Article

JOURNAL OF COMPOSITE MATERIALS

Journal of Composite Materials
0(0) 1–13

DOI: 10.1177/0021998314521258
jcm.sagepub.com
SAGE

Clustering of acoustic emission signals collected during drilling process of composite materials using unsupervised classifiers

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Abstract

Conventional methods of analysis for drilling of composite materials usually study the amount of damaged area, thrust force, and effective parameters. However, these methods do not provide the investigator with sufficient information about drilling mechanisms. In the current investigation, a procedure for diagnosing different drilling mechanisms based on the analysis of the signals of acoustic emission is presented. According to the number of time domain acoustic emission parameters, using multi-variable methods of analysis is unavoidable. In this work, unsupervised pattern recognition analyses (fuzzy C-means clustering) associated with a principal component analysis are the tools that are used for the classification of the recorded acoustic emission data. After classification of acoustic emission events, the resulting classes are correlated with the different drilling stages and mechanisms. Acoustic emission signal analysis provides a better discrimination of drilling stages than mechanic-based analyses.

Keywords

Drilling, composites, acoustic emission, fuzzy C-means clustering, principal component analysis

Introduction

Drilling of composite materials

The development of composite materials offers several advantages over homogeneous and isotropic conventional materials such as high specific stiffness, high strength, resistance to fatigue loads, tolerance to temperature extremes, dimensional stability, and weight minimization.[1,2] These superior mechanical properties have developed the field of composite materials ranging from automobile components to sporting goods. Processes such as hand lay-up, filament winding, autoclave curing, etc. are employed to fabricate composite materials. However, machining operations have to be performed to manufacture the finished components.[3]

Drilling is one of the most common and acceptable machining processes performed in the final stages of assembly of sub-components. Any defect resulting in rejection of the part represents an expensive loss. It has been reported that drilling-induced delamination accounts for 60% of all part rejections during assembly of an aircraft.[4] There are several forms of damage that occur during drilling of composite materials; among these, matrix cracking, fiber pull out, fiber breakage, matrix burning, and delamination are the most crucial.

Delamination is one of the serious problems that occur due to localized bending in the zone sited at the point of drill contact. Delamination leads to poor assembly tolerance and has the potential to reduce the

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