Ultra tough architected joints through single manufacturing step

Owing to their high strength to weight ratio, Carbon Fibre Reinforced Polymer (CFRP) Composites are widely used in aerospace. Manufacturing complex structures combining metallic and composite parts requires an efficient bonding process, but also high crack propagation resistance. However, adhesive joints suffer from time and labour-intensive processes and low to moderate fracture toughness. Several toughening strategies through joints architecturing have already been investigated such as stop holes or meshes. To improve the process efficiency, one attractive option is to perform bonding and composite curing simultaneously. As a first on the road to the integrated bonding of hybrid metallic composite structures, potential toughening strategies relying on joint architecturing are investigated in this work while co-curing two composites parts.

The co-curing is performed through resin transfer moulding. A tough patterned thermoplastic film is inserted between the composite parts. This results in a bondline made of the composite resin and the thermoplastic film that replaces conventional adhesives. The mode I fracture toughness of these joints is investigated through Double cantilever beam tests.

The internal architecture produces a stick-slip behaviour which involves three fracture toughness regimes. The first regime corresponds to a moderate fracture toughness at the order of aeronautic adhesives. The second regime is characterized by an intermediate fracture toughness while the crack arrest mechanism of the third regime results in unexpected high values. The micromechanical origin of the high toughening potential is unravelled through fracture surface analysis and finite element models including the details of the joint architecture. Finite elements analyses also allow to investigate the influence of the architecture on the shear strength of the joint, revealing the main advantage of the joint: fine tuning of the joint properties by easily controlling the film architecture.

References

[1] Zwebben, C., "Advanced composites for aerospace and further prospects", Composites, 12, pp. 235-240 (1981).
[2] Martiny, P., et al. "A multiscale parametric study of mode I fracture in metal-to-metal low-toughness adhesive joints", International Journal of Fracture, 173, pp. 105-133 (2012).
[3] Heide-Jorgensen, S., et al., "On the fracture behaviour of CFRP bonded joints under mode I loading: Effect of supporting carrier and interface contamination", Composites Science and Technology, 160, pp. 97-110 (2018).