machine with 50 kN load cell.

The results (in Figure 1) show that bearing damage initiates at very low load and grows into a progressive damage state where the load reaches a plateau and continues at a relatively stable load range until ultimate failure of the specimen. After the bearing damage is initiated, the material around the bolt is pushed to create a ripple like zone which grows with travel distance of the bolt until ultimate failure of the specimen. A correlation between the *w/D* ratio and distance pulled to ultimate failure can be also be seen.

The energy absorption capacity of this material systems is very interesting. Specific Energy Absorption (SEA) capacity of material was compared with the results from literature [3] for traditional continuous fibre reinforced composites.

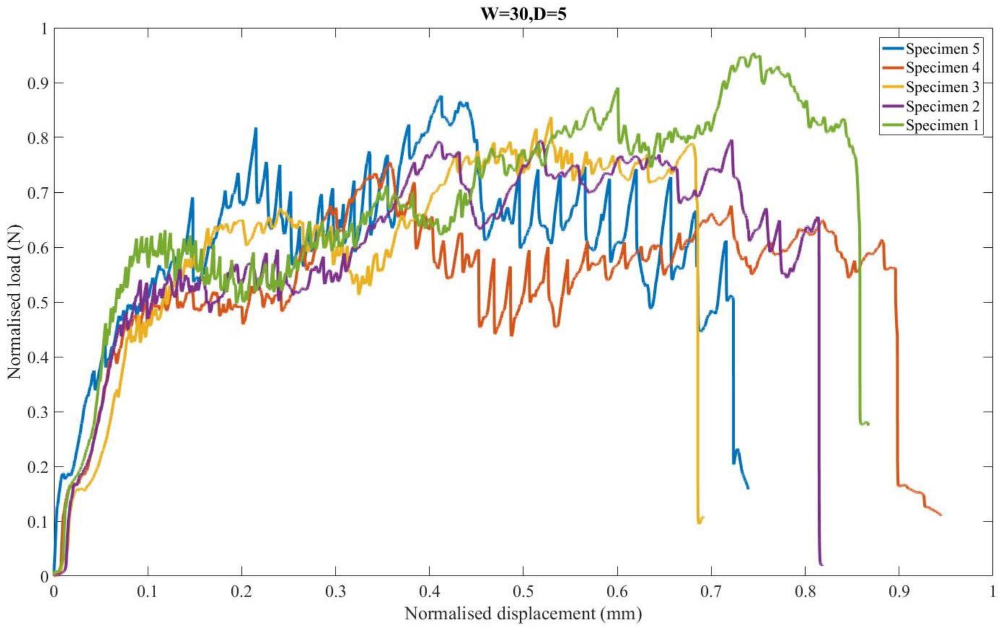

Figure 1: Normalised Load vs displacement of CF-PP discontinuous composites

Comparing average results for the current system to that of SEA of continuous composites (Figure 2) shows that the discontinuous composites are very effective material systems for energy absorption application, in addition to having a stable mode of damage propagation. Applications such as automotive crash-boxes could be of significant interest.

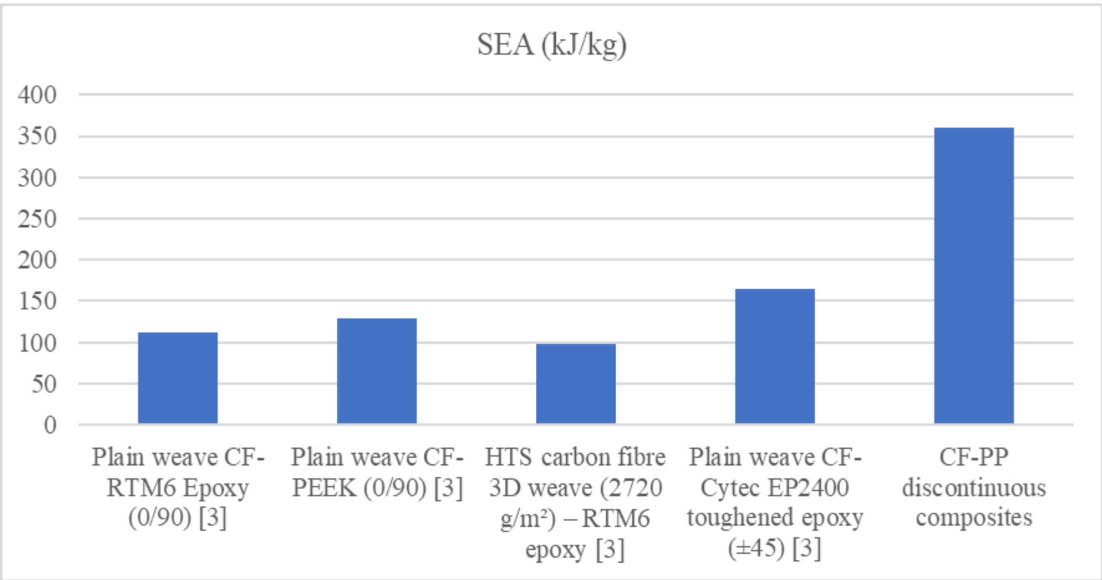

Figure 2: Comparison of SEA of various types of fiber reinforced laminates

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