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"WASTE REDUCTION IN DRILLING OF ALUMINIUM ALLOY TO MAINTAIN MINIMUM OVALITY"

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ABSTRACT

The Proper selection of drilling parameters is one of the significant challenges in the drilling process. Now a day's the application of optimization techniques are very useful for maintaining and improving both the quality and productivity. Almost half of the world's industrial and production is done by using aluminum alloy. It is not easy to machine materials like austenitic stainless steel because of their high strength, high ductility and low thermal conductivity. This work will discuss the experimental study on performance characteristics of AA6101 T6 aluminum alloy during drilling process. Factors like spindle speed, feed rate and DEPTH OF CUT affect the performance parameters such as the surface roughness and ovality in drilling process. To get minimum surface roughness and minimum ovality, the best optimal level of parameters has to be chosen carefully. This work will present the multi-objective optimization of drilling process parameters using Anova Analysis. The experiments will be conducted based on design of experiment. The experiment results are collected and analyzed using statistical software Minitab19.

Key Words: *AA6101 T6 aluminum alloy, Drilling process, Surface Roughness, Minitab19, ANOVA, Anova Analysis*

I. INTRODUCTION

Penetrating procedure is an assembling procedure. In boring procedure a drill instrument evacuate undesirable materials to shape chips to deliver a required opening. It covers wide scope of procedure for delivering openings of round and hollow shape in the work piece. Opening assembling can be considered as the most significant machining process, while for delivering productive gap is required centered practices to accomplish ideal cutting condition. In assembling industry penetrating machines are utilized regularly as metal evacuation activity.

It is in this manner, basic to upgrade quality and profitability all the while [1-4]. Efficiency can be assessed related with material evacuation rate in the machining procedure and quality related with fulfillment of client in view of item quality attributes as favored as well. There is various research papers accessible related with penetrating, reaming and exhausting. Different inquires about works indicates material expulsion rate (MRR) and surface unpleasantness are execution attributes [5-7]. Moreover, creators likewise discovered ideal qualities for information parameters, for example, speed, feed, distinctive cooling condition are determined to acquire most extreme MRR and least surfaceunpleasantness esteem. The other significant normal for boring procedure is nature of gap.

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The nature of configuration can be improved through improving the worth and yield in far reaching exercises [8]. Quality and profitability are the two noteworthy parameters which are between related. The Taguchi based DOE are likewise valuable for streamlining. Despite the fact that various enhancement strategies, Taguchi techniques are one of the most generally utilized for improving machining activities [9-12]. Likewise in any different machining process, Taguchi parameter configuration proposed a productive technique for completed advancement practices of various parameters related with quality and cost.

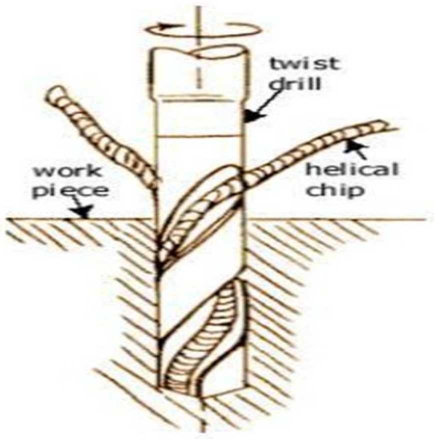

Fig. 1.1: Drilling process

1.1 OVALITY

It is defined as a deviation from a perfect circular cross-section shape, generally denoted as the total difference found at any one cross section between the individual maximum and minimum diameters, which usually occur at or about 90 degrees.

