

Ultrasonically assisted drilling of CFRP/Ti stacks

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Abstract

Carbon-fibre reinforced polymers and titanium (CFRP/Ti) stacks are being used extensively to address the need for improved strength-to-weight ratio of aerospace structures. Mechanical drilling of advanced materials such as CFRP and titanium alloys remains an important machining operation in engineering industries. In aircraft structures, bolting and riveting are the preferred techniques for fastening two dissimilar components together to create sub-assemblies; as a result, a large number of holes need to be drilled in the stack. Unfortunately, machining of these structures remains a challenge due to the poor machinability properties of both materials. Well-documented problems in drilling stacks using conventional methods include high levels of cutting forces and torques, high tool wear, large exit burrs in Ti, delamination damage in the composite and poor hole quality. Thus, there is an obvious industrial need to improve the machinability of stacks for efficient manufacture.

Here, ultrasonically assisted drilling (UAD) in CFRP/Ti stacks is carried out with the goal to obtain optimal drilling parameters for improved hole quality. The UAD process involves the use of high-frequency (typically 20 kHz or higher) low-amplitude vibration superimposed on the drill-tip movement of a conventional drilling process, converting traditional drilling into a micro-chipping process. In this study, first, individual components of the stack were studied using conventional drilling and UAD to assess machining-induced damage in the materials. Machining forces, energy consumed and hole quality were compared for the two studied drilling techniques. Our studies show that UAD outperforms conventional drilling on all aspects. Next, the optimal parameters were assessed for the entire stack, with the goal of minimising delamination damage in CFRP and eliminating burr formation in Ti.

Keywords

Ultrasonically assisted drilling (UAD), Titanium, Carbon fibre reinforced plastics (CFRP), Thrust force, Surface roughness, Hole quality.