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Experimental Investigation To Optimize Process Parameters In Drilling Operation For Composite Material

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ABSTRACT

In this thesis, the input parameters considered are point angle, tool diameter, spindle speed, feed rate and depth of cut. Different combinations of the above parameters are considered to get the maximum material removal rates using L12 orthogonal array in Taguchi method. The parameters are drilling diameter of cutting tool - 6mm, 10mm, point angle - 118^0 & 120^0, Speed – 800rpm, 1200rpm, Feed Rate – 30mm/min, 50mm/min and depth of cut – 0.5mm, 1mm. Theoretical calculations are done to calculate thrust force and torque. The assembly of work piece and tool is modeled in Creo 2.0. Structural analysis is done on the assembly to verify the stresses for different materials Mild Steel, Aluminum alloy and Glass fiber epoxy composites. Analysis is done in Ansys.

INTRODUCTION

Drilling could be a cutting method that uses a bit to chop or enlarge a hole of circular crosswise in solid materials. The bit could be a rotary cutting, typically multipoint. The bit is ironed against the work and revolved at rates from tons of to thousands of revolutions per minute. This forces the leading edge against the work piece, alienating chips (swarf) from the opening because it is trained.

Drill

A drill may be a tool fitted with a cutting attachment or driving tool attachment, typically a drilling bit or driver bit, used for boring holes in numerous materials or fastening numerous materials along with the utilization of fasteners. The attachment is gripped by a chuck at one finish of the drill and turned whereas ironed against the target material. The tip, and generally edges, of the cutting tool will do the work of cutting into the target material. This might be slicing off skinny shavings (twist drills or auger bits), grinding off little particles (oil drilling), crushing and removing items of the work (SDS masonry drill), countersinking, counter boring, or alternative operations.

LITERATURE REVIEW

In the paper by Biren Desai[1], the main focus of gift experimental study is to optimize the cutting parameters through work piece disk shape and Hole size. This paper reports associate degree experimental investigation of a full factorial style performed on skinny CFRP Laminates victimisation coated Solid inorganic compound drill with purpose angle 600 and angle three hundred by varied the drilling Parameters like spindle speeds (1500, 2500, 3500, 4500 and 6000 rpm) and feed rate (0.01, 0.03, 0.07, 0.1 And 0.15 mm/rev) to work out optimum cutting conditions. the opening quality parameters analyzed embody hole Diameter and disk shape. The objective of the work done by P. Ghabezi, M. Khoranb A[2], is to research the influence of cutting speed, feed rate, and gear diameter on the uncut fibre and delamination injury of 3 forms of

composite sandwich structures as well as PVC foam and faces manufactured from Glass/polyester. A style of experiments (full factorial) was accustomed assess the importance of the drilling parameters, and photography technique was accustomed measure the damages from drilling. The drilling operation was assessed supported 2 introduced issues as well as the delamination issue (DF) and uncut fibre factor (UCFF). Analysis of the Experimental results for DF indicated that feed rate and drill diameter were the foremost vital and insignificant Parameters, severally. however experimental results for UCFF showed that feed rate has greatest influence.

EXPERIMENTAL INVESTIGATION

In this thesis, drilling operations are conducted on the Glass Fiber Epoxy pieces with 6mm and 10mm diameter drills with 118^0 and 120^0 point angles, Speed – 800rpm, 1200rpm, Feed Rate – 30mm/min, 50mm/min and depth of cut – 0.5mm, 1mm. The initial size of glass fiber epoxy is 150*50*5mm. Cutting tool material is HSS. The experimentation is performed by taking above parameters arranged as per L12 orthogonal array in Taguchi Technique as shown in the table below.

