

Integrated manufacturing and toughening of composite joints using a PEI film

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The intensive use of Carbon Fibre Reinforced Polymer (CFRP) Composites in aerospace is motivated by their high strength to weight ratio. However, the manufacturing of complex aeronautic structures combining metallic and composite parts requires an efficient, ideally integrated, bonding process. Bonding through classical adhesives suffer from low to moderate toughness and the process requires multiple steps separating the manufacturing of the composite parts and the bonding.

(i) Objectives

In order to reduce the manufacturing time of the joints, integrated manufacturing is the new target in the field. Integrated manufacturing means that composite curing and bonding are performed in a single step. Recent work of Voleppe et al. [1] focussed on the curing of an epoxy resin with a PEI film, resulting in a tough interface (880 J/m²) and crack trapping due to the development of a morphological gradient (figure 1). Hence, the current objective is to make use of this principle in the context of integrated manufacturing of tough composite joints by inserting a PEI film between the two composite adherends.

(ii) Description

This work aims at introducing a PEI film at composite midplane before the Resin Transfer Molding (RTM) process (figure 2a). During composite curing, the contact between epoxy resin and the PEI film allows for the development of the morphological gradient resulting in a tough interface. In order to determine the fracture toughness of these joints Double Cantilever Beam tests are performed. In addition, fractographic analyses reveal the failure mechanisms taking place in the joints in order to further improve the joint fracture toughness.

(iii) Main outcomes

First, it is observed that the PEI film thickness has an influence on the joint fracture toughness. However, even if the morphological gradient resulting in a high toughness in the work of Voleppe et al. develops, inserting a PEI film results in a lower fracture toughness (< 300 J/m²) than compared to composite delamination (400 J/m²). This decrease is due to the intimate contact between the carbon fibres and the PEI film. In order to create a spacing between the film and the fibres, polyethylene (PE) fishing lines are inserted (figure 2b). The influence of the spacing between the fishing lines is investigated. The lower the spacing the higher the fracture toughness due to the larger number of fishing lines acting as bridging ligaments. However, compared to thermoplastic veils the amount of thermoplastic fibres is limited, but the joint fracture toughness increases at least by a factor 2 compared to joints made of a single PEI film. Fractography also reveals that the fishing line spacing influences the failure mechanism.

[1] Q. Voleppe et al. (2021) « Enhanced fracture resistance of thermoset/thermoplastic interfaces through crack trapping in a morphology gradient », Polymer, 218

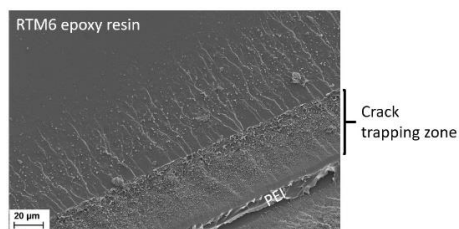


Figure 1: RTM6-PEI interphase allowing for high fracture toughness and crack trapping

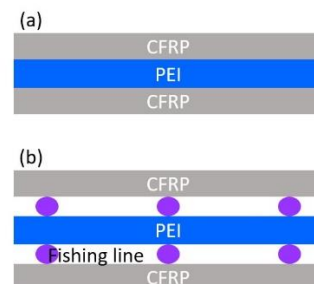


Figure 2: Composite bonding with (a) PEI and (b) PEI and fishing lines