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Optimization of Drilling Parameters on Aluminium 6351 using Taguchi Method

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Abstract: ***This paper investigates the effect of various drilling parameters such as spindle speed, feed rate and drill bit diameter on surface roughness, material removal rate and thrust force. Taguchi method is used to find out the optimal process parameters and the most significant parameters. Here aluminium alloy 6351 material is used as work piece.***

Keywords: Drilling process, Taguchi Method, Parameter Optimization, SN Ratio

1. Introduction

Drilling is a cutting process that are used to make circular hole. This drill bit is a rotary multi-point cutting tool and is pressed against work-piece and rotated at rates from hundreds to thousands of revolutions per minute. This forces the cutting edge against the work-piece, resulting in cutting off chips from the hole as it is drilled. Day by day there is an increasing demand for quality product also for higher productivity. There for drilling operation needs to be performed more efficiently. So in order to achieve a high quality product in a minimum manufacturing cost a number of investigating are conducting in modeling and optimization of process parameter.

The literatures related with experiments focusing on characteristic features of drilling operation. Shruti Topkhanewale says drilling of EN9 steel is performed by HSS tool and parameter selected for optimization is feed rate, spindle speed and diameter. The aim of this study is to optimize parameter for maximum material removal rate (MRR). The experiment was conducted based on response surface methodology (RSM) and further analyzed by Analysis of variance (ANOVA). Vinod Kumar Vankanti says the objective of the present work is to optimize process parameters namely, cutting speed, feed, point angle and chisel edge width in drilling of glass fiber reinforced polymer (GFRP) composites. In this work, experiments were carried out as per the Taguchi experimental design and an L9 orthogonal array was used to study the influence of various combinations of process parameters on hole quality.

Sengottuvel tells, experiments were conducted in CNC milling machine for carbide drill bit based on L9 orthogonal array. The process parameters investigated are spindle speed, feed rate, and drill diameter. Fuzzy rule based model is developed to predict the thrust force in drilling GFRP. R. Ramesh says Drilling operation is widely used in metal cutting industries, although modern metal cutting methods have improved in the manufacturing industries, but conventional drilling still remains one of the most common machining. Kadam Shirish says drilling parameters using the Taguchi technique to obtain minimum surface roughness (Ra) and maximum tool life (Tl). A number of drilling experiments were conducted using the L9 orthogonal array on a CNC vertical machining center. The experiments were performed on EN-24 steel blocks using uncoated M32 HSS twist drills under dry cutting conditions. Signal to Noise (S/N) ratio was employed to optimize control factors affecting the surface roughness and thrust force. T. rajmohan says Experiments were conducted on a computer numerical control vertical machining center and L18 orthogonal array was chosen for the experiments. The drilling parameters namely spindle speed, feed rate, drill type and mass fraction of mica were optimized based on the multiple performance characteristics including thrust force, surface roughness, tool wear and burr height.

2. Experimentation

Drilling process is performed on the aluminum alloy 6351 work piece material. The size of the work piece is 50 mm x 30mm x 12mm thickness. The experiments are done in vertical milling machine BFW Agni V4 (Figure 1).

Figure 1: vertical milling machine BFW Agni V4

After the experimentation, the MRR, surface roughness and thrust force are calculated. L27 orthogonal array is used for the experimental design. Process parameters and their levels for the work are as shown in the Table 1.

Table 1: Process Parameters and Levels

Parameter	Levels		
	1	2	3
Drill diameter	8	9	10
Spindle speed	900	1000	1100
Feed rate	80	100	110

he designed matrix of input parameters and the output parameters are as shown in the Table 2.

Table 2: The designed matrix

Exp. No.	Drill diameter (mm)	Spindle Speed (rpm)	Feed rate (mm/min)	Thrust force (kgf)	Surface roughness (µm)	MRR (gm/ min)
1	8	900	80	43	4.003	9.756
2	8	900	100	45	3.421	11.764
3	8	900	110	67	3.666	12.269
4	8	1000	80	48	1.533	9.345
5	8	1000	100	35	2.569	11.111
6	8	1000	110	46	2.366	12.195
7	8	1100	80	48	3.673	9.523
8	8	1100	100	54	1.797	11.299
9	8	1100	110	57	4.531	12.345
10	9	900	80	40	3.345	9.661
11	9	900	100	55	6.950	11.494
12	9	900	110	67	7.047	12.738
13	9	1000	80	32	3.899	9.756
14	9	1000	100	40	3.298	11.695
15	9	1000	110	51	3.839	13.071
10	9	1100	80	42	2.146	9.569
17	9	1100	100	65	1.920	11.627
18	9	1100	100	75	2.272	12.658
19	10	900	80	47	3.281	18.691
20	10	900	100	62	7.083	22.222
21	10	900	110	81	5.840	24.390
22	10	1000	80	50	3.000	19.047
23	10	1000	100	70	3.280	22.346
24	10	1000	110	72	5.843	24.844
25	10	1100	80	53	7.320	19.230
26	10	1100	100	62	5.957	22.727
27	10	1100	110	58	6.986	25.316

3. Results and Discussions

3.1 Effect of Input Parameter on MRR

It is found that the material removal rate is the most influenced by drill diameter. Followed by, spindle speed, and feed rate (Table 3). The optimized parameter settings for material removal rate are drill diameter 10mm, spindle speed 1100rpm, feed rate 110 mm/min (Figure 2).

