



Research Paper

AN EXPERIMENTAL STUDY USING DESIGN OF EXPERIMENT METHOD TO COMPARE THE PERFORMANCE OF SOLID CARBIDE AND HSS DRILLS IN DRILLING OF GFRP COMPOSITE MATERIAL

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This work is focused on performance comparison of Carbide and HSS drills when drilling a glass fiber reinforced general purpose resin composite. Delamination is a measure of the quality of a drilled hole, which in turn is primarily dependent on the thrust force. The comparison of thrust force and the corresponding delamination produced has been made with reference to drilling by HSS and Carbide tools with the independent variables being cutting tool geometry, drill diameter, material thickness, feed rate, and speed. Results indicate that under all drilling conditions Carbide drill has a better performance as depicted by lower thrust force and lesser delamination. As both the tool materials are widely used in the industries for drilling the composites, this comparative analysis would be helpful in the choice of the tool material when quality hole is the key consideration.

Keywords: GFRP, Drilling, Thrust, Delamination, Carbide, HSS

INTRODUCTION

Drilling is the major operation to make bolted or riveted assemblies in composite structures used in the automotive and aircraft industries. El-Sonbaty *et al.* (2004) report that over 100,000 holes are required in a small engine aircraft for fastening. Conventional high speed

steel and cemented carbide drills are widely employed in the machining of polymeric composite materials. The inappropriate selection of the tool geometry results in higher temperature, accelerated tool wear rates and higher thrust force and torque values, which lead to poor hole quality and surface damage.

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Capello (2004) regards delamination of the composite as the most critical damage caused by machining operations due to the fact that it can severely impair the performance of the finished component. According to Khashaba (2004), delamination is responsible for the rejection of approximately 60% of the components produced in the aircraft industry. Piquet et al. concluded that increasing the number of cutting edges and reducing the contact length between the tool and the work material resulted in less delamination. Hence, there is a need for a comparative study for enabling the choice of superior tool material. With this point of view, the paper investigates the influence of the cutting tool geometry, drill material, material thickness, feed and speed on the thrust force and delamination produced when drilling a glass fibre reinforced composite.

SPECIMEN PREPARATION

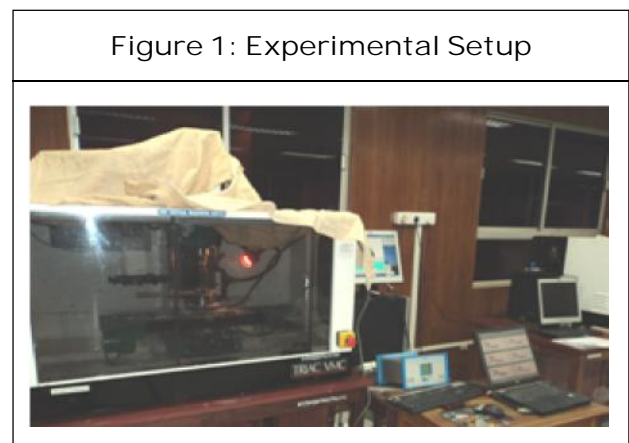
For the present work the specimen is the Glass Fiber Reinforced Polymer (GFRP) composite. The composite was prepared by hand layup method. Matrix system consists of general purpose polyester resin [GP] and a room temperature curing accelerator catalyst. The hardner used is the Methyl Ethyl Ketone Peroxide (MEKP). The density of the resin is 1.4 g/cc. The reinforcement is E-glass fiber. The properties of E-glass fiber are given in Table 1. The weight fraction of the

Density	2.56 g/cc
Tensile Strength	2 Gpa
Strain to failure	2.4%
Tensile Modulus	70 Gpa
Co-efficient of Thermal Expansion	5.0 X10 ⁻⁶ /°C

reinforcement material is 44% and it was confirmed by burn test.

EXPERIMENTAL DESIGN

Using the experimental design principles of DOE method, five factors and three levels full factorial experiments were conducted. The drilling process was carried out on TRIAC CNC Vertical machining center. The experimental setup is given in Figure 1. The tools used are HSS and Carbide. The details of the experiment are presented in Table 2. The output parameters measured are thrust and delamination.

