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Drilling of Particulate Filled GFRP Thermoset Composites

Venkat Harish[1], K. Hemalatha[2], Vardhini C[3]
[1, 2]Dept. of Mechanical Engineering, St. Martin's Engineering College, Hyderabad, India
[3]Dept. of Mechanical Engineering, SGP, Ballari, India

Abstract: Design and Fabrication of Graphite and Alumina filled glass epoxy using hand lay-up technique. An experimental study on the effect of different drill tool diameter on the thrust force, torque and flank wear when drilling particulate filled GFR thermoset composites. Investigation on the effect of cutting parameters (rate of feed and speed cutting) on material and tool when drilling particulate filled GFR thermosets composites. Flank wear will be measured using Optical Microscope. Glass fibers are the earliest known fibers used to reinforce materials. Ceramic and metal fibers were subsequently found out and put to extensive use, to render composites stiffer more resistant to heat.

FRPCs is majorly uses as fiber which mainly contains Glass fiber due to its low cost compared to other materials and having good mechanical properties like strength, chemical resistance, and good insulating properties. It has some other main important application like in marine, moisture strength loss due to load. E-glass (also called "fiberglass") and S-glass are the main two types. The E in E-glass originally designed for electrical. However, it is used for decoration and structural are the some of application for E-glass. The S in S-glass mainly contains high rate of silica. It continues to have its strength at higher temperature and also have more fatigue strength, but it has one disadvantage is more costlier than E-glass. The FRPCs drawbacks is low operating temperature, thermal coefficient is high and expansion of moisture, and low transverse direction of elastic properties.

Keywords: Graphite glass epoxy, Alumina glass epoxy, GFR thermosets, E-glass, S-glass, Optical Microscope

I. INTRODUCTION

Composites are materials that consist of two or more constituents. The constituents are combined in such a way that they keep their individual physical phases and are not soluble in each other or not to form a new chemical compound. One constituent is called reinforcing phase and the one in which the reinforcing phase is embedded is called matrix. Historical or natural examples of composites are abundant: brick made of clay reinforced with straw, mud wall with bamboo shoots, concrete, concrete reinforced with steel rebar, granite consisting of quartz, mica and feldspar, wood (cellulose fibers in lignin matrix), etc.

In aerospace industry are used mainly most advanced composites required for better results for developments of different components to sustain and to meet required necessary applications. They normally used good performance fibers as reinforcing phases and polymers or metals as matrices. Because of very high stiffness and strength the fibers are used mainly. Glass fibers are the earliest known fibers used to reinforce materials. The subsequent available fibers are Ceramic and metal found out and put to extensive use, to render composites stiffer more resistant to heat.

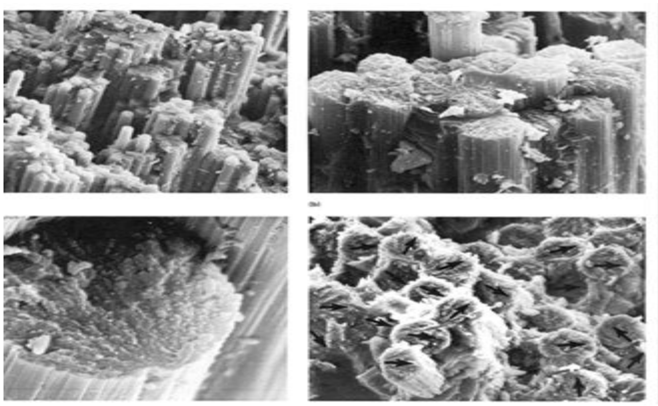

Fig 1: Microscopic view of Fiber Reinforced composites

Here we are conducted the test of drilling of GFRP composite by HSS conventional drill bit, also by changing the geometry of drill bit generated some more results. The cutting results show the effect of drill geometry performance of GFRP composite. By observing the results the fiber orientations and geometry of drill plays a key role on the cut quality and delamination.

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II. LITERATURE REVIEW

Ho-Cheng used a fracture mechanics approach to analyze the delamination of fiber-reinforced material. His analysis predicts the critical thrust force above which delamination is initiated. Tagliaferri and his co-researchers studied the effects of machining parameters and tool conditions on the damage, finish and mechanica1 properties of fiber-reinforced composite materials and the cutting mechanism in drilling. A close relationship between the thrust force and amount of damage was confirmed. It was also found that the width of damage zone is correlated to the ratio between drilling speed and feed rate. The higher the ratio ,the better the cut quality. It has already been found that the increase of cutting speed may decrease the cutting force when cutting aluminum.

Bhatnagar have reported temperature behavior in drilling of fiber reinforced plastics (FRP) composites along with the specific problems in tool tip temperature measurement and also developed inverted cone drill point for producing cleaner holes in thin aramid FRP laminates.

