ANALYSIS EFFECT OF DRILLING PARAMETERS ON HOLE DELAMINATION DURING DRILLING OF GLASS FIBER REINFORCED PLASTIC (GFRP) COMPOSITE MATERIALS

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Abstract

Glass fiber reinforced plastic (GFRP) composite materials are widely used industrial, aerospace, and automotive sector. Its have excellent properties such as high strength to weight ratio, higher fatigue limit high stiffness to weight ratio, corrosion resistance and design flexibility. Drilling is one of the major machining operations that are carried out on fiber reinforced metal composite materials to the need for components assembly. There are many problems encountered when drilling Glass fiber reinforced plastic (GFRP) composites. These problems include delaminating of the composite, poor surface roughness and hole deviation. In present experimental investigation analyse the effect of various machining parameters i.e. cutting speed, the feed rate, and the drill diameter on the quality of the drilled holes. Hole deviation of each hole is measured with help of digital vernier calliper. Taguhi's and ANOVA Technique have been employed to study the effect of the interactions between different drilling parameters on deviation of holes. After experiments suggests the optimal conditions for minimum hole deviation.

Keywords: *Composite Material, Deviation, GFRP, ANNOVA, and Taguchi Methods*

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1. INTRODUCTION

Glass fiber reinforced plastic (GFRP) composite materials have excellent properties such as high strength to weight ratio, higher fatigue limit, high stiffness to weight ratio, corrosion resistance and design flexibility. So that it's have wide applications in automotive sector, Electrical sector, medical sector, sports sector, and Textile sector.

Drilling is major machining operations for components assembly in mechanical structures. It is mostly used machining processes in various manufacturing industries such as automotive, aircraft and aerospace, Dies/Molds, and Electronic equipment industries. The quality of the drilled hole can be critical to the life of the joints for which the holes are used. There is a huge effect of the machining parameters on the damage, finish and mechanical properties of fiber reinforced composite materials, and damaged the surface roughness. Aspects of hole such a waviness/roundness of its wall surface, axial straightness and roundness of the hole cross sections can cause high stresses on the joints, leading to its failure.

J.P. Nobre et al. (2013) Residual strains induced by drilling of glass-fibre reinforced polymers (GFRPs) were determined using a hybrid experimental–numerical methodology. Experimentally, a set of GFRP specimens were drilled under well-defined tensile (calibration) stresses, using an especially designed tensile test device. To remove the effect of the initial residual stresses, this methodology considers differential stress values instead of absolute ones.

P. Mehbudi et al. (2013) studied ultrasonic assisted drilling is applied to reduce thrust force in drilling of GFRP laminates. In order to conduct experiments a setup is designed and fabricated to apply both vibrations and rotation to drill bits. Using Taguchi method, a set of experiments is conducted with feed rate, spindle speed, and ultrasonic vibration amplitude as control factors. The results show that applying ultrasonic vibration reduces the thrust force and therefore the drilling induced delaminating dramatically.

M. Adam Khan et al. (2011) were developed two different evolutionary algorithm-based neural network models to optimise the unit production cost. The hybrid neural network models are, namely, genetic algorithm-based neural network (GA-NN) model and particle swarm optimization based neural network (PSO-NN) model. These hybrid neural network models were used to find the optimal cutting conditions of Ti[C, N] mixed alumina-based ceramic cutting tool (CC650) and SiC whisker-reinforced alumina based ceramic cutting tool (CC670) on machining glass fibre-reinforced plastic (GFRP) composite.

2. EXPERIMENTAL SETUP

Glass fiber reinforced plastics (GFRP) have been fabricated by using hand lay-up techniques. The plan of experiment constitutes 27 experiments. There are three levels for drill diameters, three levels for spindle speed and three levels for feed rate.

Table - 1: Parameters for experiments

Drill Diameters (mm)	Spindle speeds (rpm)	Feed Rates (mm/rev)
5	560	0.2
8	1000	0.5
10	1440	0.8

3. RESULTS AND DISCUSSION

This sections represents the investigated results of hole deviation obtained during drilling of GFRP. The results were obtained at variation of drill diameter e.g. from 5 to 10 mm, cutting speed e.g. from 560 to 1440 rpm and feed rate e.g. from 0.2 to 0.8 mm/rev.

