Optimizations Parameters in Drilling using Taguchi Method

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Abstract— The main objectives of this analysis study is to investigate and evaluate the effect of different input process parameters (cutting diameter cutting speed and feed rate) on, Material removal rate and surface roughness response. Parameters have been considered for Each Experiment. Experimentation was planned as per L9 Orthogonal array during machining of Aluminium plate (work material). For Material removal rate and surface roughness the effective input parameter is cutting diameter (10mm), cutting speed (1000rpm) and feed rate (0.014mm/rev) are the most significant factors.
Keywords—Drilling Machine, Taguchi Method, Surface Roughness, Machining in Aluminium, Orthogonal Array

I. INTRODUCTION

Drilling is one of the most common machining process. One estimate is that 75% of all metal cutting comes from drilling operations. Drilling involves the creation of holes that are right circular cylinders. This is accomplished most typically by using a twist drill. The figure illustrates a cross section of a hole being cut by a common twist drill:

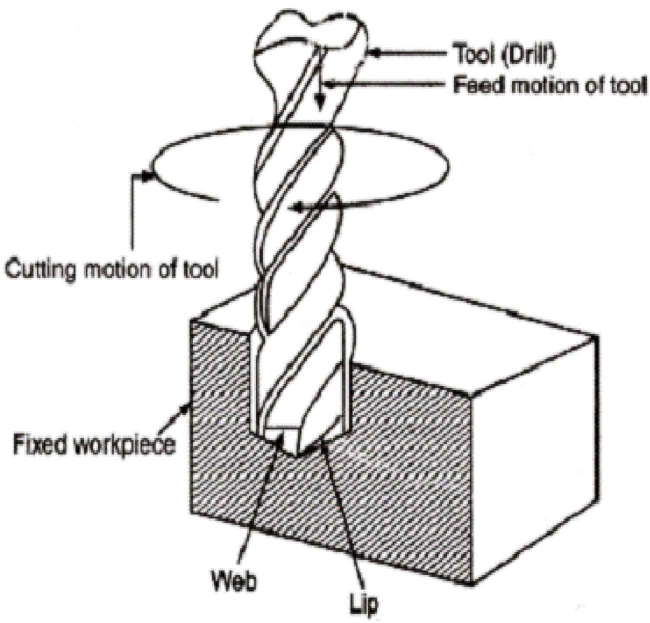

Figure 1. Drilling operation

A drilling machine, called a drill press, is used to cut holes into or through metal, wood, or other materials (Figure). Drilling machines use a drilling tool that has cutting edges at its point. This cutting tool is held in the drill press by a chuck or Morse taper and is rotated and fed into the work at variable speeds. Drilling machines may be used to perform other operations. They can perform countersinking, boring, counter boring, spot facing, reaming, and tapping.

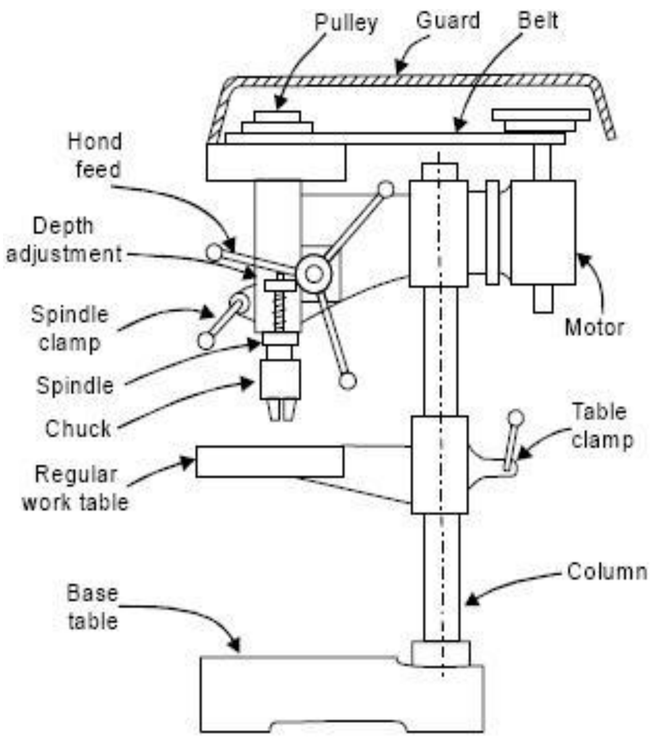

Figure 2. Drilling machine diagram

II. LITERATURE REVIEW

C. Manickam et al (2019) The various drill holes to produce in AISISS317L material based on given input parameters of speed, feed and selected drill tool. The SS317L material basically high hardness and high corrosion resistivity material using in various industrial applications. The output parametric optimization has been performed in thrust force, torque, material removal rate and surface finish based on the results confirmations using in minitab-17 tool.