Mathew have presented results of an experimental investigation into the effect of the geometry of a trepanning tool on thrust and torque during the drilling of unidirectional (UD) glass fiber reinforced plastics (GFRP) laminates. In another research finding, same authors have reported on delamination studies on drilling of UD composites using trepanning tool.

III. EXPERIMENTAL WORK

A. Hand Lay-up Technique

Fabrication is defined as the process of converting raw materials into finished product. Particulate filled GFR thermoset composites will be fabricated using a simple hand lay –up technique followed by compression moulding.

B. Raw Materials

1) Resin-Epoxy (Lapoxy) L – 12
2) Hardener K – 6
3) Acetone
4) E-Glass fabric woven sheet
5) Fillers (Alumina, Graphite and Clay Fillers)

C. Apparatus

1) Measuring Jar
2) Stirrer
3) Polythene Sheets
4) Mixing Jar

Fig 2. Glass woven fabric sheets

Fig 3. Mixture of Resin, Hardener and Filler

IV. MATERIALS USED FOR EXPERIMENTATION

Table : 1 Materials used for Experimentation

Sl No.	Sample	Matrix	Reinforcement	Filler
1	G.E	Epoxy	E Glass Woven Fabric (200 GSM)	-
		40%	60%	
2	Al_2O_3+G.E	Epoxy	E Glass Woven Fabric (200 GSM)	Alumina
		32.50%	60%	7.5%
3	G.E	Epoxy	E Glass Woven Fabric (460 GSM)	-
		40%	60%	
4	Gr+G.E	Epoxy	E Glass Woven Fabric (460 GSM)	Graphite
		32.50%	60%	7.5%
		30%	60%	10%
5	Clay + G.E	Epoxy	E Glass Woven Fabric (460 GSM)	Clay
		32.50%	60%	7.5%
		30%	60%	10%
		27.50%	60%	12.5%

V. EXPERIMENTAL PROCEDURE

A. Column Drilling Machine

Our preferred drilling machine is runs at speed of 78-2040 RPM and possible rate of feed is 0.11-0.35 mm/rev is shown in fig 4.5. The dynamometers mainly used to determine the cutting forces such as mechanical, hydraulic, pneumatic, electrical and optical. In the experiment the electrical dynamometer (strain gauge type) is used for testing process.

Fig 4. column drilling machine

Fig 5. Mitutoyo Optical Microscope

VI. CALCULATIONS

Calculation for 7.5% Alumina Oxide filled Glass Epoxy.
Thickness of E Glass Woven Fabric Sheet (460 GSM)
= 0.47mm
No of sheets required for 10mm thick plate = 10/0.47
=21sheets
Weight of 21 sheets for 300x300mm plate = 895gm (for 60% of Reinforcement)
Weight of Resin = (895x32.5)/60 = 533gm (for 32.5% of Matrix)
Weight of Hardener = 533x0.125 = 66.6gm (for 12.5% Hardener)
.
Weight of Alumina Filler = (895x7.5)/60 = 111.8gm (for 7.5% of Filler)

VII. RESULTS

A. *Prediction of Thrust Force and Torque*

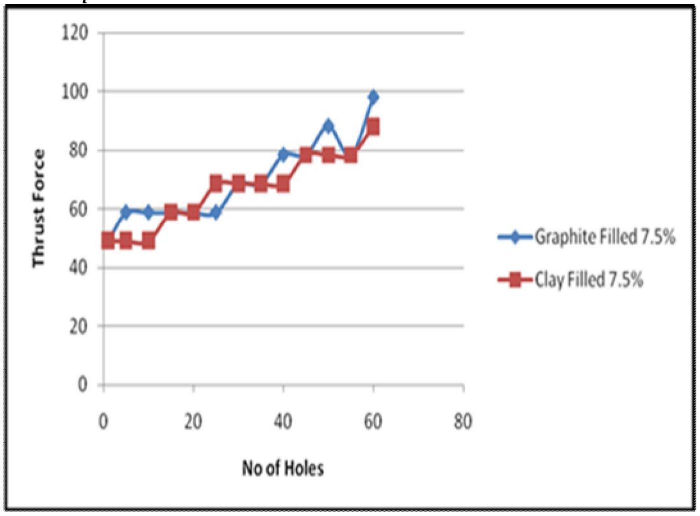

Fig 6. Variation of Thrust Force for Clay and Graphite filled Glass Epoxy with 6mm HSS drill bit.

