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Experimental Investigations on Drilling of GFRP Composite using Solid and Hollow Drill Point Geometry

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ABSTRACT

Fibrous composite material are widely used because of its various enhanced properties as com- pared to the conventional material. Machining of these Composite materials is entirely different as compared with the conventional materials because machining depends upon the physical and me- chanical properties of the fiber, amount of fiber, type of fiber and the chemical composition of the fiber in the composite. In this paper conventional drills of solid and hollow drill are used to drill holes and its effects are studied on Glass fibre reinforced polymer composite(GFRP) prepared by hand lay up method. Implications of tool geometry ,speed, feed on delamination and machining time has been studied.
Keywords: Drilling, GFRP composite, Hollow drill, Solid drill.

1. Introduction

Fiber Reinforced Polymer composites are different from traditional construction materials such as steel or aluminum because these composites are anisotropic having properties only apparent in the direction of the applied load whereas steel or aluminum is isotropic which have uniform properties in all directions, independent of applied load. The commonly used fibers are glass, carbon or aramid. In glass fiber reinforced composites, glass fibers in woven, mat, knytex or cloth form are used as a reinforcing agent to provide the strength and toughness to the composite. Glass fibers are the syn- thetic material which are widely used in field of engineering because of its useful properties like incombustibility, corrosion resistance, high strength at low densities,good thermal and sound insulation and theirelectrical properties[6]. Glass Fiber Reinforced Composites are extensively used in the aerospace, aircraft and shipping industries because of its light weight and lowcost.

As composites have large scale applications it becomes necessary to perform machining operations. For making different size structures joining of composites becomes necessary. Mechanical joining with the help of nuts-bolts and screws are commonly used for joining of composites as these are temporary joints which are easier to inspect and repair while quality control.

Drilling is the machining process for producing round holes in a solid material or enlarging existing holes with the use of multi tooth cutting tools called drill or drill bits. Drill bits are attached with the drill to create the holes, which provide them power to cut through the work piece by rotation. In this research an attempt is made to study theeffect of type of drill bit and machining parameters on the quality of hole produced.

2. Experimentation

Composite laminate of 4mm thickness is prepared by using woven E glass fiber mats and epoxy resin. It is prepared by conventional hand layup technique at room temperature. Composite have 8 layers of glass fiber of 180 GSM. The fiber –volume fraction is 0.60 -0.65 and had density of 2.58 g/cm^3. The resin and hardener were mixed and stirred thoroughly.

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The basic raw material used for the manufacturing of composite are given in the Table no. 1 and prepared sample is shown in fig 1.

Table no 1. Composition of GFRP composite laminate

Matrix	Epoxy, Araldite AW
Hardener	Hardener HW 953
Reinforcement	E Glass fiber (woven form), bidi-rectional (0º/90º)

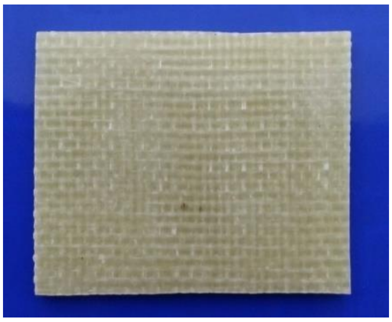


Fig 1. Prepared GFRP Sample

Fig 2. Hole Saw Drill Bit

Fig. no.3. Twist drill

Fig 4 . Vertical Drill Machine

Table 2 Drill specifications

Type of Drill	Specifications	Material
Hole saw drill	Drill outside Diameter = 3.5mm Drill inside diameter = 12.5mm Thickness of drill bit = 1mm Inside cutting depth = 18mm Centre Drill bit diameter = 3.5mm	Carbon steel
Twist Drill	Drill Diameter = 13.5mm Point angle = 90º Helix angle = 20º Body length = 55mm, Shank length = 59.5mm	Carbon steel

In this study, two types of drill is used hole saw drill(fig 2) and twist drill(fig 3).their specifications are listed in table 2. Experimentation has been performed on the Vertical M1TR drill machine having 2 H.P. power shown in fig 4. Effect of drilling parameter, spindle speed and feed are considered and are varied keeping one parameter constant. machining time and delamination factor are evaluated for the differentspeed and feed combinations for both the drills and are listed in table 4 and table 5.

Table no. 3. Design of experiment

S.no.	S,spindle speed (rpm)	F,feed (mm/rev)
1	600	0.038
2	600	0.125
3	600	0.203
4	1000	0.038
5	1000	0.125
6	1000	0.203
7	1400	0.038
8	1400	0.125
9	1400	0.203

After performing the drilling operation onthe glass fiber reinforced composite some output responses are measured such as delamination factor and machining time. Machining time **is** calculated with the stop watch by making the following arrangement.