K. Siva Prasad (2019) The parameters considered for drilling operation are speed, feed, thickness, fiber orientation and material thickness. The optimization of process parameters done by Taguchi's S/N ratio analysis for delamination in drilling of GFRP composites. ANOVA (Analysis of Variance) test was conducted to analyze the significant effect of process parameters on delamination. From the experimental results it is evident that Peel-up delamination is highly influenced by the material thickness and followed by the feed rate and fiber orientation, similarly the feed rate having the significant effect on the Push-down delamination next to the material thickness.

Vipina et al (2018) Modeling of Drilling cutting parameters using Taguchi Method based response surface analysis. The influence of Drilling parameters such as tool material, cutting

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speed, feed rate, drill diameter and workpiece material on surface roughness and hole diameter error were investigated during dry drilling of EN31, H11 and HCHCr die steels. Firstly, Experimental study conducted on CNC vertical Machining centre by employing Taguchi L18 (21 ×34) orthogonal array with M2 and M35 HSS Drills as tool material.

Marcello Lepore et al (2017) based on a finite element approach, is proposed to simulate multiple three-dimensional crack propagation in a welded structure. Cracks are introduced in a friction stir welded AA2024-T3 butt joint, affected by a process-induced residual stress scenario. The residual stress field was inferred by a thermo-mechanical FEM simulation of the process, considering temperature dependent elastic-plastic material properties, material softening and isotropic hardening. Afterwards, cracks introduced in the selected location of FEM computational domain allow stress redistribution and fatigue crack growth. The proposed approach has been validated by comparison with numerical outcomes provided by a consolidated FEM-DBEM procedure, available in literature.

SikiruOluwarotimi Ismail et al (2016) Worked on the combination of MTM 44-1/CFRP and 19/HFRP in new reinforced composite components makes the machining of these promising materials challenging. In order to adequately describe the workpiece quality, delamination and surface roughness must both be analysed. Using the example of a CFRP and HFRP composite material, the dependency of these characteristic quality parameters on process and tool parameters shall be analysed. The work described here compares and drilling with an HSS drilling tool process from both a technological (workpiece quality) and an economical (processing time) point of view.

Robert Voss et. al. (2015) In his paper presented a comparison between conventional and orbital drilling of heavy-to-cut unidirectional CFRP material with diamond coated tools. The material contains high fibre content and a polished-like surface at bore exit. Focus of the process comparison is on introduced workpiece damages, tool wear, bore diameter variances as well as cycle times. Three-dimensional bore exit microscopy, micrographs and expansion tests with conical pin are used to evaluate the workpiece integrity.

III. METHODE

A Ram turret milling or a M1TR Milling has a stationary spindle and the table is moved both perpendicular and parallel to the spindle axis to accomplish cutting. Turret mills often have a quill which allows the milling cutter to be raised and lowered in a manner similar to a drill machine. This type of machine provides two methods of cutting in the vertical (Z) direction: by raising or lowering the quill, and by moving.The advantage of horizontal milling machines lies in arbour-mounted cutters, called side and face mills. Quite heavy cuts can be taken enabling rapid material removal rates. These are used to mill grooves and slots. Several cutters may be ganged together on the arbour to mill a complex shape of slots and planes.

Figure 3. M1TR machine

A. MRR (Material Removal Rate)

Material removal rate (MRR) is the amount of material removed per time unit, directly aiming at the process productivity. In roughing operations and the production of large batches, this needs to be maximized. However, in finishing operations, it is a factor to be put on hold, bringing roughness and precision to the forefront. For low roughness, usually low cutting speeds and feed per tooth are both applied, as MRR is usually very low for finishing.

$$MRR = Area\ of\ drill \times Feed\ rate \times Cutting\ speed$$

B. Surface Roughness

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Surface roughness is an important parameter used to determine the suitability of a surface for a particular purpose. The irregularities on a machined surface impact the quality and performance of that surface and the performance of the end product. Rougher surfaces typically wear more quickly than smoother surfaces and are more vulnerable to corrosion and cracks, but they can also promote adhesion. A roughness tester, also referred to as roughness gauge or roughness meter, is a portable device that is used to quickly and easily measure the surface roughness (surface finish) of an object.

Figure 4. Roughness tester

C. Specimen Preprasion and level selection

Aluminum was selected as the workpiece material of Plate of 50mm x 50mm x 20mm, then drilling operation were performed on that workpiece on M1TR milling machine.

