International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-3, January 2020

Optimizing the Process Parameters of Drilling on Aluminium Alloy 7075 using taguchi and Anova Techniques

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Abstract: In many material processing and manufacturing industries quality and productivity are two important requirements but these are more antithetical criteria in any machining operations. So, it is vital to optimize the productivity and quality simultaneously. The main objective of this paper is to optimize the process parameters of drilling operations such as cutting speed, feed, and point angle on aluminum alloy 7075. Al 7075 is one of the multifunctional materials in various applications. Taguchi is mostly used for data analysis and optimization of process parameters for getting maximum material removal rate and least surface roughness factor. Machining operations were conducted on CNC milling machine. The number of drilling experiments was performed on aluminum 7075 using HSS drill bit on CNC milling machine. The investigation of variance (ANOVA) was engaged to find the most notable control factors affecting the material removal rate & surface roughness. The conclusions of present work were drawn from several experimental trails; it was found that at the 9th experimental trail, point angle was most significant x factor for surface roughness and feed is the most affecting factor for material removal rate.

Keywords :. Drilling 1; aluminum7075 2; material removal rate 3; surface roughness 4; Taguchi & CNC 5

I. INTRODUCTION

Drilling

Hole making is one of the most important operations in manufacturing Industries. Drilling is a chief and public of hole making process. It is the cutting process of using a drill bit to cut or enlarge the existing holes in solid materials. Dissimilar tools & methods are used for drillingis depending on the kind of materials used, the magnitude of hole dimension, the quantity of holes, and the time required tocompletetheprocess. Drilling process can be defined as a process where a multi-point tool is used for undesirable materials removal to produce an anticipated hole. It is an important metal cutting processes with which holes are manufactured in components made of metallic and non-metallic materials. The cylindrical holes of prerequisite diameter are cut out of the module with a cutting tool, called drill bit. The different machineries available are portable drilling,multiple, radial,spindle and upright drilling etc.

Revised Manuscript Received on January 30, 2020.

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It is vital to optimizing the quality and productivity w.r.sto drilling operation as it being very free operation in manufacturing.

Several research scholars have worked on drilling operation. Optimum values of input parameters such as, feed, multiple spindles drilling as well as different cooling condition are premeditated to obtain required surface roughness value with maximum material removal rate.Most of the examines in the area of drilling are generally correlated to hole precision.Most of these have been targeted toward the study of delamination. Surface Roughness is indicated as an important design feature in many circumstances such as parts subjected to fatigue loads, precision fits, along with visual requirements. In addition to tolerances, surface roughness imposes one of the most unwarranted restraints for the assortment of machines and cutting parameters in process planning. Since Taguchi method systematically reveals the multifaceted cause and effect affiliation between design parameter along with performance, many researchers were used Taguchi techniques for design of trial studies. The present study focuses on the investigations made on drilling using Taguchi method

Process Parameters

a). Cutting speed b). Feed Rate c). Point Angle d) .Surface Roughness e). Material Removal Rate

Taguchi Method

Taguchi method involves decreasing the changes in a process through robust design of experimentations. The overall objective of this methodis to get great quality product satlowercostto the manufacturer.The Taguchi method was developedby Dr. Genichi Taguchi of Japan who retained that variation. Genichi's TAGUCHI is a Japanese quality management adviser who has establi she dand promo teda view point and approach for continuous quality enhancement in products and processes. In this philosophy, Taguch is hows that how the arithmetic design of experiments(SDOE/DOE) can help engineers to design and manufacture the products that are of higher qualityand lower costs.Taguchi technically advanced method for designing experiments to examine how dissimilar parameters affect them and variance of a process shows characteristic that defines how well the process is functioning. The experimental designwished-forby TAGUCHI involves by using orthogonal arraystoe stablish the parameters affecting the progressionandthelevelsatwhich they should be varies. Instead of testing all possible permutations like the factorial design, the Taguchi method experiment of combinations.

That can allows for the gathering of the requireds tatistics or data to determine which factor smost affect the product quality with a least amount of experimentation, thus saving the time andresources.

Taguchi approach:

However, conventional experimental design techniques are too intricate and not easy touse. Additionally,a large number of experiments have to be conceded out when the number of the process parameters increases ,to solve this problem, usually,there are 3 categories of quality features.

A). Smaller-the--Better:

$$S/N = -10\log_{10}\left(\frac{\sum y_i^2}{n}\right)$$

B). Larger-the-Better :

$$S/N = -10\log_{10}\left(\frac{1}{n}\sum\frac{1}{y_i^2}\right)$$

C). Nominal-the-Best:

$$S/N = 10\log_{10}\left(\frac{y^2}{s^2}\right)$$

Anova Technique:

A. History and terminology

ANOVA is as pecific form of statistical hypo the sis testing, profoundly usedin the analysis of experimental data collection. A statistical premise test is a process of making decisions using data, when aprobability (p-value) isless than a threshold explains the rejection of the null hypothesis, but only if the prior probability of the null hypothesis is nothighin typical application of ANOVA.Experimenter salsowishto limit Type II mistakes(falsenegatives resulting in missed scientific innovations

B. Logic of Anova

The calculations of ANOVA can be characterizedas calculating the number of means and variances, dividing two variances and relating the ratio to the hand book values to determine arithmetical significance. Subdividing of the sum of squares. ANOV Ausestr aditional standardized terminology. The definitional equation of sample variance is

$$s^2=\sum(y_i-y_{mean}^2)/n-1 \quad \text{…………(1)}$$

where, the ivisoris calledthedegreesoffreedom(Do.F),theabstractiscalledthesum ofsquares(S.S),theresult is called mean square (M.S) and the squared terms are deviances from the illustrationmean.