Table – Arrangement of machining parameters as per L12 orthogonal array

JOB NO.	Speed (rpm)	Feed Rate (mm/min)	Depth of cut (mm)	Tool Angle (^{0})	Tool Dia (mm)
1	800	30	0.5	118	6
2	800	30	0.5	118	6
3	800	30	1.0	120	10
4	800	50	0.5	120	10
5	800	50	1.0	118	10
6	800	50	1.0	120	6
7	1200	30	1.0	120	6
8	1200	30	1.0	118	10
9	1200	30	0.5	120	10
10	1200	50	1.0	118	6

11	1200	50	0.5	120	6
12	1200	50	0.5	118	10

The drilling operations are done on a CNC milling machine.

Fig – Final Component with all drilled holes

The time taken for drilling is specified in the below table.

Table – Time Taken for drilling at different speeds and drill angles for different drill diameters

JOB NO.	**Speed (rpm)**	**Feed Rate (mm/min)**	**Depth of cut (mm)**	**Tool Angle (^{0})**	**Tool Dia. (mm)**	**Time**
1	800	30	0.5	118	6	1min 20secs
2	800	30	0.5	118	6	1min 20secs
3	800	30	1.0	120	10	1min 30secs
4	800	50	0.5	120	10	1min 10secs
5	800	50	1.0	118	10	1min 15secs
6	800	50	1.0	120	6	1min 14secs
7	1200	30	1.0	120	6	1min

8	1200	30	1.0	118	10	1min 4secs
9	1200	30	0.5	120	10	1min 2secs
10	1200	50	1.0	118	6	55secs
11	1200	50	0.5	120	6	48secs
12	1200	50	0.5	118	10	57secs

Calculations for material removal rate

The material removal rate is

$MRR = (\pi D^2 / 4) (f)$

D = Drill Dia.

f = feed rate

The MRR values are specified in below table.

Table – MRR for drilling at different speeds and drill angles for different drill diameters

JOB NO.	Speed (rpm)	Feed Rate (mm/min)	Depth of cut (mm)	Tool Angle (^{0})	Tool Dia. (mm)	MRR (mm^3/min)
1	800	30	0.5	118	6	847.8
2	800	30	0.5	118	6	847.8
3	800	30	1.0	120	10	2355
4	800	50	0.5	120	10	3925
5	800	50	1.0	118	10	3925
6	800	50	1.0	120	6	1413

7	1200	30	1.0	120	6	847.8
8	1200	30	1.0	118	10	2355
9	1200	30	0.5	120	10	2355
10	1200	50	1.0	118	6	1413
11	1200	50	0.5	120	6	1413
12	1200	50	0.5	118	10	3925

Taguchi parameter design to optimize process parameters in drilling of glass fiber epoxy composite using Minitab software

Procedure

In order to identify the process parameters affecting the selected machine quality characteristics of drilling, the following process parameters are selected for the present work: Speed, Feed Rate, Depth of cut, Drill dia. And Drill angle. The selection of parameters of interest and their ranges is based on literature experiments conducted.

Selection of Orthogonal Array

The process parameters and their values are given in table. It was also decided to study the 2 – level and 5 – factor interaction effects of process parameters on the selected characteristics while drilling Glass Epoxy composite. Table – Time Taken for drilling at different speeds and drill angles for different drill diameters

Table – Process Parameters and their respective values

JOB NO.	Speed (rpm)	Feed Rate (mm/min)	Depth of cut (mm)	Tool Angle (^{0})	Tool Dia. (mm)
1	800	30	0.5	118	6
2	800	30	0.5	118	6
3	800	30	1.0	120	10
4	800	50	0.5	120	10

5	800	50	1.0	118	10
6	800	50	1.0	120	6
7	1200	30	1.0	120	6
8	1200	30	1.0	118	10
9	1200	30	0.5	120	10
10	1200	50	1.0	118	6
11	1200	50	0.5	120	6
12	1200	50	0.5	118	10

Optimization for less time taken while drilling

Observed values from experimentation

Table – Time Taken for drilling at different speeds and drill angles for different drill diameters Options – Smaller is better