Ovality % = (Max diameter – Min diameter)/Nominal diameter x 100

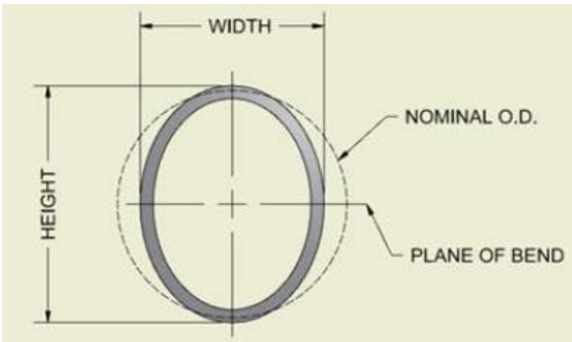

Fig. 1.2: Ovality

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II. METHOD

2.1 TAGUCHI METHOD

Taguchi procedure is factual strategy created by Genichi Taguchi to improve the exhibition and nature of the items. In view of Taguchi, the primary concern just before investigation is foundation of the examination. Just by this strategy, it's conceivable to improve the nature of the procedure. This technique could accomplish the last yield esteem and diminished the inconstancy over the yield an incentive by least expense. He accepted that the most straightforward approach to upgrade quality was to make and develop it into the item. The primary motivation behind this technique is to make great quality item at modest to the maker. The new design sorted out basically by Taguchi includes putting on symmetrical clusters to build the rules affecting on the technique in addition to the sum where they should be differs. Rather than encountering to assess all conceivable blend simply like the factorial format, the genuine Taguchi approach checks individuals of mixes. The accompanying will take into consideration the amount of the important actualities to reveal which factors practically all affect items top quality utilizing most reduced volume of testing, along these lines sparing your time in addition to assets. The Taguchi exhibits is regularly created or even investigated littler clusters is frequently delayed by hand; enormous exhibits can be based for deterministic calculations. For the most part, clusters can be acquired on the web. The exhibits are chosen basically by the quantity of rules (factors) in addition to the quantity of reaches (states).

2.1.1 DESIGN OF EXPERIMENT

The general advances dynamic in the Taguchi strategy are these:

•Determine the machining parameters which are to impact by the machining procedure factors The forthcoming of a methodology may likewise be a base or ideal, similar to; the planned might be to diminish the ovality.

•Establish the system factors influencing the machining procedure. Factors are parameters inside the methodology that impact the presentation estimates, for example, cutting pace, feed rate and so forth that might be essentially controlled.

•Build symmetrical clusters for the factors configuration demonstrating what number of and circumstances for each examination. The choice of symmetrical exhibits is based on the measure of factors and the amounts of variety for each parameter, and will be examined beneath.

•Perform the examinations as per symmetrical cluster to get information on the outcome on the presentation measure attributes.

•Total information investigation to find the delayed consequence of various factors on the presentation measure.

2.1.2 ORTHOGONAL ARRAY

As indicated by parameters and their levels the plan proposed will used to inspect the impact of various parameters on the exhibition trademark. Following the factors influencing a procedure which can be overseen have recently been resolved, the levels at which these factors ought to be differed should absolutely be resolved. Choosing what degrees of parameters are requiring an inside and out understanding the procedure, similar to the base, greatest and ongoing

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estimation of the parameter. In the event that the quantity of parameter is little, at that point less worth could be tried or the qualities tried could be shut together. The cost of performing trials should absolutely be viewed as when choosing the quantity of degrees of a parameter to fuse in the trial plan.

2.2 ANOVA ANALYSIS

Examination of difference, or ANOVA, is a factual technique that isolates watched fluctuation information into various parts to use for extra tests. A one-wayANOVA is utilized for at least three gatherings of information, to pick up data about the connection between the reliant and autonomous factors.

Examination of Variance (ANOVA) is a factual strategy used to test contrasts between at least two methods. It might appear to be odd that the system is classified "Investigation of Variance" instead of "Examination of Means." As you will see, the name is suitable in light of the fact that inductions about methods are made by breaking down change.

