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Impact Damage Tolerance of Thermoset Composites Reinforced With Hybrid Commingled Yarns

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Abstract

This paper examines the potential of low-cost thermoplastic fibres in improving the impact damage resistance and damage tolerance of thermoset (glass-epoxy) composites. Polypropylene (PP) fibres, commodity fibres without any surface modifications, have been incorporated at tow-scale with the aid of air jet commingling process. Glass-PP hybrid yarns with varying proportion of PP fibres (0-35%) are converted into several non-crimp cross-ply laminates and a plain-woven laminate. Damage resistance in terms of damage area and depth are assessed for low energy (20-50J) as well as high energy (500J) drop-weight impacts; damage tolerance is assessed through Compression after Impact (CAI) tests. Overall density of the composite laminate has reduced by 16% due to the introduction of PP fibres; at the same time total absorbed energy has increased by 22% during a high velocity impact test due to a toughing mechanism by PP fibres. Non-crimp laminates absorbed more energy at low velocity impacts in comparison to woven laminates, possibly due to extensive tow-level delaminations. On the other hand, a much larger dent depth was observed in the woven laminate after low energy impact. Compression after Impact (CAI) tests indicated that woven laminates retained 83% of compressive strength while non-crimp laminates retained 50-60%, depending on proportion of thermoplastic fibres, and standard glass fibre laminates retain around