Results Table

Worksheet 1 ***

	C1	C2	C3	C4	C5	C6	C7
	Speed (rpm)	Feed Rate (mm/min)	Depth of Cut (mm)	Tool Angle	Tool Dia	Time taken (Secs)	SNRA1
1	800	30	0.5	118	6	80	-38.0618
2	800	30	0.5	118	6	80	*
3	800	30	1.0	120	10	90	-39.0849
4	800	50	0.5	120	10	70	-36.9020
5	800	50	1.0	118	10	75	-37.5012
6	800	50	1.0	120	6	74	-37.3846
7	1200	30	1.0	120	6	60	-35.5630
8	1200	30	1.0	118	10	64	-36.1236
9	1200	30	0.5	120	10	62	-35.8478
10	1200	50	1.0	118	6	55	-34.8073
11	1200	50	0.5	120	6	48	-33.6248
12	1200	50	0.5	118	10	57	-35.1175

Table – Calculated Signal to Noise Ratios for Smaller is better

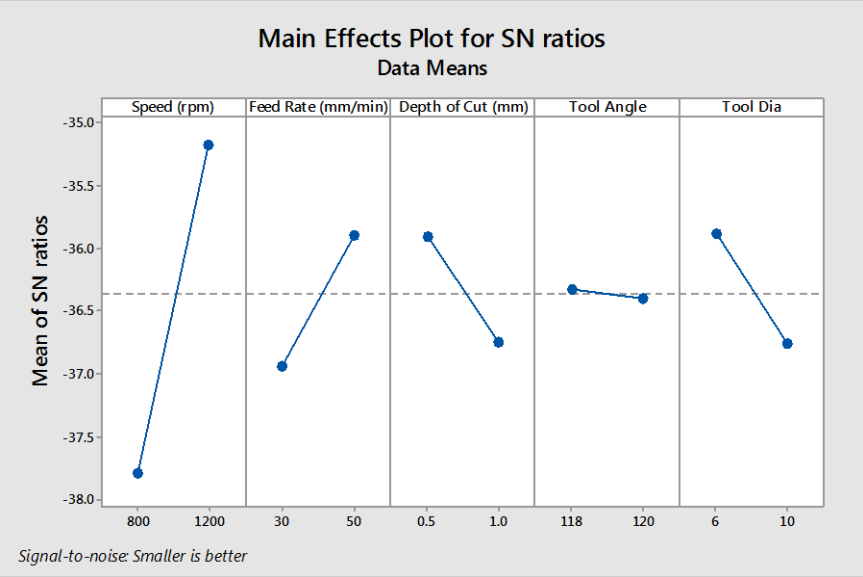

Fig - Effect of machining parameters on time taken for S/N ratio for Smaller is better

Analysis and Discussion

Regardless of the category of the performance characteristics, a greater S/N value corresponds to a better performance. Therefore, the optimal level of the machining parameters is the level with the greatest value.

Speed:- The effect of parameter Speed on time taken for drilling is shown above figure S/N ratio. So the optimum Speed is 1200rpm.

Feed Rate:- The effect of parameter feed rate on time taken for drilling is shown above figure S/N ratio. So the optimum feed rate is 50mm/min.

Depth of cut:- The effect of parameter Depth of cut on time taken for drilling is shown above figure S/N ratio. So the optimum Depth of cut is 0.5mm.

Results Table

Tool Angle - The effect of parameter Tool Angle on time taken for drilling is shown above figure S/N ratio. So the optimum Tool Angle is 118^0.

Tool Dia. - The effect of parameter Tool Dia. on time taken for drilling is shown above figure S/N ratio. So the optimum Tool Dia. is 6mm.

Optimization for higher MRR

Taguchi method is used to optimize the process parameters Speed, Feed rate, Depth of cut, Tool angle and Tool dia. for higher Material Removal Rate values. Table – MRR for drilling at different speeds and drill angles for different drill diameters.

