Title

SELF-HEALING OF FIBRE REINFORCED THERMOSET COMPOSITES BASED ON COMPARTMENTED FIBRES CONTAINING LIQUID HEALING AGENTS

Abstract text

Modern fibre reinforced polymer-based composites have an extremely attractive set of properties in terms of mechanical and chemical resistance. Unfortunately, they remain sensitive to local damage, which is inclined to grow unavoidably into large scale damage and catastrophic component failure. A relatively new route to make such composites less sensitive to local damage is the route of self-healing behaviour. In the case of extrinsic self-healing composites the self-healing ability is due to the incorporation of special structural entities which are responsible for bestowing the self-healing behaviour. To date, two routes of extrinsic self-healing composites have been explored: i) the inclusion of spherical capsules containing a liquid adhesive and ii) the inclusion of hollow fibres filled with the liquid healing agent. The first route has the drawback that the spherical capsules do not distribute uniformly during composite manufacturing and the second route has the drawback that bleeding due to the first damage event will destroy the healing capabilities upon a second damage event. In this presentation we like to demonstrate the unique potential offered by fibres containing discrete vacuoles filled with healing agent along their length. Such fibres cause minimal manufacturing problems and bestow upon the composite a rare multiple self-healing ability.

Fibres were spun from an oil/water emulsion of a healing agent dispersed in an aqueous solution of sodium alginate. Fibres contain either a thiol or an epoxy based liquid agent. The encapsulation of liquid is realised by the coagulation of the alginate polymer with bivalent ions during the fibre formation. Several additives were added to the alginate solution in order to improve the mechanical properties of the fibres as well as their handling characteristics.

The developed compartmented fibres were incorporated in a thermoset matrix using standard composite processing techniques. Upon matrix fracture, the liquid healing agents are released into the crack where they react thereby restoring the damage. The healing behaviour of this system is investigated not only by measuring the mechanical properties before and after damage but also by non-destructive testing (NDT) techniques, such as scanning acoustic microscopy and x-ray micro-computed tomography.

Results show that the developed composite materials were able to partially recover their mechanical properties. Multiple local healing events were observed in the same specimen. The NDT techniques provided new insights on the healing of the matrix-fibre delaminations which is an essential step in obtaining a full recovery of structural properties in fibre reinforced polymer composites.

Keywords

SELF-HEALING, POLYMER COMPOSITES, COMPARTMENTED FIBRE, NDT TECHNIQUES

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