Table 1. Parameters used in drilling operation

Factors	Parameters	Level		
		1	2	3
A	Cutting dia (mm)	5	10	15
B	Cutting speed (rpm)	500	1000	1500
C	Feed rate (mm/rev)	0.012	0.014	0.016

D. Taguchi Method

The experimental results are then transformed into a signal-to-noise (S/N) ratio. It uses the S/N ratio as a measure of quality characteristics deviating from or nearing to the desired values. There are three categories of quality characteristics in the analysis of the S/N ratio, i.e., the lower the better, the higher the better, and the nominal the better. The formula used for calculating S/N ratio is given below.

Nominal the best: It is used where the nominal or target value and variation about that value is minimum.

$$S/N\text{Ratio} = -10log\frac{y^2}{\sigma^2}$$

Where σ = mean and μ= variance.

Taguchi suggested a standard procedure for optimizing any process parameters.

E. Case Design

In the Taguchi OA design, only the main effects and two-factor interactions are considered, and higher-order interactions are assumed to be non-existent. In addition, designers are asked to identify (based on their knowledge of the subject matter) which interactions might be significant before conducting the design.

Table 2. Case design using orthogonal array (OA) L9

Experiment No.	A	B	C
1.	1	1	1
2.	1	2	2
3.	1	3	3
4.	2	1	3
5.	2	2	1
6.	2	3	1
7.	3	1	3
8.	3	2	1
9.	3	3	2

IV. Results

The graph shows the mean effect plot for means of Drill dia, cutting speed and feed rate. The 'nominal is best' criteria is used for optimizing the process parameter. The drill dia should be at 10mm, cutting speed at 1000 rpm and feed rate at 0.014 mm/rev Single to noise ratio are obtained in experiments is defined in below tableThis study will help in removing the surface roughness in drilling by using best parameters. In addition, studying best parameters will open various opportunities in the field of drilling. The study will also help in attaining better finish during drilling along with more options and approaches for the same.

Table 3. Experiment result S/N ratio

S. N.	Drill Dia(mm)	Cutting Speed(rpm)	Feed Rate	MRR	Surface Roughness	S/n ratio
1	5	500	0.012	117.804	0.35	-38.38
2	5	1000	0.014	276.846	0.75	-45.81
3	5	1500	0.016	471.216	0.97	-50.43
4	10	500	0.014	549.733	1.73	-51.76
5	10	1000	0.016	1256.624	2.11	-58.95
6	10	1500	0.012	1413.702	3.12	-59.97
7	15	500	0.016	1413.712	2.45	-59.98
8	15	1000	0.012	2120.568	3.99	-63.50
9	15	1500	0.014	3710.994	4.01	-68.37

Response Table for Signal to Noise Ratios

Nominal is best (-10×Log10(s^2))

Table 4. response table for s/n ratio

Level	Drill Dia(mm)	Cutting Speed(rpm)	Feed Rate
1	-44.88	-50.04	-53.96
2	-56.90	-56.09	-55.32
3	-63.95	-59.59	-56.46
Delta	19.07	9.55	2.50
Rank	1	2	3

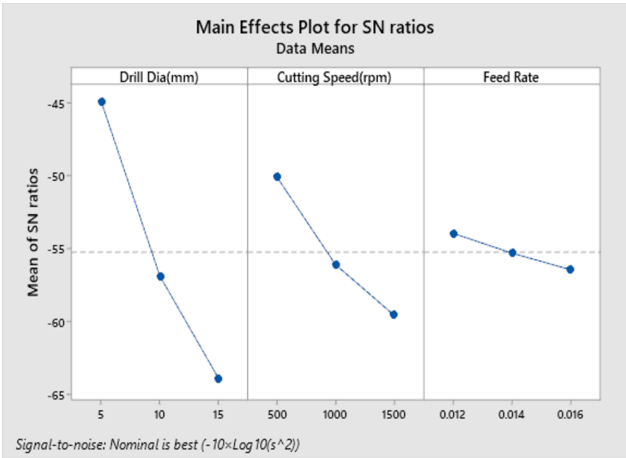

Figure 5. main effects plot for SN ratios

V. CONCLUSION

- Optimum MRR and surface roughness is attained because of using 'nominal is best' criteria.

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- As per the response table, drilling dia is at rank 1, cutting speed is at rank 2 followed by feed rate at rank 3.
- The drill dia should be at 10mm, cutting speed at 1000 rpm and feed rate at 0.014 mm/rev for obtaining best results

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