Solid-State Self-Healing of Fibre-Reinforced Composites Materials

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Self-healing of fibre-reinforced composites is an important area of research, because such composites are susceptible to so-called 'barely visible damage' in the form of delaminations and matrix cracks. Such damage is difficult to detect without using non-destructive evaluation techniques, but can substantially degrade the mechanical properties of the composite, meaning that components which have such damage within them either require replacement or repair, both of which can be uneconomic prospects. Therefore, the concept of self-healing, in which a composite displaying the early stages of barely visible damage is able to respond, thus limiting the spread of the damage and decay of the component, is very attractive.

Much of the work on self-healing has employed liquid resin delivery either from capsules [1,2] or hollow fibres [3,4]. However, this paper discusses results from an alternative solid-state healing system that has been developed at the University of Sheffield [5]. This resin system is based on conventional thermosetting matrices, with a specially selected thermoplastic resin dissolved into it to act as the healing agent. This healing agent (in the current work poly(bisphenol-A-co-epichlorohydrin)) is selected to have a solubility parameter that is close to that of the resin system (in this case DGEBA), so that it stays in a single phase morphology even after cure of the resin. Upon fracture, the thermoplastic molecules can be mobilised with the application of heat, and diffuse across the crack-face effecting a healing response. As the resin is in the form of a single-phase liquid, it resembles a conventional matrix system from the point-of-view of manufacture of composites. In studies of the unreinforced resin, it has proved possible to recover greater than 60% of the pre-damage strength of the resin after application of an optimum healing cycle [5]. Using this resin, production of composite materials using both resin-infusion and pre-preg routes has been possible.

This paper will discuss the results of healing experiments performed on fibre-reinforced composites, aimed at determining the efficacy of healing on the recovery of mechanical properties. The results of visual inspection of the damage, along with mechanical tests aimed at assessing the level of recovery afforded by the healing system will be presented, in comparison with both composite samples produced using unmodified resin, and also samples containing the modified resin but which have not undergone a healing cycle. In this way an understanding of the effect of how the recovery of resin mechanical properties translates in to composite properties will be presented.

References

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