II. EXPERIMENTAL WORK

Work Material Details

7075 Al alloy is an aluminiumalloy, with zincas the major alloying element. It has exceptional mechanical properties, and itexhibit high strength, good ductility, toughness and resistance to fatigue. It is more susceptible to embrittlement than any other Al alloys because of micro segregation, but has ominously better corrosion resistance than the 2000 alloys. It is one of the most regularly used aluminium alloy for extremely stressed structural applications, and has been comprehensively utilized in aircraft structural parts.

7075 Al alloy's composition as follows 5.6–6.1% zinc , 1.2–1.6% copper,2.1–2.5% magnesium and less than 0.5 of silicon, , manganese, , iron, chromium, titanium and other metals.

Experimental Setup:

Fig.1 .CNC Drilling Machine

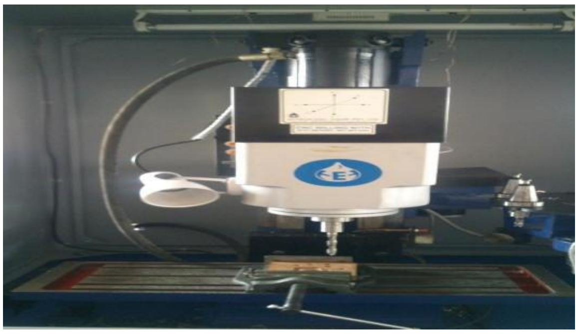


Fig .2. Drilling Operation

This work was focused on analyzing the stimulus of drilling parameters on the strength of the GFR fabric laminates and training the residual stress distribution around the enlarged hole after drilling. Holes were drilled at the Centre of the samples in a CNC machining Centre using 6 mm dia. of micro grain carbide drill for various spindle speeds (1000 4000 rpm) and feed rates (0.02, 0.06, 0.10 and 0.20 rev/min). Degree of mutilation depends on the feed rate and spindle speed. Investigational results designate that failure strength and stress concentration are related to the drilling bounds and a drilling parameter (3000 rpm and 0.02 mm/rev), which gives better mechanical strength.

Surface Finish Measuring Device :

Fig . 3. Portable surface roughness tester

A. Process parameters and levels

Three parameters-Point angle, Cutting speed, Feed rate with three levels as shown in the table below are taken under consideration in drilling as the process parameters

Table 1: Process parameters and their levels

Levels	Process parameters		
	Cutting speed (rpm)	Point angle(degree)	Feed rate(mm/min)
1	1600	110	20
2	1800	118	30
3	2000	135	40

B. TAGUCHI data for Al 7075 16mm thickness

The L_9 orthogonal array formed by Taguchi method by taking the 3 parameters and 3 levels using the array selector

Table 2: TAGUCHI Data For Al 7075 ,16mm Thickness

S.no	Cutting speed(rpm)	Point angle(degree)	Feed rate(mm/min)
1	1600	110	20
2	1800	110	30
3	2000	110	40
4	1600	118	30
5	1800	118	40
6	2000	118	20
7	1600	135	40
8	1800	135	20
9	2000	135	30

Work material after Drilling process

Fig 4: Work piece after completion of experiment

III. ANALYZING THE RESULTS

A. Calculated values:

Three values of the surface roughness are taken and the average value is found out for further analysis.

Observed Surface roughness (Ra) values			Average surface roughness(Ra)
2.061	1.571	1.819	1.817
2.336	2.217	1.537	2.03
3.098	4.286	2.292	3.2253
2.757	2.812	3.225	2.9413
3.680	4.432	3.749	3.95367
2.396	2.044	2.831	2.42367
1.097	1.169	1.628	1.298
2.061	1.080	1.755	1.632
1.427	2.093	1.768	1.76267

Table 3: Calculated values

B. Table values:

S.no	Point angle (degree)	Feed rate (mm/min)	Cutting speed (rpm)	Average Surface roughness (Ra)	Material removal rate (cm^3/min)
1	110	20	1600	1.817	1.4398
2	110	30	1800	2.03	2.2288
3	110	40	2000	3.2253	2.91187
4	118	30	1600	2.9413	1.99
5	118	40	1800	3.95367	2.879
6	118	20	2000	2.42367	1.517
7	135	40	1600	1.298	2.971
8	135	20	1800	1.632	1.4946
9	135	30	2000	1.76267	2.1399

