Accepted Manuscript

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PII: S0263-8223(17)31782-8
DOI: http://dx.doi.org/10.1016/j.compstruct.2017.06.043
Reference: COST 8630

To appear in: *Composite Structures*

Received Date: 5 June 2017
Accepted Date: 19 June 2017

Influence of cutting parameters on tool wear and hole quality in composite aerospace components drilling

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ABSTRACT

Composite Fiber Reinforced Plastics (CFRP) are characterized by their outstanding mechanical properties combined with reduced density and good resistance to corrosion and fatigue which make them suitable for aerospace components. During assembly procedures, one shoot drilling operations, usually including countersinking cycle, are required to minimize positional errors, enhance tight tolerances and reduce process time.

Countersink drill bits were tested on CFRP test specimens, representative of aircraft components. Along testing, tool wear was monitored with an optical microscope to track its evolution and determine the dominant wear mechanism. On the other hand, hole quality was evaluated since tool life criterion is based on the assessment of machined surface quality.

The influence of cutting speed and feed was analyzed with the objective of looking for extended tool life and more productive cutting parameters.

The information gathered from monitoring tool wear and inspecting hole quality can be used for the enhancement of CFRP drilling and the improvement of the manufacturing process competitiveness, in terms of production cost and time.

Keywords: Composites drilling, cutting parameters, quality inspection, tool wear

1. Introduction

The employment of composite materials by aerospace industry has stood out in the last decade due to their outstanding mechanical properties, combined with reduced density and good resistance to corrosion and fatigue, until today when they shape over 50% of the structural weight of some aircraft. In particular, Composite Fiber Reinforced Plastics (CFRP) have high specific strength and superior fracture toughness [1].

Even though composite materials are characterized by its manufacturing process, which allows to produce near net shape, machining is unavoidable for assembly purposes, being drilling the most common operation. The different components are stacked together to perform the operation in single shot, obtaining the required tolerances of the hole and removing the reaming cycle. Usually, it is included countersinking to avoid interferences of the head of the rivet with the aerodynamic shape. This minimize positional errors, enhance tight tolerances and reduce process time.

Although kinematics of composites machining process remains the same as in metal machining [2], there are several differences due to the fact that composites are inhomogeneous and anisotropic materials made from two constituents: the reinforcements which use to be brittle and the matrix which, for its part, tends to be more ductile. Hence, machining process is based on intermittent fractures and bouncing cutting forces.

The drilling operation is produced by two different material removal processes, related with conventional drill bits geometry. The main cutting edges eliminates most of the material, analogously to an orthogonal cutting, which generates the bulk of the torque or cutting force. On the other hand, the chisel edge behaves as a blunt edge with a high rake angle which work as a punching process and producing most of the thrust force [3]. Regarding chip formation process, it is caused by multiple cutting edges which encounter the fibers at difference orientations despite of the material is made of