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DAMAGE ASSESSMENT IN COMPOSITE LAMINATES – A FRACTAL APPROACH

Jorge M.P. Silva[1], João Matos[2], Stella Abreu[2], João Manuel R. S. Tavares[3], Luís M. P. Durão[1(*)]

[1] ISEP/CIDEM, School of Engineering-Polytechnic of Porto, Rua Doutor António Bernardino de Almeida, 431, Porto 4200-072, Portugal Portugal
[2] ISEP/LEMA, School of Engineering-Polytechnic of Porto, Rua Doutor António Bernardino de Almeida, 431, Porto 4200-072, Portugal Portugal
[3] Instituto de Engenharia Mecânica e Gestão Industrial, Departamento de Engenharia Mecânica, Faculdade de Engenharia, Universidade do Porto, Portugal
[(*)] *Email:* lmd@isep.ipp.pt

ABSTRACT

This work focuses on the assessment of the damaged area originated by drilling of composite laminates. A batch of carbon/epoxy plates was cut into test coupons and drilled under different conditions regarding feed rate and spindle speed. The use of enhanced radiography allowed the determination and assessment of the damaged area. Besides the damage assessment, other mathematical functions were used, like fractals, to characterize the damaged area. Finally the plates were mechanically tested for correlation of results.

Keywords: Carbon fibre, Machining, Damage Assessment, Mechanical Testing.

INTRODUCTION

The characteristics of fibre reinforced laminates have widened their use from aerospace to domestic appliances. New possibilities for their usage emerge almost every day. Their ability to be tailored for use and endless possibilities provided by the combination of reinforcements together with their alignment and fiber fraction allow design engineers to have almost total freedom in the design of parts. Unique properties, such as low weight, high strength and stiffness, are normally referred to as advantages of these materials.

Machining operations like drilling are frequently needed in composite structures, as the use of bolts, rivets or screws is required to join the parts involved. Generally, machined parts have poor surface appearance and tool wear is higher. One of the problems related with the machining of composite materials is the nature of the fibre reinforcement, which is usually very abrasive and causes rapid tool wear and deterioration of the machined surfaces.

The special characteristics of the composite materials make them difficult to machine when compared to traditional materials. It is known that a drilling process that reduces the drill thrust force can decrease the risk of delamination thus increasing the reliability. The most frequent and noticeable evidence of these damages is the existence of an irregular edge around the machined hole, namely at the exit side of the drill, as a consequence of the drilling process. In this region, it is possible to observe, by visual or enhanced inspection, the separation of adjacent plies of the laminate. This damage is known as delamination, Figure 1. Delamination is considered as the most critical damage that occurs when drilling composite parts as it can contribute to a decrease on their mechanical strength. Therefore, the reduction of this damage is very important to the industry of composites. For that, damage assessment

methods based on data extracted from images of drilled plates are of primordial importance (Chen, 1997; Davim, 2007; Tsao, 2012).

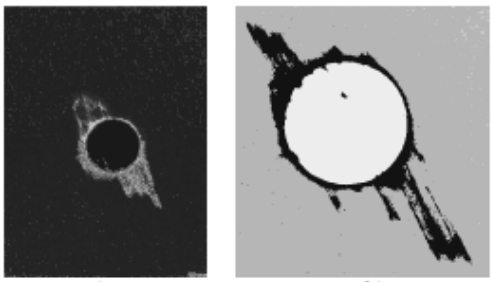

Fig. 1- (a) Enhanced radiography of a drilled composite laminate; (b) damage region identified using techniques of image processing and analysis (Durão, 2013).

In this work, a batch of carbon/epoxy plates was drilled in order to acquire enhanced radiographic images that were processed for damage assessment. A number of published criteria for damage assessment were compared and correlated with mechanical test results, particularly from the bearing test. Also, the development of mathematical functions for the classification of the damage region – like fractals – will be presented as a new way to contribute towards its enhanced assessment.

RESULTS AND CONCLUSIONS

This work will underline the importance of the damage extension in the selection of the best drilling parameters and the need for an adequate characterization of all the geometrical factors related to the damaged region, including diameter, area and irregularity of the region.

The results demonstrate the importance of an adequate assessment of the damage area in composite laminate parts and the proper selection of drilling parameters, including tool selection, to extend the life cycle of the parts as a consequence of enhanced reliability.

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