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Prediction of delamination growth in carbon/epoxy composites using a novel acoustic emission-based approach

Reza Mohammadi[1], Milad Saeedifar[1], Hossein Hosseini Toudeshky[2], Mehdi Ahmadi Najafabadi[1] and Mohamad Fotouhi[1]

Abstract

Delamination is the most common failure mode in laminated composites and it leads to loss of structural strength and stiffness. In this paper, acoustic emission monitoring was applied on the carbon/epoxy laminated composites when subjected to mode I, mode II, and mixed-mode I and II loading conditions. The main objective is to investigate delamination behavior and to predict propagation curve of the delamination in different G_{II}/G_T modal ratio values by the acoustic emission. First, a combination of acoustic emission and mechanical data (sentry function) is used to characterize the propagation stage of the delamination. Next, the crack tip location during propagation of the delamination in the specimens is identified using two methods. In the first method, by determining the velocity of the acoustic emission waves in the specimens, the position of the crack tip can be estimated throughout the tests. In the second method, the cumulative energy of the acoustic emission signals is utilized for localization of the crack tip. Agreement between the predicted crack length and the actual crack length verifies the presented procedures. It can be concluded from the results that the acoustic emission method is a powerful approach to investigate the delamination behavior and to estimate the crack tip position in the composites.

Keywords

Delamination, carbon/epoxy, acoustic emission, sentry function, localization

Introduction

Carbon fiber reinforced plastics (CFRP) have many advantages such as high specific strength, specific stiffness, etc. In contrary, these materials suffer from different damage mechanisms. The principal mode of failure of layered composites is the separation along the interfaces of the layers, viz. delamination.[1] In real laminated composite structures, delamination may occur mainly in mode I, mode II, or the combination of these pure modes, resulting in a dramatic loss of the residual strength and the stiffness of the structures.[2] Therefore, there is an increasing trend to investigate this failure mechanism. Having better knowledge about the delamination would help us to produce laminated composites with higher strength against crack initiation and propagation.

This paper is an attempt to investigate the delamination initiation and propagation in the woven type carbon/epoxy laminated composite. In order to achieve this aim, the acoustic emission (AE) technique, which has a good applicability to investigate delamination damage,[3] is used. The AE signal is a transient wave resulting from damage mechanisms that occur during the initiation and propagation of delamination failure. These damage mechanisms, i.e. matrix cracking, fiber

[1]Non-destructive Testing Lab, Department of Mechanical Engineering, Amirkabir University of Technology, Tehran, Iran
[2]Department of Aerospace Engineering, Amirkabir University of Technology, Tehran, Iran

Corresponding author:
Mehdi Ahmadi Najafabadi, Non-destructive Testing Lab, Department of Mechanical Engineering, Amirkabir University of Technology, 424 Hafez Ave, 15914 Tehran, Iran.
Email: Ahmadin@aut.ac.ir