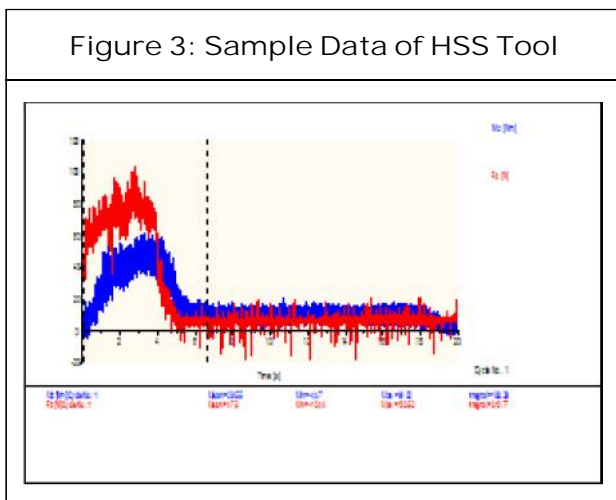
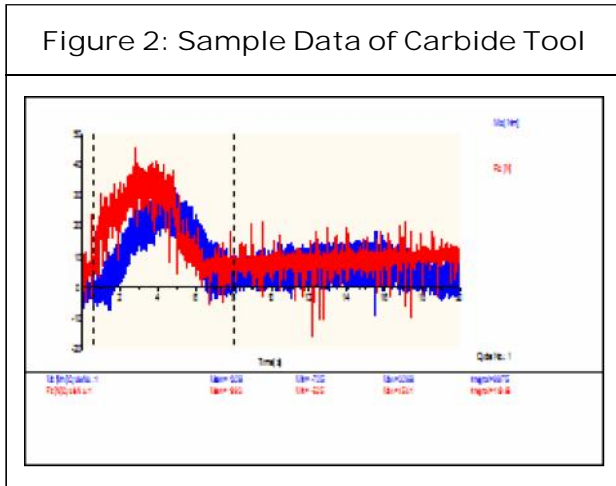


Drill Diameter	6 mm, 8 mm and 10 mm
Point Angle	90°, 103° and 118°
Material Thickness	8 mm, 10 mm and 12 mm
Speed	900, 1200 and 1500 rpm
Feed Rate	75, 110 and 150 mm/min

MEASUREMENT OF THRUST FORCE

The thrust force was measured using a Kistler piezoelectric dynamometer connected to a charge amplifier and data acquisition board. Dynaware (Kistler) software was employed to collect the data at an acquisition rate of

300 Hz. Sample of data obtained from the dynamometer for Solid Carbide and HSS tools are presented in Figures 2 and 3.



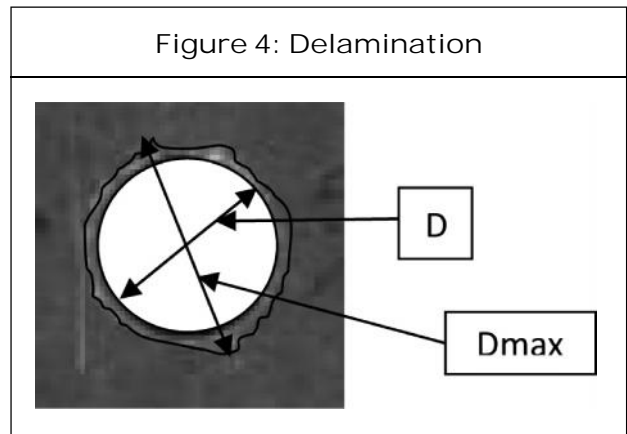
MEASUREMENT OF DELAMINATION

In order to assess the delamination, the scanned image of each hole has taken using a scanner of 1200 dpi. To measure the dimensions of scanned holes Catia software was used. The delamination factor was calculated by using the formula:

$$Df = D_{max}/D$$

D_{max} = Maximum damaged area

D = Actual diameter of the drill bit



RESULTS AND DISCUSSION

The results of drilling experiments at various drilling conditions are presented in the following figures. Figures 5-9 indicate that as drill diameter, material thickness, speed and feed rate increases the thrust generated during drilling will also increase but as the drill point angle increases, the thrust decreases. Also they are indicating that in all drilling conditions HSS drills produced greater thrust than Carbide drills. And it is the known fact that in drilling of composite material, the delamination is primarily dependent on the thrust and torque generated during drilling. Hence in most of the drilling process higher value of thrust greater will be the delamination. Therefore it is better to reduce the thrust in order to produce good quality holes. Figures 10-14 indicate the change in delamination factor with respect to variation in the input independent parameters. From these figures we can observe that, as there is increment in the values of independent variables such as tool diameter, tool point angle, material thickness, drilling speed and feed rate of tool, there is increment in the delamination factor. So we can say that, the delamination of work piece is dependent on all these input parameters. Figures also reveals that, in all machining conditions the

Figure 5: Thrust (N) v/s Drill Diameter (mm)