Exp No.	Drill Diameter (mm)	Spindle Speed (N) (rpm)	Feed Rate (f) (mm/rev)	Deviation (mm)
1	5	560	0.2	0.20
2	5	560	0.2	0.38
3	5	560	0.2	0.14
4	5	1000	0.5	0.12
5	5	1000	0.5	0.14
6	5	1000	0.5	0.18
7	5	1440	0.8	0.10
8	5	1440	0.8	0.10
9	5	1440	0.8	0.12
10	8	560	0.5	0.44
11	8	560	0.5	0.32
12	8	560	0.5	0.30
13	8	1000	0.8	0.30
14	8	1000	0.8	0.24
15	8	1000	0.8	0.20
16	8	1440	0.2	0.22
17	8	1440	0.2	0.20
18	8	1440	0.2	0.10
19	10	560	0.8	0.62
20	10	560	0.8	0.70
21	10	560	0.8	0.68
22	10	1000	0.2	0.60
23	10	1000	0.2	0.58
24	10	1000	0.2	0.58
25	10	1440	0.5	0.54
26	10	1440	0.5	0.52
27	10	1440	0.5	0.48

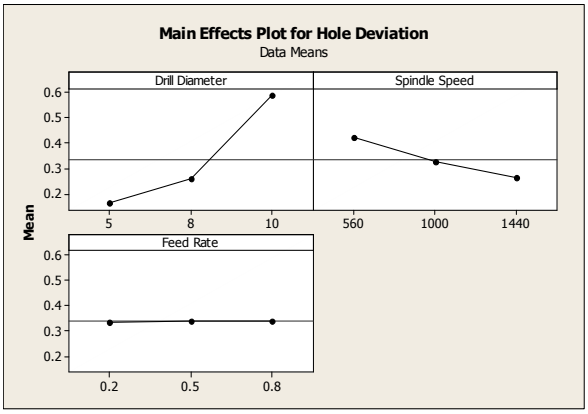

Fig 1: Showing the effect of Drilling Parameters on Mean Hole Deviation

Fig:1 shows effect of various drilling parameters on the mean of hole deviation plotted utilizing the drilling results obtained. From the figure, it is observed that the mean value of hole deviation is increase by increasing the drill diameter from 5 to 8 mm and 8 to 10 mm. The mean of hole deviation decrease constantly by increasing the value of cutting speed from 560 to 1000 rpm and 1000 to 1440 rpm. The mean of hole deviation is almost constant by increasing feed rate from 0.2 to 0.5 mm/rev and 0.5 to 0.8 mm/rev.

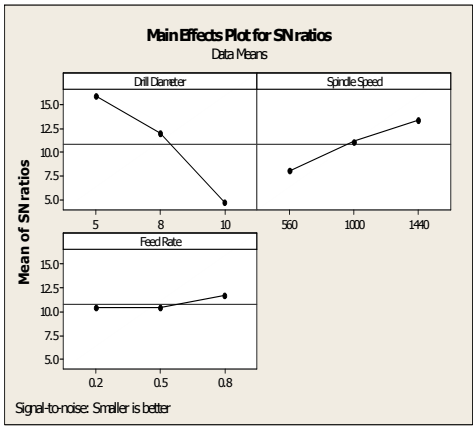

Fig 2: Showing the effect of Drilling Parameters on Mean of S/N ratio of Hole Deviation

Fig:2 shows effect of various drilling parameters on the mean of S/N Ratio of hole deviation plotted utilizing the drilling results obtained. From the figure, it is observed that the mean value of S/N Ratio of hole deviation is decrease by increasing the drill diameter from 5 to 8 mm and 8 to 10 mm. The mean of S/N Ratio of hole deviation increase constantly by increasing the value of cutting speed from 560 to 1000 rpm and 1000 to 1440 rpm. The mean of S/N Ratio hole deviation is almost constant by increasing feed rate from 0.2 to 0.5

mm/rev and after that if further increase the feed rate from 0.5 to 0.8 mm/rev the of S/N Ratio of hole deviation is increase.

Analysis of Variance for Hole Deviation, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Drill Diameter	2	0.89550	0.89550	0.44775	136.26	0.000
Spindle Speed	2	0.11034	0.11034	0.05517	16.79	0.000
Feed Rate	2	0.00021	0.00021	0.00010	0.03	0.969
Error	20	0.06572	0.06572	0.00329		
Total	26	1.07176				

S = 0.0573230 R-Sq = 93.87% R-Sq(adj) = 92.03%

Unusual Observations for Hole Deviation

Obs	Hole Deviation	Fit	SE Fit	Residual	St Resid
2	0.380000	0.243704	0.029187	0.136296	2.76 R
3	0.140000	0.243704	0.029187	-0.103704	-2.10 R

R denotes an observation with a large standardized residual.