Table 4: Tabulating material removal rate and surface roughness

C. S/N ratios for Material Removal Rate (MRR) and The Surface Roughness

The S/N ratios for the surface roughness and metal removal rate are given below table as SNRA-1 AND SNRA-2,

SNRA-1	SNRA-2
3.16604	-5.18710
6.96142	-6.14992
9.28344	-10.1714
5.97706	-9.37079
9.18483	-11.9400
3.62028	-7.68947
9.45805	-2.26549
3.49050	-4.25440
6.60787	-4.92342

Table 5: S/N ratios for Material Removal Rate (MRR) and Surface Roughness

D. TAGUCHI Analysis

a). Ra versus Point Angle, Cutting Speed, Feed :Response Table for Signal to Noise Ratios **.** i.e,Smaller is better

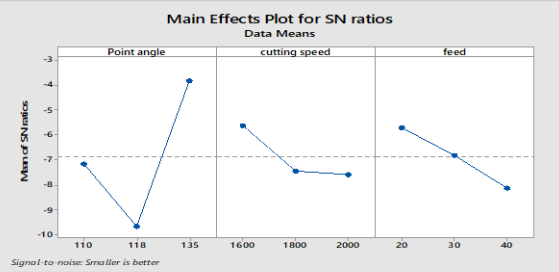
level	Cutting speed	Point angle	Feed rate
1	-5.608	-7.169	-5.710
2	-7.448	-9.667	-6.815

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication (BEIESP)

3	-7.595	-3.814	-8.126
Delta	1.987	5.852	2.415
Rank	3	1	2

Table 6: Response Table for Signal to Noise Ratios

b). S/N ratios for surface roughness



Graph.1: S/N ratios for surface roughness

The graphs show that the maximum value of the S/N ratios is at the point angle 135, cutting speed 1600 and feed 20.

c). Analysis of Variance for surface roughness:

The table shows that the contribution of point angle on metal removal rate (MRR) is very high occupying the first place as 59.00% and next comes the feed rate with a contribution of 19.41% and finally the cutting speed with its least contribution of 19.41%. The percentage of error occurred in about 13.67.

E. TAGUCHI Analysis

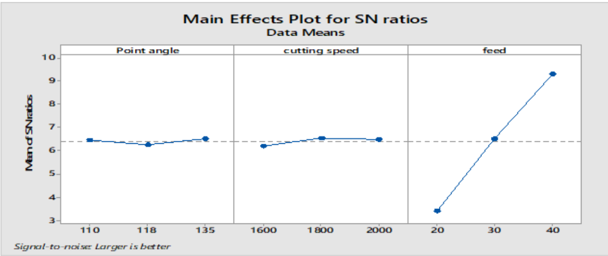
1). MRR versus Point angle, cutting speed, feed

Response Table for Signal to Noise Ratios:Larger is better

Table 7:Response Table for Signal to Noise Ratios

Level	Cutting speed	Point angle	Feed rate
1	6.2	6.47	3.426
2	6.546	6.261	6.515
3	6.504	6519	9.309
Delta	0.345	0.258	5.883
Rank	2	3	1

2). S/N ratios for M.R.R:



Graph 2: S/N ratios for MRR

The

Table 9: Analysis of Variance for M .R .R

Source	DF	Contribution	Adj MS	Seq SS	Adj SS	F-Value	P-value
Point angle	2	0.31%	0.0048	0.009	0.0096	0.5	0.6
Cutting speed	2	0.25%	0.00389	0.00778	0.00778	0.4	0.7
Feed	2	98.84%	1.55511	3.11021	3.11021	161.6	0.06
Error	2	0.61%	0.00962	0.01925	0.01925	-	-
Total	8	100%	-	3.14686	-	-	-

3).Analysis of Variance for Material Removal Rate:

IV. CONCLUSIONS

1. The table shows that the contribution of point angle on metal removal rate (MRR) is very high occupying the first place as 59.00% and next comes the feed rate with a contribution of 19.41% and finally the cutting speed with its least contribution of 19.41%. The percentage of error occurred in about 13.67.

2. After calculating the average S/N ratios for the three parameters- cutting angle, cutting speed and feed rate, the range of feed rate is the highest with a range of 5.883, occupying the rank 1. The range of cutting speed comes next as 0.345, occupying the rank 2. The cutting angle has the least range 0.258, occupying the rank 3

3. The table shows that the contribution of feed on metaremoval rate (MRR) is very high occupying the first place as 98.84% and next comes the point angle with a contribution of 0.31% and finally the cutting speed with its least contribution of 0.25%. The percentage of error occurred in about 0.61

4. Out of the studies made the important conclusions may be drawn as:.Taguchi technique has proved to be the best tool for determining the optimum machining conditions, improving performance characteristics, their main effects and in finding out other significant factors. The multiple performance characteristics such as tool life, cutting force, surface roughness as well as the overall productivity can be improved by using Taguchi Techniques. It can also be concluded that at quite large cutting speeds with smaller feed rate, good surface quality along with dimensional accuracy can be achieved.

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