

RESIN TRANSFER MOULDING OF SELF-HEALING COMPOSITE MATERIALS

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ABSTRACT

Synthetic composite materials have played a significant role in the advancement of many areas of industry, including most prominently aerospace, automotive and construction. However they have one major weakness in that their failure can seem unpredictable due to microcracks within the structure which are difficult to detect. Non-destructive evaluation techniques, such as radiography and ultrasonic testing, are time-consuming and require expert technicians and tools. Even then this is not always possible with certain geometries, and most often not economically feasible. This has somewhat inhibited the introduction of these materials into more diverse markets where technological advancement is a less crucial factor in product profitability. Nevertheless this desire to overcome the limitations of composites in order to reap their obvious benefits has led to the conception of an entirely new class of materials; 'self-healing' materials.

Several methods for the regeneration of mechanical properties have been proposed, each with their own advantages which make them suitable for particular applications or environments. Active or 'non-autonomic' methods have been developed [1] where the reformation of bonds within the matrix is instigated by an external stimulus, such as Modified Matrix which regains structural integrity with the application of heat to a damage site. Early work [2] on this method used a standard DGEBA-based formulation resin (LY1556) cured with an acid anhydride (NMA), modified by a high molecular weight linear polymer healing agent (polybisphenol A-co-epichlorohydrin). One of the main disadvantages of this method is that the healing agent imparts a high viscosity to the blend, making it unsuitable for many industrial manufacturing processes, including injection moulding, resin transfer moulding (RTM) and filament winding.

In order to address this issue, an investigation has been undertaken into the further modification of this resin in order that the viscosity is reduced without compromising the self-healing ability. This new system is required to have handling properties which make it suitable for use in industrial RTM. Previous work has achieved viscosity reduction by the use of lower molecular weight healing agents [3], and the use of vary concentrations of healing agent Fig. 1. It can be seen that inclusion of the healing agent has increased the resin viscosity to the extent that RTM processing would not be possible. Further modification has been achieved by the inclusion of a reactive diluent to create the viscosity profile required for RTM. This paper will report on initial mechanical tests of the new system.

Rheometric comparison of new resin systems against previous self-healing ones and industrial RTM resin displays to what extent the handling properties of the modified self-healing resin have been adapted.

Rheometry was carried out on a TA Instruments AR2000 rheometer in linear temperature ramp mode for the viscosity profile of the uncured resin using a parallel plate 40mm geometry, and in oscillation

mode for cure monitoring of the reaction. These tests provide some insight into the extent and timescale of the reactions.

Compact tension testing has been used to monitor the degree of healing in the resin following modification. This method was used as it is an established route and provides information comparable with previous systems. Testing was carried out according to the specification detailed in BS ISO 13586:2000 on a sample of pure resin. This data allowed comparison of the fracture toughness of different resins, and of the healability intrinsic to them by retesting the fracture toughness after a healing heat cycle.

Production of composite materials will be achieved by an RTM procedure to produce testable specimens. Once modified resin systems have been formulated they will be characterized by this method, which will provide the evidence for the possibility of large scale manufacture of self-healable composite materials using industrial manufacturing routes.

It is possible to create resins with a self-healing ability by the modified matrix method by the addition of viscosity-lowering diluents. The characterisation of these resins in terms of healing properties of resin will be discussed. Once satisfactory results have been obtained for the viscosity profile and healability of the modified systems, composites manufacture and mechanical testing will be carried out in order to assess their potential in service.

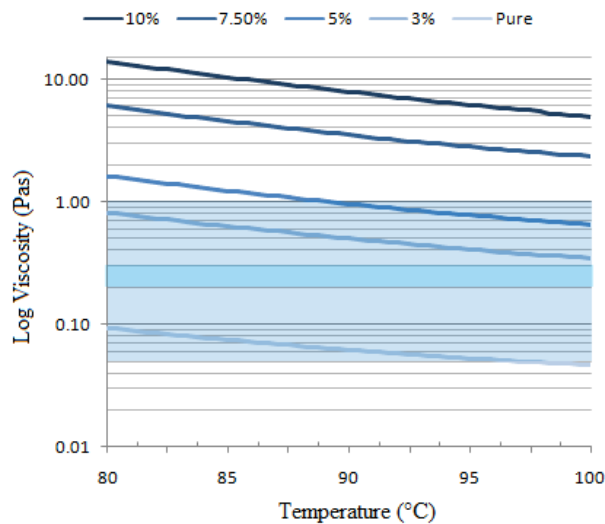


Fig.1. Viscosity of self-healable resin with varying concentration of healing agent. Shaded areas represent the viscosity range suitable (light) and ideal (dark) for RTM manufacture.

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