ANOVA is utilized to test general instead of explicit contrasts among methods. This can be seen best by model. For the situation study "Grins and Leniency," the impact of various kinds of grins on the mercy appeared to an individual was explored. Four distinct kinds of grins (impartial, false, felt, hopeless) were explored. NOVA tests the non-explicit invalid speculation that each of the four populace means are equivalent. That is,

2.3 MINITAB SOFTWARE

Minitab is extremely an insights bundle. Minitab offers an accumulation of programming, bolster materials and administrations that empower you to control your quality and strategy advancement forms. This application is valuable for Data and File Management-spread sheet for better information investigation; Analysis of Differ; Regression Analysis; Power and Sample Size; In this regard, the Minitab 19 software is useful for obtaining ANOVA.

III. EXPERIMENTAL PLAN

The objectives of the present work have already been discussed in previous chapter.

Accordingly we have completed experiment step by step.

1. Checking and preparing the power hacksaw for performing the cutting operation.

Fig. 3.1: Aluminium alloy sheet procured from market

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Cutting of aluminium sheet according to required length on power hack saw.

Aluminium alloys AA6101 T6 has been cut into the required size are by power hacksaw cutting.

Sample is ready for drilling operation.

Fig. 3.2: Sample ready for drilling operation

3.1 MATERIAL USED

In our experimental we will use AA6101 T6 grade aluminium alloy sheets of 10 mm thickness 255 mm x 100 mm. The composition and material properties of aluminium alloys are given in table 3.1 and table 3.2 respectively.

Table 3.1: Chemical Composition by wt%

Material	Mg	Mn	Si	Fe	Cu	Zn	Cr	Ti	Ni	Al
AA6101 T6	0.91	0.09	0.52	0.32	0.21	0.095	0.11	0.04	-	Balance

Table 3.2: Mechanical Properties

Material	UTS (MPa)	Yield Strength (MPa)	% Elongation	Hardness (HV)
AA6101 T6	312	240	26	107

3.2 DRILL TOOL USED

These are slicing apparatuses which is utilized to make openings of roundabout cross-segment by evacuating material. It is effectively accessible in market and accessible in various sizes, shape, and it can likewise make various types of openings in a wide range of materials. The way toward making openings is straightforward right off the bat it is fixed to a drill, which is physically works it to slice through it, normally by revolution of cutting device. Shank in throw holds the boring apparatus which is fixed in drill machine.

Aluminum composite is a material which is machined effectively. We have to hold the bit in shank effectively to get ideal outcomes. HSS (High Speed Steel) boring tools are utilized for penetrating activity in chose aluminum combination. Since these are effectively accessible in market and are financially savvy as well.

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Fig. 3.3: HSS tool used in drilling

3.3 MACHINE USED

Using VMC-400 experiments were conducted. Basically it is a vertical milling/drilling machine, which is manufactured by HMT. This vertical machining centre is equipped with the Fanuc India series O-M controller for the execution of programs. The machine is capable of running at 4000rpm of spindle speed. The maximum feed that can be attained in this specific machine is 2000mm/min.

3.4 PROCESS VARIABLES AND THEIR LIMITS

We will perform penetrating activity utilizing CNC boring machine, with instrument fast steel, to upgrade different procedure parameters utilizing Taguchi technique and L9 based DOE, ANOVA utilized to look at the centrality and rate commitment to accomplish surface completion.

In the present trial study axle speed, feed rate and Profundity OF CUT have been considered as procedure factors. The procedure factors with their levels are appeared in Table 3.3.

Table 3.3: Process variables and their limits

Parameters/Factors	level		
	1	2	3
Spindle speed (rpm)	200	400	600
Feed rate (mm/min)	20	40	60
DEPTH OF CUT(mm)	2	4	6

3.5 DESIGN OF EXPERIMENT

Utilizing three parameters and levels 9 tests blend have been made in Minitab utilizing Taguchi's L9 Symmetrical Exhibit (OA) DOE having 9 mixes of axle speed, feed rate and boring apparatus distance across. For each exploratory run surface harshness and ovality will be assessed. As appeared in table underneath we will utilize cutting condition for boring activity on aluminum combination for each run information will be recorded.