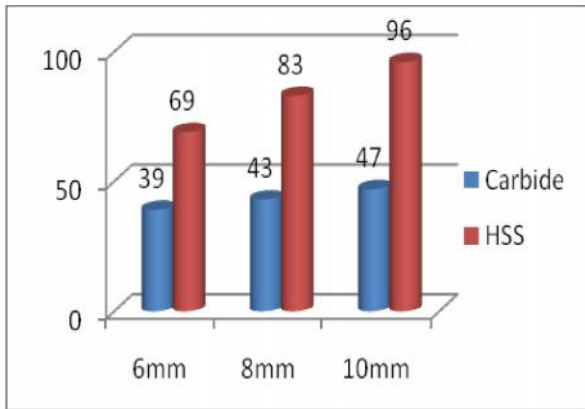


Figure 8: Thrust (N) v/s Feed Rate (mm/min)

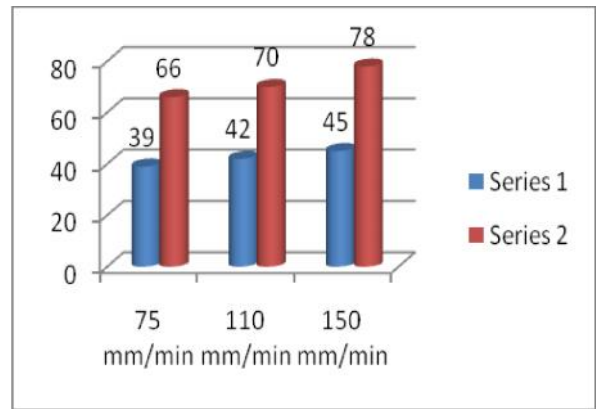


Figure 6: Thrust (N) v/s Drill Point Angle (Deg)

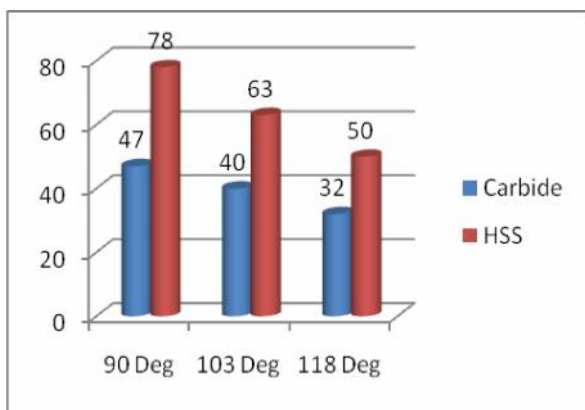


Figure 9: Thrust (N) v/s Material Thickness (mm)

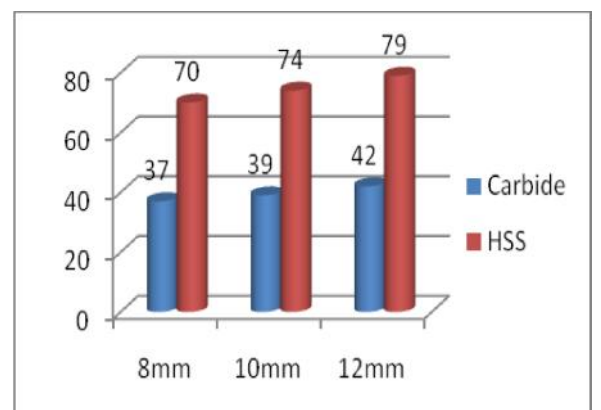


Figure 7: Thrust (N) v/s Spindle Speed (RPM)

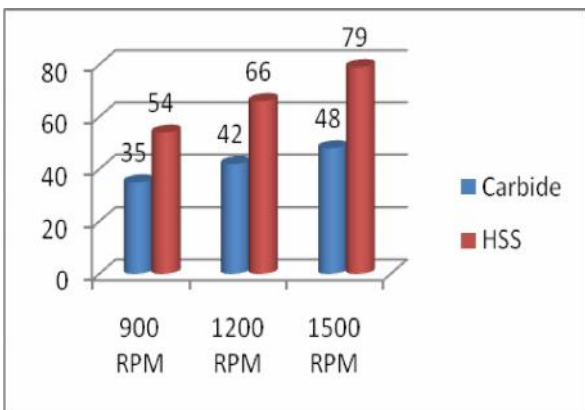


Figure 10: Delamination Factor v/s Drill Diameter (mm)