Options – Larger is better

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Worksheet 1 ***

↓	C1	C2	C3	C4	C5	C6	C7
	Speed (rpm)	Feed Rate (mm/min)	Depth of Cut (mm)	Tool Angle	Tool Dia	MRR	SNRA2
1	800	30	0.5	118	6	847.8	58.5659
2	800	30	0.5	118	6	847.8	*
3	800	30	1.0	120	10	2355.0	67.4398
4	800	50	0.5	120	10	3925.0	71.8768
5	800	50	1.0	118	10	3925.0	71.8768
6	800	50	1.0	120	6	1413.0	63.0028
7	1200	30	1.0	120	6	847.8	58.5659
8	1200	30	1.0	118	10	2355.0	67.4398
9	1200	30	0.5	120	10	2355.0	67.4398
10	1200	50	1.0	118	6	1413.0	63.0028
11	1200	50	0.5	120	6	1413.0	63.0028
12	1200	50	0.5	118	10	3925.0	71.8768

Table – Calculated Signal to Noise Ratios for Larger is better

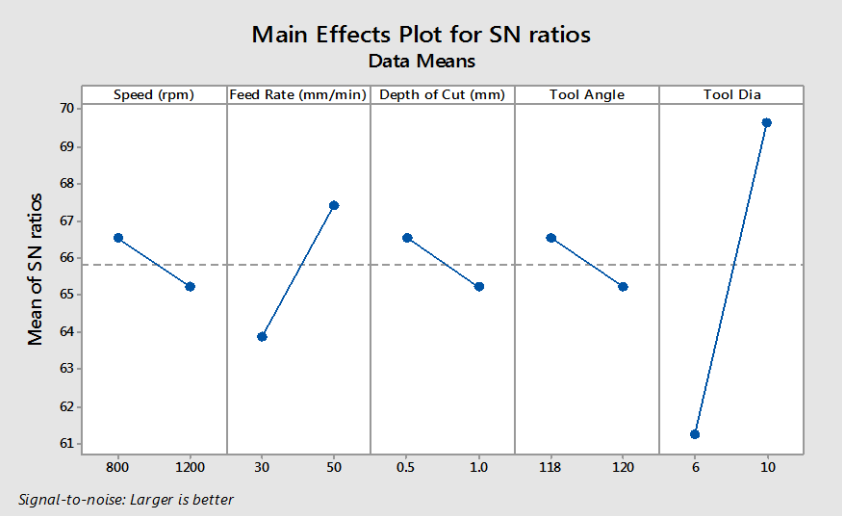

Fig - Effect of machining parameters on MRR for S/N ratio for Larger is better

Analysis and Discussion

Regardless of the category of the performance characteristics, a greater S/N value corresponds to a better performance. Therefore, the optimal level of the machining parameters is the level with the greatest value.

Speed:- The effect of parameter Speed on MRR is shown above figure S/N ratio. So the optimum Speed is 800rpm.

Feed Rate:- The effect of parameter feed rate on MRR is shown above figure S/N ratio. So the optimum feed rate is 50mm/min.

Depth of cut:- The effect of parameter Depth of cut on MRR is shown above figure S/N ratio. So the optimum Depth of cut is 0.5mm.

Tool Angle - The effect of parameter Tool Angle on MRR is shown above figure S/N ratio. So the optimum Tool Angle is 118^0.

Tool Dia. - The effect of parameter Tool Dia. on MRR is shown above figure S/N ratio. So the optimum Tool Dia. is 10mm.

CONCLUSION

From the experimental results and Taguchi results, the following conclusions can be made:

The important parameters affecting time taken for drilling are Speed, Feed Rate & drill dia. and for MRR are drill dia. & Feed Rate. So it can be concluded that tool angle and depth of cut do not affect time and MRR. By observing the Taguchi results to optimize parameters for time taken for drilling, the optimum speed is 1200rpm, feed rate is 50mm/min, depth of cut is 0.5mm, tool angle is 118^0 and drill dia. is 6mm. Optimize parameters for MRR, the optimum speed is 800rpm, feed rate is 50mm/min, depth of cut is 0.5mm, tool angle is 118^0 and drill dia. is 10mm.

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