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Table 3.4: Parameters and levels

Experiment no.	Spindle speed (rpm)	Feed rate (mm/min)	Depth of cut (mm)
1	200	20	2
2	200	40	4
3	200	60	6
4	400	20	4
5	400	40	6
6	400	60	2
7	600	20	6
8	600	40	4
9	600	60	2

3.6 TEST CONDUCTED

3.6.1 SURFACE ROUGHNESS MEASUREMENT

Since surface harshness is a significant yield parameter related with nature of a mechanical item and it can likewise influences assembling cost as well. As we can characterize it in section 1, it is related with inconsistencies found on metal surface which is created from

different past machining forms. In the present examination, 9 investigations were directed and 9 Ra qualities were estimated from the machined zone. For every 9 trial runs, surface harshness esteems will be recorded by a SURFTEST SJ–410 unpleasantness analyzer instrument. Recorded surface harshness esteems are referenced in table 3.5.

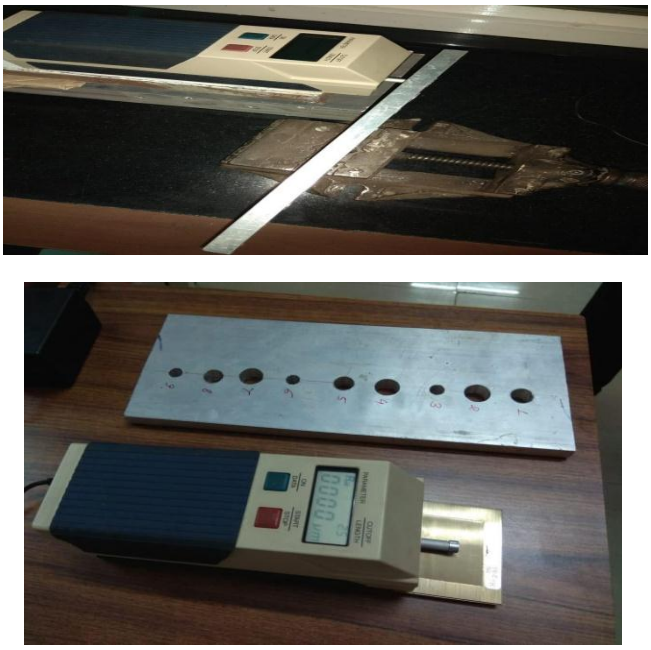

Fig 3.4 face roughness test

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Table 3.5: Surface roughness test result

Experiment no.	Spindle speed (rpm)	Feed rate (mm/min)	Depth of cut (mm)	Surface roughness (μm)
1	200	20	2	3.045
2	200	40	4	3.209
3	200	60	6	3.560
4	400	20	4	5.043
5	400	40	6	3.963
6	400	60	2	3.701
7	600	20	6	4.831
8	600	40	4	4.376
9	600	60	2	3.865

3.6.2 OVALITY MEASUREMENT

Ovality will be measured using the Coordinate measuring machine (CMM). It has a vertical probe which moves up and down and along edges of the holes. The work piece is placed flat on the table and the probe measures the ovality of the drilled hole. The machine used is Brown &sharpe CRT-A C544 three-dimensional coordinate measuring machine (CMM) device. Minimum 2 points were measured to obtain the ovality of drilled hole.

Ovality = [Max. diameter – min. diameter]/Nominal diameter x 100

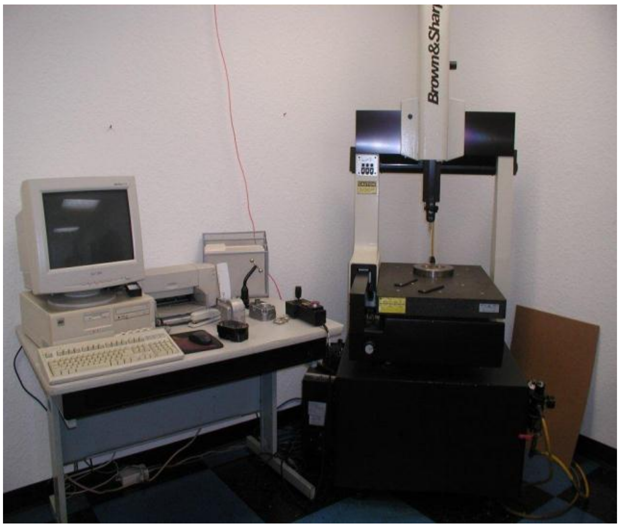

Fig. 3.5: Coordinate Measuring Machine

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Table 3.6: Ovality test result