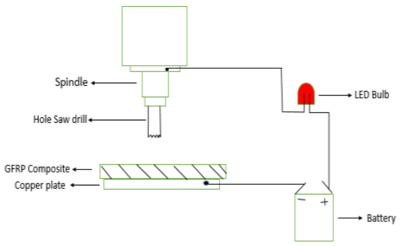


Fig. no. 5.Arrangement for calculating machiningtime with Hole Saw drill

The Fig. no. 5 and Fig 6 shows the ar- rangement for calculating the accurate drill- ing time while drilling with Hole saw drill and twist drill. When the spindle starts rotat-ing, the drill moves downward and comes incontact with the composite. As the drill comes in contact with copper plate, the cir- cuit is completed and the bulb glows to in- dicate the completion of drilling.

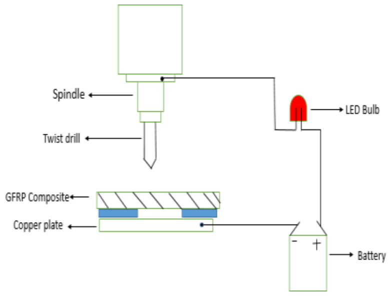


Fig. 6.Arrangement for calculating machiningtime with Twist drill

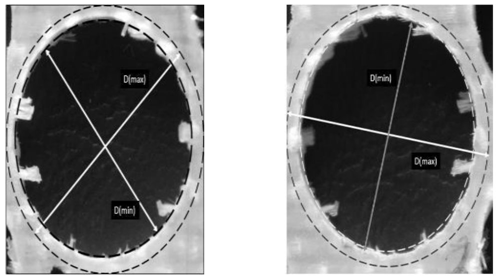
Delamination factor:

It is defined as the ratio of maximum hole diameter such as damage place of the hole to the nominal diameter of the tool. Mathematically delamination can be express as:

$$F_d = \frac{D_{max}}{d}$$

Where, F_d = Delamination Factor, D_{max} = maximum diameter of composite hole afterdrill at damage place, d = actual diameterof hole that are equal to drill bit.

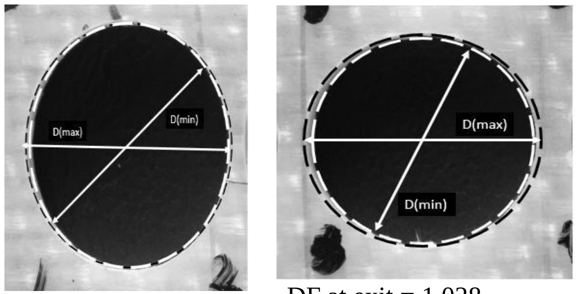
DAMAGE FACTOR FOR TWIST DRILL



DF at entry = 1.125 DF at exit =1.333

Fig. 7. Damage in holes measured through Optical microscope for twist drill

DAMAGE FACTOR FOR HOLE SAWDRILL



DF at entry = 1.025 DF at exit = 1.028

Fig. 8. Damage in holes measured through Optical microscope for twist drill

Table 4. Experimental results for hole saw drill

S.no.	Ma- chining time (sec)	Delamina- tion factor (at entery)	Delamina- tion factor (at exit)
1.	6.00	1.092	1.074
2.	3.01	1.096	1.088
3.	1.97	1.111	1.103
4.	4.34	1.054	1.044
5.	2.46	1.059	1.051
6.	1.44	1.066	1.066
7.	3.10	1.025	1.028
8.	1.51	1.029	1.037
9.	0.89	1.044	1.045

Table 5. Experimental results for twist drill

Exp. No.	Machining-Time (S)	Delamination factor (At Entry)	Delamina- tion factor (At Exit)
1	20.53	1.251	1.274
4	9.11	1.311	1.303
3	6.25	1.325	1.322
4	10.33	1.207	1.214
5	5.25	1.222	1.237
6	3.54	1.251	1.244
7	7.55	1.125	1.133
8	3.95	1.140	1.177
9	2.30	1.185	1.192

