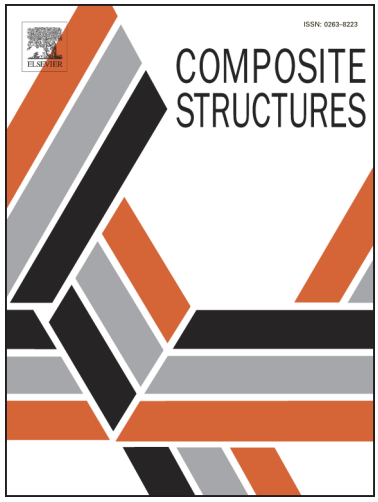

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A novel vibration based non-destructive testing for predicting glass fibre/matrix volume fraction in composites using a neural network model

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Abstract

This study proposes a novel approach to determine the fibre volume fraction in composites using vibration based non-destructive technique with a neural network. Currently, the volume fraction of a glass fibre/matrix based composite material is assessed using destructive techniques. Instead of changing or destroying the structure, a new non-destructive approach based on vibration analysis is proposed. Complete experimental protocols were developed to capture the vibration pattern. An auto-regressive model was developed as a feature extraction tool to classify the fibre volume fractions and as a pole tracking algorithm. The classification performances were within the range of 90% to 98%. For NDT method to be efficient, the classification results were then compared with destructive burn-out technique. The results of non-destructive test showed good agreement with those obtained through destructive test suggesting that the proposed method is an alternative to ASTM D2584−11 for determining the volume fraction of a glass fibre/matrix composite.

Keywords: Volume fraction, composites material, vibration signal, non-destructive testing, neural network model.

Introduction

In recent years, the mechanical properties of composite materials have been of interest to researchers and have further contributed to fields applying such composite materials.There have been numerous studies globally dealing with the mechanical properties of composite structures owing to their influence on the design of composite structures [1]–[4]. Messiry[4] stated that among the roles that contribute to determining the mechanical properties of a composite, one of the most significant is the fibre volume fraction.

In the industrial field, it is important to note that the fibre/matrix volume fraction has a large impact on the strength and stiffness of a composite material. The fibre volume fraction was found to have a significant effect on the properties of a composite, including the failure mode and ultimate strength. The mechanical properties of a composite can be improved by increasing the fibre volume fraction [5].However, when the fibre volume fraction is quite large, the composite ultimate strength is degraded, which is due to the interfacial adhesion between the matrix and the fibre; for example, if the fibre is increased up to 70% V_f, the tensile stiffness may