Fig 3: ANOVA Test for Means

The results are analyzed using ANOVA for identifying the significant factor affecting the performance measure of drilling on GFRP. ANOVA results shows that drill diameters and Spindle speed are significant factor because its P value is 0.000. Other factor feed rate is not significant because their P value is larger than .05.

Taguchi Analysis: Hole Deviati versus Drill Diamet, Spindle Spee, Feed Rate

Response Table for Signal to Noise Ratios
Smaller is better

Level	Drill Diameter	Spindle Speed	Feed Rate
1	15.877	8.030	10.382
2	11.928	11.073	10.412
3	4.641	13.343	11.652
Delta	11.236	5.313	1.269
Rank	1	2	3

Fig 4: Ranking for Signal to Noise Ratios Smaller is better

Fig;4 shows the ranking of drilling parameters for optimizing the hole deviation. It can be observed that drill diameter has the largest effect on the hole deviation by drilling of GFRP. The Feed Rate has the smallest effect on the on the hole deviation by drilling of GFRP.

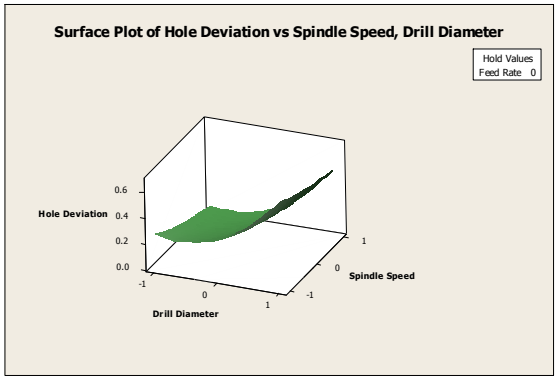

Fig 5: Surface Plot of hole deviation Spindle speed vs. drill diameters

Fig:5 shows the surface plot of hole deviation spindle speed vs. drill diameters. From this figure it is clear that the minimum hole deviation is notice at lower level of drill diameters and higher level of spindle speed.

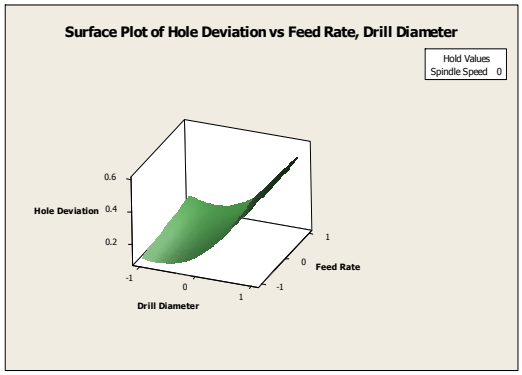

Fig 6: Surface Plot of hole deviation Feed Rate vs. drill diameters

Fig:6 shows the surface plot of hole deviation feed rate vs. drill diameters. From this figure it is clear that the minimum hole deviation is notice at lower level of feed rate and lower level of drill diameters.

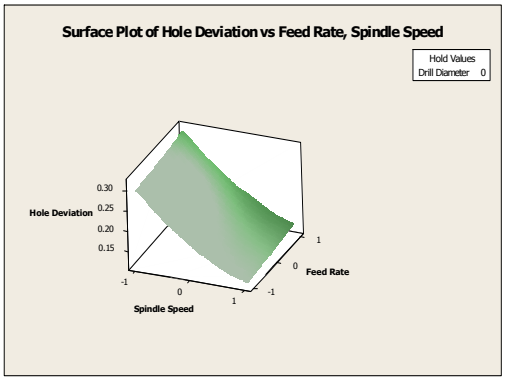

Fig 7: Surface Plot of hole deviation Spindle speed vs. Feed Rate

The above figure shows the surface plot of hole deviation spindle speed vs. feed rate. From this figure it is clear that the minimum hole deviation is notice at lower level of feed rate and higher level of spindle speed.

CONCLUSIONS

1. The mean value of hole deviation is smaller for 5 mm of drill diameter which is 0.1644mm.
2. It is observed that the mean value of hole deviation is smaller for 1440 rpm of spindle speed which is around 0.2644 mm.
3. It is observed that the mean value of hole deviation is smaller for 0.2 mm/rev of feed rate which is 0.3333 mm.

4. For Glass fiber reinforced plastic (GFRP) composite materials the optimum machining condition for minimum hole deviation with drill diameter (5 mm), spindle speed (1440 rpm), and feed rate (0.02 mm/rev).

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BIOGRAPHIES

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