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COMPARISON GRAPHS BETWEEN BOTH DRILLS FOR MACHINING TIME

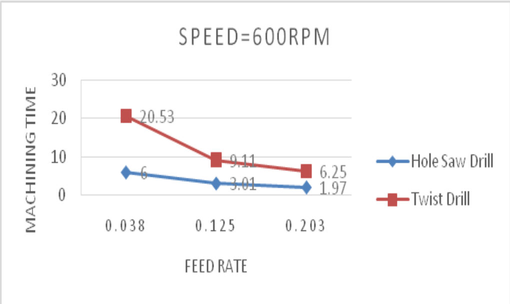

Fig. 9. Comparison between feed rate and machining time when speed =600rpm

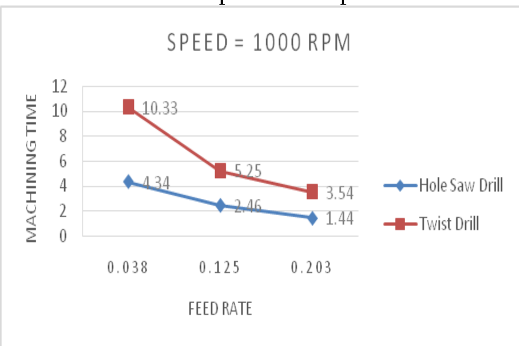

Fig. 10. Comparison between feed rate and machining time when speed =1000rpm

Fig. 11. Comparison between feed rate and machining time when speed =1400rpm

COMPARISON GRAPHS BETWEEN BOTH DRILLS FOR DAMAGE FACTORAT ENTRY

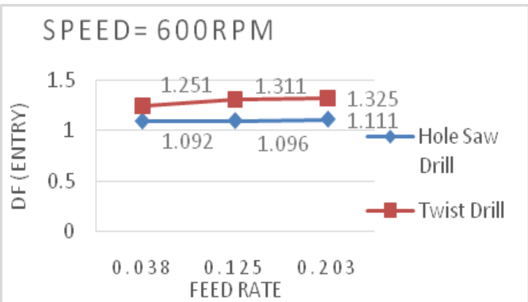

Fig. 12. Comparison between feed rate and Damage factor at entry when speed =600rpm

Fig. 13. Comparison between feed rate and Damage factor at entry when speed =1000rpm

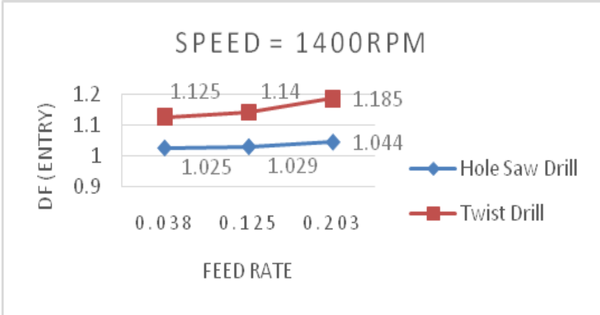

Fig. 14. Comparison between feed rate and Damage factor at entry when speed =1400rpm

COMPARISON GRAPHS BETWEEN BOTH DRILLS FOR DAMAGE FACTORAT EXIT

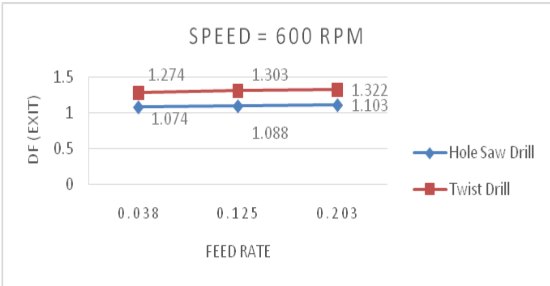

Fig. 15. Comparison between feed rate and Damage factor at exit when speed =600rpm

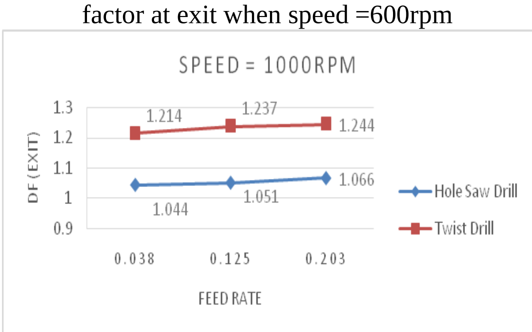

Fig. 16. Comparison between feed rate and Damage factor at exit when speed =1000rpm

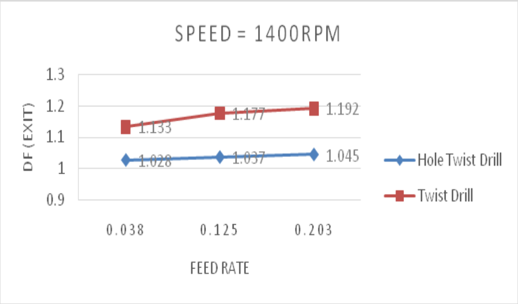

Fig. 17. Comparison between feed rate and Damage factor at exit when speed =1400rpm

CONCLUSION:

In this study, drilling is performed by us- ing solid and hollow drills on the GFRPcomposite which is fabricated by hand Lay- up technique. It is found from the experi- ments that tool geometry play a major role while drilling in a composite material.

Spindle speed, and feed rate are taken as the input parameters while the machiningtime and delamination factors are taken as the output response factors.

The following conclusions can be drawn from the present study are as

1. Hollow drill gives better results as compared to the solid drill due to minimum thickness of the hollow drill, less material is removed only along its periphery, which reduces the delamination damage around the hole.
2. Reduced machining time is found when drilling with hole saw drill as compared to the twist drill.
3. It is found from the experimentation that speed has more influence on the responses as compared to the feed.

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