Experiment no.	Spindle speed (rpm)	Feed rate (mm/min)	Depth of cut (mm)	Maximum diameter, mm	Minimum diameter, mm	Ovality, %
1	200	20	2	8.7362	8.3874	4.36
2	200	40	4	12.6836	12.1132	7.13
3	200	60	6	14.9768	14.3641	7.65
4	400	20	4	12.8214	12.2631	6.97
5	400	40	6	14.9547	14.3214	7.91
6	400	60	2	8.6947	8.31171	4.79
7	600	20	6	14.9123	14.2874	7.81
8	600	40	4	8.6814	8.2961	4.82
9	600	60	2	12.7917	12.2548	6.71

Ovality = Max – min/ nominal dia(8mm)

IV. RESULT & DISCUSSION

4.1Taguchi Method

Table 4.1Response Table for Means

Level	Spindle Speed	Feed	Depth of Cut
1	3.271	4.306	3.707
2	4.236	3.849	4.039
3	4.357	3.709	4.118
Delta	1.086	0.598	0.411
Rank	1	2	3

Spindle Speed: 200

Feed: 60

Depth: 2

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Table 4.2 Smaller is better

Level	Spindle Speed	Feed	Depth of Cut
1	-10.28	-12.47	-11.29
2	-12.46	-11.64	-11.97
3	-12.75	-11.38	-12.22
Delta	2.47	1.09	0.94
Rank	1	2	3

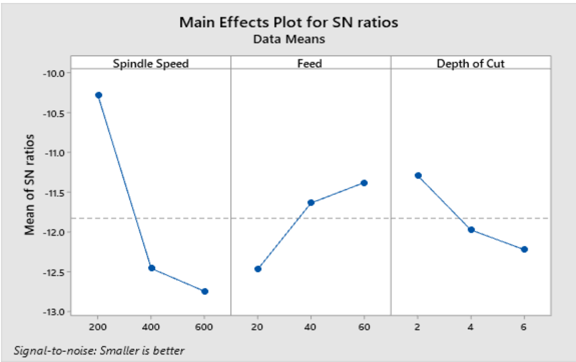

Fig. 4.1 Main effects plot for SN ratios

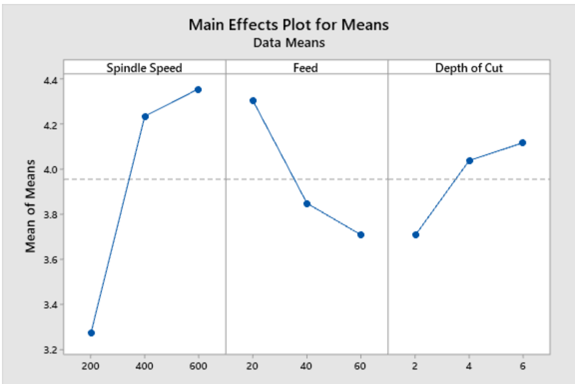

Fig. 4.2 Main effects plot for Means

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4.2 ANNOVA METHOD

4.2.1 Method

Null hypothesis	All means are equal
Alternative hypothesis	Not all means are equal
Significance level	α = 0.05

Equal variances were assumed for the analysis.

