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Performance of cryogenically treated WC drill using tool wear measurements on the cutting edge and hole surface topography when drilling CFRP

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Abstract

Drilling CFRP poses major challenges from the perspective of rapid tool wear and poor hole quality, with the development of higher strength fibers further accentuating these problems. Cryogenic treatment is one way of increasing tool hardness thereby improving tool life and hole quality through longer retention of cutting edge sharpness. In this study, tool wear is monitored by measuring flank wear, cutting edge flatting (CEF), peak flatting (PF) and cutting edge surface roughness (CESR). While flank wear is unable to distinguish the better performance of the cryo-treated drill from the untreated drill, the other wear parameters are able to account for the better hole quality (exit delamination) produced by this drill. CEF and PF are direct measures of the extent of cutting edge blunting unlike flank wear which measures wear along the flank due to rubbing. Fiber pullout is the primary reason for deterioration in surface finish and Rz and Rv are better measures than Ra in estimating surface quality.

Keywords: CFRP drilling; cryogenic treatment; cutting edge flatting; peak flatting; cutting edge surface roughness; hole surface finish.

Introduction

The proportion of composite materials in the aircrafts of this generation is more than four times that of the previous generation ones. This is mainly due to their high strength combined with light weight, good corrosion resistance and other desirable properties. In today's competitive environment, structural weight savings leading to better fuel economy, greater load carrying capacity and reduced carbon footprint make carbon fiber plastics an exciting prospect for aerospace, automotive, energy, electronics and other industries [1]. The differences among these materials in terms of resin, fiber diameter, fiber fabric, layup, fiber-volume fraction, curing temperature, etc., pose major challenges in their design and manufacture. While composite materials are manufactured to complex shapes by bonding, they must be attached to other structural members (made of composites or metals) using fasteners. This necessitates drilling holes in these materials [1,2].

The alternate engagement of the cutting tool with the relatively soft, tough matrix and strong, abrasive fibers makes their machining a challenge which should be overcome differently from that of homogenous metals. Splintering / fraying, matrix heating, delamination due to the layered structure, etc., are some of the problems encountered when machining composites [3,4]. While the difficulty to machine them has increased with the development of stronger and stiffer carbon fibers, the demand for better cutting tool performance and machined quality has also increased. This requires cutting tools which can match these demands while being economical.

Hole quality has always been one of the primary concerns in drilling CFRP mainly because of the rapid abrasive wear to which the drill is subjected to. Tool wear has been found to be directly related to deterioration in hole