ABSTRACT

Polymer Matrix Composites (PMCs) are composed of resins, reinforcements, fillers and additives. Each of these constituent materials or ingredients plays an important role in the processing and final performance of the end product. The resin or polymer is the "glue" that holds the composite together and influences the physical properties of the end product. The reinforcement provides the mechanical strength. The fillers and additives are used to impart special properties to the end product.

The advantages of composites are high stiffness to weight ratio, good fatigue characteristics, light weight, high strength to weight ratio, high directional strength, good corrosion resistance, good weather résistance and good dimensional stability. The type, quantity and volume or weight of materials selected in addition to the manufacturing process to fabricate the product, determine the mechanical properties and performance.

The drilling operation carried out on GFRP composites has several undesirable effects such as fiber breakage, de-bonding, fiber pull out, stress concentration, thermal damage, micro cracking and delamination. The delamination of the polymer material over the conventional materials is largely from their higher anisotropic nature .Delamination can be quantified by a ratio known as delamination factor. Delamination factor is the ratio between the diameters of the hole created to the required diameter. If

delamination factor is 1, then there is no delamination, but if is more than 1 then delamination exists.

The following are the objectives of the present research work:

1. To evaluate the effect of fiber orientation on delamination factor and cutting forces during the drilling operation of GFRP.
2. To analyze effect of drill bit geometry, matrix material and drill bit geometry on delamination factor and cutting forces during the drilling operation of GFRP.
3. To analyze the effect of process variables of high speed drilling on GFRP/Aluminium stack.

Glass fiber reinforced composite laminates were prepared by hand lay-up method. The woven fibers of 80 gram per square meter were used throughout this work. Fiber matrix ratio was maintained at 3:2 (60%fiber and 40% matrix) by weight. Air bubbles were squeezed out by applying hand rollers and placing uniform load. Laminates were cured at atmospheric temperature and pressure for 10 days. Laminates were prepared for a thickness of 5 mm (±0.2mm) in almost all the experiments. Experiments were carried out in conventional drilling machine and Makino vertical machining center.

Influence of orientation of fibres: Three types of laminates were prepared (Cross ply, angle ply and random orientation). Three spindle speeds and three feed rates were adopted to conduct a 27 run DoE-experiment.

Influence of fibre orientation on the machining process was assessed. It can be concluded that, the delamination was minimum when the fibers were randomly oriented.

Influence of drill bit geometry: Three different drill bit geometries namely twist drill bit, brad drill bit and spade drill made by high speed steel were used for the experiments. Rotational speed of the drill bit (rpm), feed of the drill bit (mm/rev) and drill bit geometry were three input parameters that were varied at three levels in a full factorial experiment. Normal twist drill bit creates more delamination both on the entry side and exit side. It is probably owing to the fact that special drill bits cut the periphery first and thus maximizes the chance that the fibers can be cut cleanly, rather than having them pull messily out of the GFRP composite from the center of the hole. It is concluded that defects were less in spade drill bit geometry compared to twist and brad drill bits

Influence of matrix material (Resin): In this investigation drilling studies were conducted on GRFP composites made up of three different thermo-set resins namely epoxy bisphenol and vinyl ester. The tool used in the experimentation was twist drill bit of cemented carbide. Three input variables considered for this work are spindle speed (rpm), feed (mm/rev) and matrix used in the composite (epoxy, bisphenol and vinyl ester). Lesser delamination occurs for epoxy matrix material. Since the strain that a laminate can reach before micro cracking depends strongly on the toughness and adhesive properties of the resin system. For brittle resin systems, such as most polyester, this point occurs a long way before laminate failure, and so severely limits the strains to which such laminates can be subjected.

Effect of tool material: An attempt was made to study the influence of drill bit material on the drilling of GFRP composite. Machine tool parameters such as spindle speed, feed rate and twist drill bit material were varied at three levels. A 27 run 3 factors and 3 levels full factorial design was adopted. Spindle speed and feed were varied at three levels and also twist drill bit material was varied at three levels such as high speed steel (HSS), Tungsten carbide and Poly crystalline diamond (PCD). Being the hardest material poly crystalline diamond (PCD) gave better results in terms of lesser thrust force, torque and less delamination at the entry and exit.

Effect of stacking**:** Use of Glass-fibre reinforced plastic (GFRP) in the commercial aircraft along with aluminium or along with titanium is increasing. The work materials used in this experiment are GFRP laminate and Aluminium 2024 alloy. Laminate was made to the thickness of 5 mm. A 5 mm thickness Aluminium 2024 plate was used along with GFRP laminate as the workpiece for the study. Thrust force and torque rise steeply when drill enters aluminum when compared to GFRP. It is found that delamination effect is reduced by stacking.