Table 3: Effect on Material Removal Rate

Level	Drill Diameter	Spindle Speed	Feed Rate
1	20.83	22.90	21.62
2	21.05	22.89	23.15
3	26.83	22.92	23.95
Delta	6.00	0.03	2.33
Rank	1	3	2

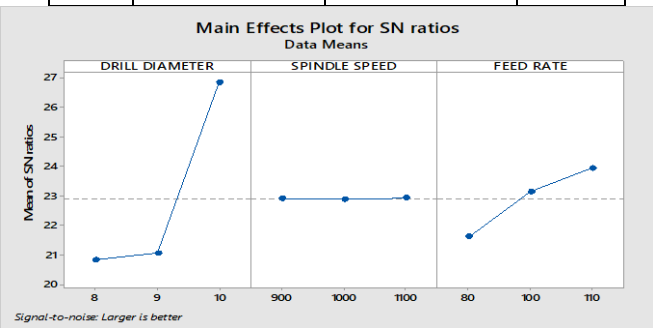

Figure 2: Mean Effects Plot of MRR

The regression equation for the optimized MRR is given by

MRR = -44.59 + 5.511 drill diameter
+ 0.00073 spindle speed + 0.1291 feed rate. (1)

MRR for optimum input combination is found to be 25.524 gm/min.

3.2 Effect of Input Parameters on Surface Roughness

It is found that the surface roughness is the most influenced by drill diameter. Followed by, spindle speed, and feed rate (Table 4). The optimized parameter settings for material removal rate are drill diameter 8mm, spindle speed 1000rpm, feed rate 80 mm/min (Figure 3).

Table 4: Effect on Surface Roughness

Level	Drill Diameter	Spindle Speed	Feed Rate
1	-9.213	-13.439	-10.350
2	-10.843	-9.827	-11.074
3	-14.169	-10.957	-12.801
Delta	4.956	3.612	2.451
Rank	1	2	3

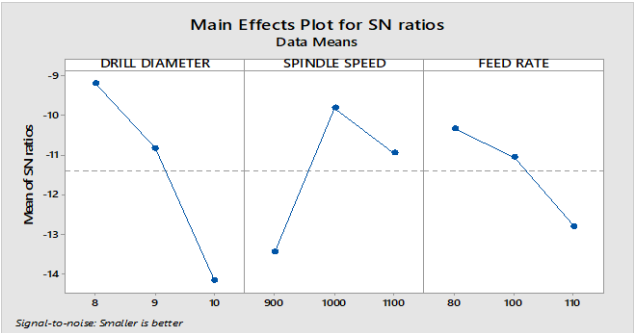

Figure 3: Mean Effects Plot of Surface Roughness

The regression equation for the optimized Surface roughness is given by

Surface Roughness = -6.10 + 1.168 drill diameter -
0.00446 spindle speed + 0.0356 feed rate. (2)

Surface Roughness for optimum input combination is found to be 1.632µm.

3.3 Effect of Input Parameters on Thrust Force

It is found that the Thrust force is the most influenced by feed rate. Followed by drill diameter and spindle speed (Table 5). The optimized parameter settings for material removal rate are drill diameter 9mm, spindle speed 1000rpm, feed rate 80 mm/min (Figure 4).

Table 5: Effect on Thrust Force

Level	Drill Diameter	Spindle Speed	Feed Rate
1	-34.07	-35.11	-32.83
2	-33.99	-33.56	-34.91
3	-35.64	-35.02	-35.96
Delta	1.66	1.54	3.13
Rank	2	3	1

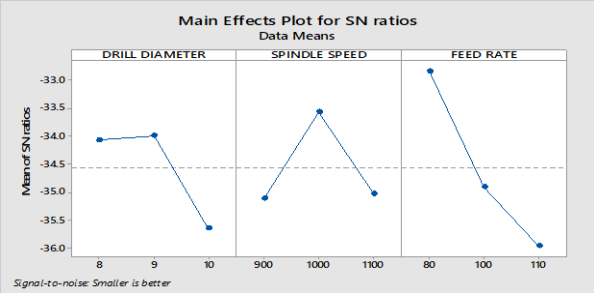

Figure 4: Mean Effects Plot of Thrust Force

The regression equation for the optimized Thrust force is given by

Thrust force = -58.6 + 5.11 drill diameter
0.0072 spindle speed + 0.650 feed rate. (3)
Thrust force for optimum input combination is found to be 32.14 kgf.

4. Conclusion

The conclusions made based on the experimental investigations of Drilling Aluminum 6351 alloy are as follows;

- It was found that Drill Diameter is the main influence parameter in the MRR. Feed rate is the main influence parameter in the thrust force. Drill diameter is the main influence, parameter in the surface roughness.
- The optimum combination of process parameters of material removal rate, surface roughness and thrust force were found.

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