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Monitoring the initiation and growth of delamination in composite materials using acoustic emission under quasi-static three-point bending test

M. Fotouhi, F. Pashmforoush, M. Ahmadi and A. Refahi Oskouei

Abstract

Control and optimization of machining processes are important issues affecting the development of productivity. Monitoring systems have become indispensable in the evaluation of materials during machining. In this paper, the path toward the delamination-free drilling of glass/epoxy composite material is established using some novel methods based on acoustic emission features. Acoustic emission monitoring with three techniques, sentry function, acoustic emission energy distribution, and acoustic emission count distribution, are developed to detect and realize the critical force at the onset of delamination process on glass/epoxy composite materials. The three-point bending test simulates thrust force, the most effective factor in delamination, throughout the process of drilling without backup plate. Sentry function is regarded as a new method based on the combination of AE information and mechanical behavior of composite materials. The sentry function was used to study the initiation and growth of delamination process. Two types of specimen with different layups, woven $[0, 90]_s$ and unidirectional $[0]_s$, leading to different levels of damage evolution, were studied. Results show that AE parameters and sentry function method are useful tools for the examination of initiation and the growth of delamination during drilling process and can help to avoid delamination damage while drilling.

Keywords

polymer composites, acoustic emission, sentry function, delamination, three-point bending

Introduction

In recent years, glass fiber–reinforced plastics (GFRP) are increasingly applied in many engineering fields, especially in gas and oil industry. This increasing application is due to their excellent properties, such as high specific modulus of elasticity, high specific strength, good corrosion resistance, lightweight, etc.[1]

As the fields of application increase, the use of different machining processes such as drilling, turning, cutting-off, and milling become necessary for fabrication of composite materials.[2] Although near-net shape processes have caught a lot of interest, modular and more complicated products require secondary machining for the drilling of final assemblies.[3] Composite materials are the combination of two or more elements, which differ in chemical properties and physical shape. The purpose of combination of two or more elements is to employ superior properties of all the elements.[4] However, due to the existence of two or more different phases, carbon fiber–reinforced plastics (CFRP) composites suffer from different kinds of machining problems. Therefore, the mechanism of machining of composites completely differs from that of homogeneous metal removal of conventional materials.[5,6] The most important characteristics of composite materials are anisotropic structure, non-homogeneity, and lack of plastic deformation.[7,8] It has been shown that

Non-destructive Testing Lab, Department of Mechanical Engineering, Amirkabir University of Technology, Tehran, Iran.

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