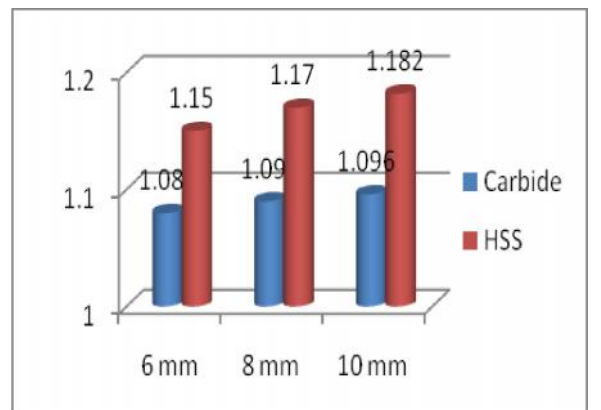


Figure 11: Delamination Factor v/s Material Thickness (mm)

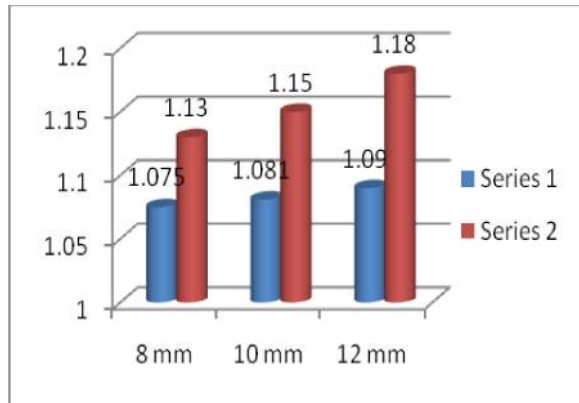


Figure 14: Delamination v/s Feed Rate (mm/min)

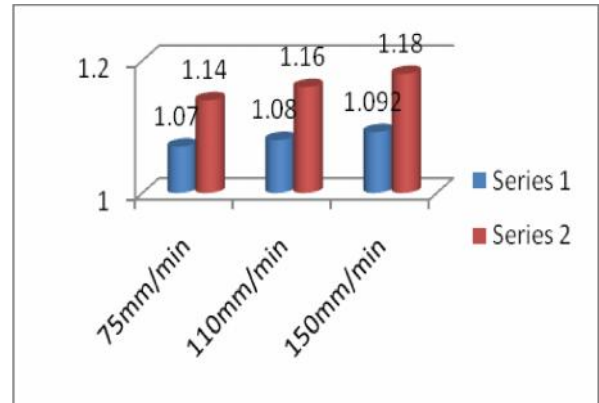


Figure 12: Delamination v/s Drill Point Angle (Deg)

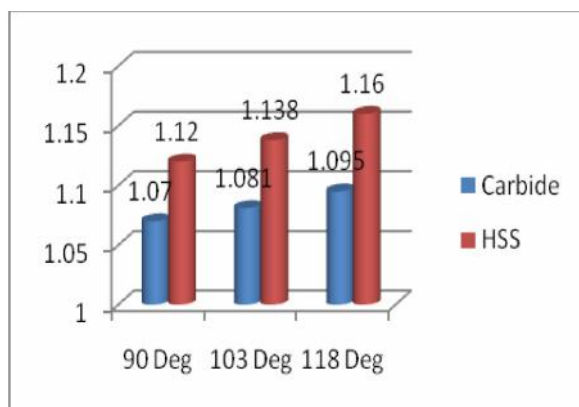
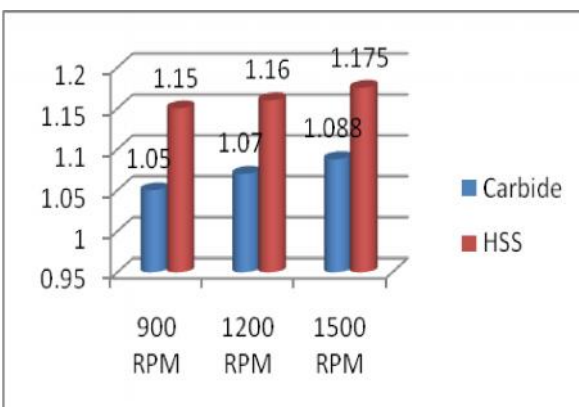


Figure 13: Delamination v/s Spindle Speed (RPM)



delamination produced by the HSS drill is higher than Carbide one. In the present work we made the comparison between the thrust force generated and as well as delamination produced by both HSS and Carbide drills in various drilling conditions. From the results we can say that the thrust and delamination not only affected by selected independent variables but also affected by the material of the tool. Present work indicates that in all drilling conditions the Carbide tool performs better than HSS tool.

CONCLUSION

- Results shows that drill material has significant effect on the quality of drilled hole.
- Results indicate that under all experimental drilling condition, the thrust force and delamination in case of HSS drill is greater than that of Carbide drill.
- Thrust force is influenced by work material thickness.

From the present experimental results it can be concluded that Carbide drill produced higher quality of drilled hole in comparison with HSS. 🌀

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