4.2.1 Table Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Spindle Speed	2	2.124	1.0621	3.94	0.081
Error	6	1.618	0.2696		
Total	8	3.742			

4.2.2 Table Means for Spindle

Spindle Speed	N	Mean	StDev	95% CI
200	3	3.271	0.263	(2.538, 4.005)
400	3	4.236	0.711	(3.502, 4.969)
600	3	4.357	0.483	(3.624, 5.091)

Pooled St. Dev = 0.519221

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4.2.3 Table Analysis of Variance for Feed

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Feed	2	0.5858	0.2929	0.56	0.600
Error	6	3.1558	0.5260		
Total	8	3.7417			

4.2.4 Table Analysis of Variance for Feed Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.725240	15.66%	0.00%	0.00%

4.2.5 Table Analysis of Variance for Feed Model Summary Means

Feed	N	Mean	StDev	95% CI
20	3	4.306	1.097	(3.282, 5.331)
40	3	3.849	0.592	(2.825, 4.874)
60	3	3.7087	0.1526	(2.6841, 4.7332)

Pooled StDev = 0.725240

4.2.6 Table Analysis of Variance for Depth of cut

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Depth of Cut	2	0.2849	0.1424	0.25	0.789
Error	6	3.4568	0.5761		
Total	8	3.7417			

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4.2.7 Table for Model Summary for Depth of Cut

S	R-sq	R-sq(adj)	R-sq(pred)
0.759033	7.61%	0.00%	0.00%

4.2.8 Table for Means for Depth of Cut

Depth of Cut	N	Mean	StDev	95% CI
2	3	3.707	0.666	(2.635, 4.780)
4	3	4.039	0.929	(2.967, 5.111)
6	3	4.118	0.650	(3.046, 5.190)

Pooled St. Dev = 0.759033

Spindle Speed : 200

Feed:60

Depth: 2

4.3 CONFIRMATION TEST

The last step in this work is to verify the performance characteristic of the optimum parameter combination by performing confirmation experiment [11]. From Anova analysis the optimal combination we have found is A1 B3 C1. Hence the confirmation experiment is carried with A1 B3 C1 combination. The output responses for experiments are measured. For the validation purpose confirmation test has been carried out to prove the improvement of performance characteristics in the drilling process for surface roughness and ovality. The optimum parameters are selected for the confirmation test as presented in Table 4.3

Table 4.3: Optimum parameters and levels

Parameter designation	**Process parameters**	**Optimal levels**
A	Spindle speed (rpm)	1(200)
B	feed rate (mm/min)	3(60)
C	DEPTH OF CUT(mm)	1(2)

In order to test the predicted result, confirmation experiment has been conducted by running three trials at the optimal setting of the process parameters determine from the analysis.

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V. CONCLUSION

The Annova method based on the Taguchi method's response table proposed as a way of studying the optimization of drilling process parameters. The optimal machining parameters have been evaluated by the grey relational grade for multi objectives performance is surface roughness and ovality. Using DOE based on L9 orthogonal array have been performed. The following conclusions can be drawn from this study.

1. The spindle speed is the most operative parameter and that the small variation will shows large decrease in surface roughness.
2. From the Annovamethod graph, it is observed that the minimum value of the spindle speed of 200 rpm and feed rate of 60 mm/min with DEPTH OF CUT 8 mm. Thus, it is the recommended level of the input parameters of the drilling operations to get maximum better hole accuracy and minimum surface roughness.
3. For surface roughness, it shows the decrease in the response values which are on the x-axis with the variation in the parameter's values which are on the y axis. Here, with the increase in feed the values are decreasing. As in these interactions ovality increases rapidly with the increase in the spindle speed. It shows the decrease in the response values other than the interactions of point angle in which case the values are increasing, which are on the x-axis with the variation in the parameter's values y axis.

VI. FUTURE SCOPE LUSION

This exploration has been founded on unadulterated trial technique for research strategy. Thus, every one of the constraints of test technique are pertinent to this examination as well, for example commotion impacts, machine instrument and estimating confinements, natural variety and so forth. The examinations are primarily founded on measurable outcomes and the impediments of factual devices are additionally material to this exploration.

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