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Fibre prestressed polymer-matrix composites: a review

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Abstract

This article reviews the literature studies based on improving the mechanical properties of fibre-reinforced composites using fibre-prestressing method. The idea is characterized by pretensioning the fibres either elastically or viscoelastically prior matrix curing. The beginnings of the studies in this field were focused on reducing fibre waviness and breaking the weaker fibres by pretensioning the fibres to a relatively high stress level prior moulding process. In the last three decades, the concept of fibre prestressing had been developed to include its ability to reduce the effect of undesired residual stresses existence accompanying manufacturing process of fibre-reinforced composites. The main advantage of fibre prestressing method is to generate a desired and controlled residual stress state within the matrix in order to obstruct the initiation and propagation of cracks. Various techniques of fibre prestressing have been reviewed to show their scope of applications, developments and limitations. Therefore, the findings drawn from this review can be used for further studies in the field of fibre prestressed composites in order to select the most suitable methodology and develop it to fit the manufacturing process requirements towards a production of high-performance composites without a considerable additional cost.

Keywords

Fibre pretension, polymeric matrix composites, prestressing method, microcracks, residual stresses

Introduction

Nowadays, using of composite materials in aerospace, automotive and marine industries is increasing day by day, leading to increase in the demand for developing the manufacturing techniques, which can improve the mechanical performance of such advanced materials.[1–3] Although currently available composites have superior mechanical properties compared with conventional metallic materials, the improvements are still on-going. In fact, the cost of producing more reliable composite component needs either additive materials and/or improved fabrication techniques. It is generally believed that when manufacturing of the composite materials, residual stresses are generated within the structure.[4–6] These residual stresses can be developed in composite materials due to several reasons such as chemical shrinkage of polymer matrix, different thermomechanical properties of the constitutions and humidity absorption.[6–12] Residual stresses results from chemical shrinkage occurred during the polymerization process of the resin where the resin has changed its phase from liquid to solid state.[4,6] The mismatch in coefficient of thermal expansion between the fibre and the matrix could produce residual stresses in composite when it cooled from its curing temperature.[4,6,7,13–16] Whereas, moisture absorption by the polymeric matrix and fibre leads the composite constituents to deform and expand at different levels depending on the swelling permeability.[17] Manufacturing process such as the filament winding fabrication technique can add another source of induced

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