ABSTRACT

Composites are used together with other material to form a stack of multiple materials, which results in a higher strength/weight ratio. The composite of Carbon Fiber Reinforced Plastic (CFRP) with Aluminum (Al) or Titanium alloy (Ti6Al4V) has been widely used by the aerospace industries.Commercial aircraft structural components are made extensively using light weight and high strength materials like CFRP, Ti6Al4V, and stacks composite such like CFRP/Ti6Al4V,CFRP/Al and CFRP/Al/Ti6Al4V. Although materials can be manufactured separately and stacked together to attain a near-net shape; it still involves post processing operations such as trimming and drilling. It is a challenging task to drill CFRP/Ti6Al4V or CFRP/Al or Al/CFRP/Ti6Al4V at one time due to the lack of uniformity in the properties of the material.

Based on the literature review, the present work attempted to investigate on hole quality during drilling of CFRP/Ti6Al4V stacks. An experimental study was carried out on drilling of CFRP/Ti6Al4V stack using Ø5mm solid carbide drill tool coated with Titanium Aluminium Nitrate (TiAlN). It is vital to have an optimal machining condition and tool geometry for better hole quality and tool life.

The focus was to study the influence of modified solid twist drill geometry. Investigations on the drilling of stacks was made in different modules; (i) Experimental study on drilling of CFRP/Ti6Al4V stacks was carried out using a K20 carbide drill. Perforation features were evaluated

based on thrust and torque generated during drilling, delamination caused during drilling of CFRP, quality of hole produced (hole diameter and roundness), and burr formation in Ti6Al4V while drilling and an attempt has been made to maximize hole quality by determining combination of parameters using multi-object optimization using the weighted sum method. Structured experimental study was performed using four level and two factor L 16 Taguchi based DOE with three replicate and a total of 48 trials.

(ii) Experimental work on drilling of CFRP/Ti6Al4V stacks was carried out using three types of drills (Y-Tech, Coro drill and SGS Solid twist drill). The suitable machining parameters (speed and feed) were selected based on cutting tool manufacturer's recommendation. Tools wear study was performed by drilling of 180 holes for different geometries under dry condition. The effect of cutting force (Thrust force and Torque), the delamination factor of CFRP, Surface roughness on titanium alloy and CFRP, burr height of Ti6Al4V alloy and Quality of holes (Hole Diameter and Roundness) were also studied.

(iii) Based on the extensive experimental study on the drilling of the CFRP / Ti6Al4V stacks using different types of drill bits, three combinations of modified drilling tools (TG1, TG2 and TG3) were designed and developed and their performance was studied based on the experimental analysis using L 27 orthogonal array based design of experiments and monitoring of the condition of the online tool using the Acoustic Emission (AE) sensor. Helix angle and point angle has a great influence on tool performance and cutting force.It was found that a tool geometry (TG1) with a helix angle of 35 ° and point angle of 130 ° results in a reduction in the thrust force which is in the range of 150-500 N , but the TG2 also behaves almost as TG1, but when compared to the AErms voltage generated during the drilling, it was found that the progressive increase of voltage in TG1 is lower

with respect to TG2, which can be attributed to the useful life of the tool. In this drilling process, wear monitoring was performed using the crest factor as the monitoring index. The voltage of AErms was measured and correlated with the performance of the drills. The optimization of multiple responses of the performance measures (drilling force and hole quality) were carried out using Taguchi integrated TOPSIS and Deng's similarity-based approach revealed that spindle speed (895 rpm), feed (0.05 mm / rev) and drill tool with 130º point angle gave satisfactory performance while drilling CFRP/Ti6Al4V stack.

(iv) Study on drilling of CFRP/Ti6Al4V stacks under Minimum Quantity Lubrication (MQL) condition using LRT 30 oil with varying flow rate, spindle speed and feed have been carried out using three modified drill tools. The recital of the tools was evaluated based on hole quality, burr height, thrust force, chip formation and tool wear. The structured experimental analysis was performed using L 27 orthogonal array based design of experiments.It was found that TG1 tool performance was better by producing a minimum burr height while drilling Ti6Al4V. TG2 performance was better by producing minimum force and better hole quality.