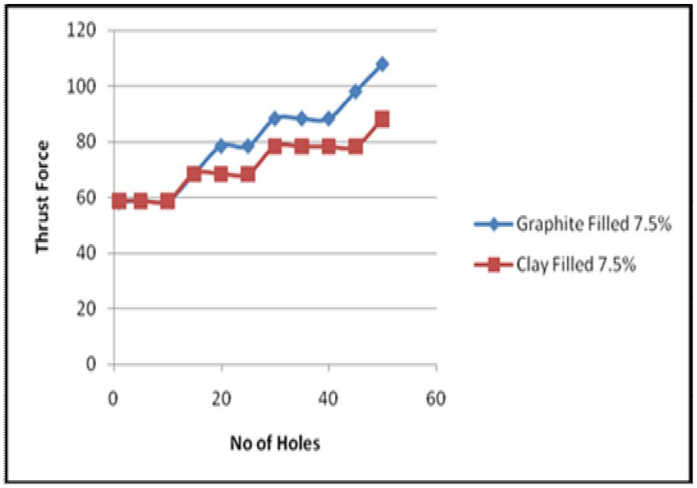

Fig 7. Variation of Thrust Force for graphite and clay filled Glass Epoxy with 8mm HSS drill bit.

In Fig 6 & 7, Using HSS drill 6mm and 8mm respectively, thrust continuously increases with number of holes for both the materials. The values of Thrust are higher for Graphite filled Glass Epoxy compare to Clay filled Glass Epoxy.

B. Prediction of Flank Wear

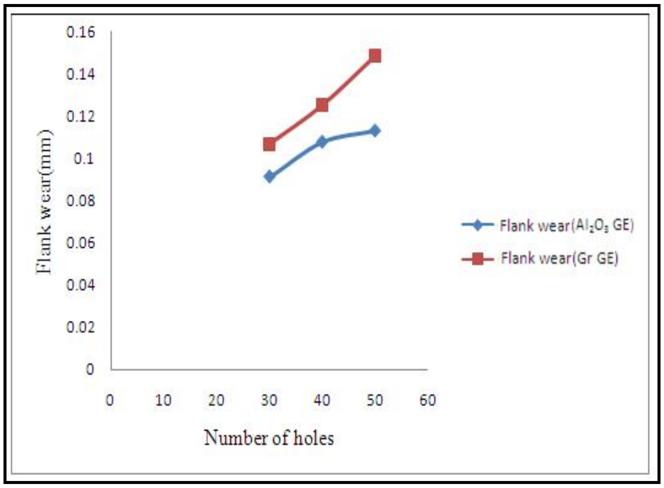

Fig 8. Variation of Flank wear for Alumina and Graphite filled Glass Epoxy with 6mm HSS drill bit.

In Fig 8. The flank wear which causes more number of holes. F1ank wear is more for Graphite filled Glass Epoxy laminates as compared to Alumina filled Glass Epoxy laminates with 6mm HSS drill bit, the speed recorded during the operation is 1360rpm and feed rate of 0.11mm/rev.

Fig 9. Microscopic View of 6mm HSS drill bit used for Graphite & Alumina Filled GFRP Composites

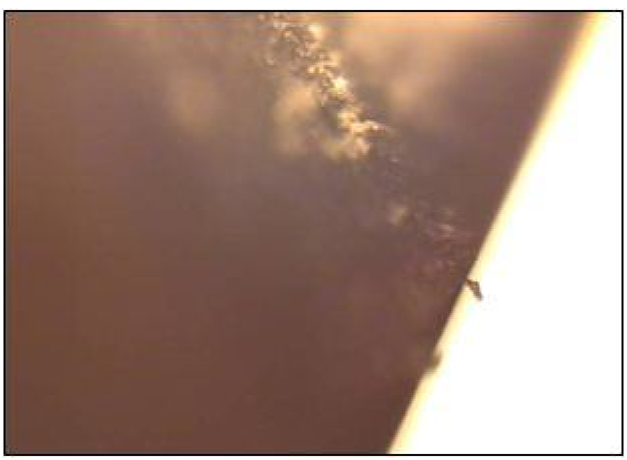

Fig 10. Microscopic View of 6mm CARBIDE drill bit used for Graphite & Alumina Filled GFRP Composites

VIII. CONCLUSION

In the present project Glass fiber reinforced thermoset composites having graphite and clay fillers have been successfully fabricated and experiments were carried out to investigate the machinability characteristics of the same.

A. Drilling was taken as the machining operation. It is observed that clay filled GFR composite is better machinable than graphite filled GFR composites.
B. Thrust and torque induced are much higher in drilling of graphite filled glass epoxy than clay filled glass epoxy composites. This behavior can be attributed to uniform dispersion of graphite and higher percentage of graphite filler in glass epoxy composites than that of clay glass epoxy composites.
C. Flank wear increases is directly proportional to the increase in the number of holes drilled in both the specimens.
D. The Flank wear measured is higher when drilling of Graphite Filled Glass Epoxy Composites than Alumina Filled Glass Epoxy Composites.
E. By comparing with the Carbide drill performance the HSS drill produces some low results for both the materials. In other words the flank wear of the carbide drill was less than the flank wear of the HSS drill tool.

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