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Self-healing of matrix cracking and delamination damage assessment in microcapsules reinforced carbon fibre epoxy composite under flexural loading

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ABSTRACT

Structural integrity of micro cracked CFRP composite structures can be re-established by incorporating the microcapsules based self-healing system into the composite. In the current study, in order to fabricate capsules reinforced CFRP composite, 0.54: 0.39: 0.07 vol fractions of matrix, carbon fibre and separately encapsulated epoxy, hardener microcapsules were employed. Effect of microcapsules addition and induced damage on the flexural strength of the composite were investigated. It was noticed that flexural strength decreases with the increase in capsules concentration and for 5 wt% capsules reinforced composite flexural strength reduced by 21.73%, 29.32% due to induce of matrix cracking and delamination damage respectively. In order to assess self-healing performance of the composite, different damage events were induced in the composite and healing efficiency was evaluated based on the recovery in flexural strength. Effect of capsules wt%, healing temperature and pressure on the healing efficiency were assessed and noticed higher healing efficiencies at elevated temperature and pressure healing conditions. Healing efficiencies of 71.30%, 54.21% were obtained at optimal healing conditions for matrix cracking, delamination damage recovery respectively. Crack path deflection, crack pinning and capsules rupture mechanisms were observed in the microstructural investigation of fracture surface of capsule reinforced composite.

1. Introduction

Synthetic materials like polymers, fibre reinforced composites have been widely used in numerous industries such as marine, automotive and construction due to their attractive properties such as good corrosion resistance, high stiffness to weight ratio and tailorable properties. To avoid early failure of the structure, selected materials in the designing of structural components should withstand harsh environmental conditions and also offer good mechanical properties under various loading conditions. Composite materials such carbon fibre reinforced polymer (CFRP) composites offer multi directional load bearing capacity due to their inherent structure. Because of structural advantages such as high specific strength and design flexibilities, composite materials have been replacing most of the conventional materials in the applications such as aircraft frames, wings and engine components [1]. However, these composites experience deterioration, damage and failure due to various thermo mechanical loads and impact loads such as bird strikes and lightning strikes. In general, damage begins at microscopic level in the form of micro voids and then extends to microcracking, interfacial fracture and finally leads to failure of the component. But, due to anisotropic nature of the composites detection and repair of these damage events at microscopic level is a challenging task. Though few repair strategies [2,3] were available they can't be employed to repair micro cracks because of their inefficiency for invisible damage events. Hence to address these challenges and to offer a promising solution, few authors [4–6] employed self-healing technology in the composite structures. These self-healing materials provide autonomic detection, repair of the micro cracks and thus restores the functionality and extends the service life of the component.

Most of the common matrix material chosen in the polymer composite structures is epoxy. The characteristics such as better adhesion capabilities, lower shrinkage and superior mechanical properties made

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