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Optimizing of Cutting Parameter on Aluminum Alloy 6063 for Maximum MRR and minimum SR using Taguchi Approach

Ankita Kar[1], Prof. Nishant Singh Kushwah[2]
[1]M.Tech. Scholar, [2]Prof. Mech. Engg. Deptt., VITM, Gwalior

***Abstract:** The present study is to be found the optimum turning parameter during machining of Aluminium Allow 6063 with Carbide insert. Taguchi DOE has been used to obtain maximum MRR and minimum SR with different process parameter (Spindle Speed, Feed Rate and Depth of cut). Regression model for MRR and SR are developed to study the effects of cutting parameters on machining response. The investigation shows the important and dominating factor which effects the response of turning operation.*
***Keywords:** CNC Turning, Taguchi, ANOVA, MRR, SR, S/N Ratio.*

I. INTRODUCTION

In order to meet the growing demand to production complicated components of high accuracy in large amount of production, sophisticated machining parts and machinery have been established. The CNC machines often service the several mechatronics elements that have been developed over the years. To govern the machine tool G-code and M-code are used for perform any operation. Material is removed from the outer diameter of a rotation cylindrical work piece. To reduce the outer diameter of work piece the turning operation is performed, usually to a specified dimension, and to produce a smooth finish on the work piece.

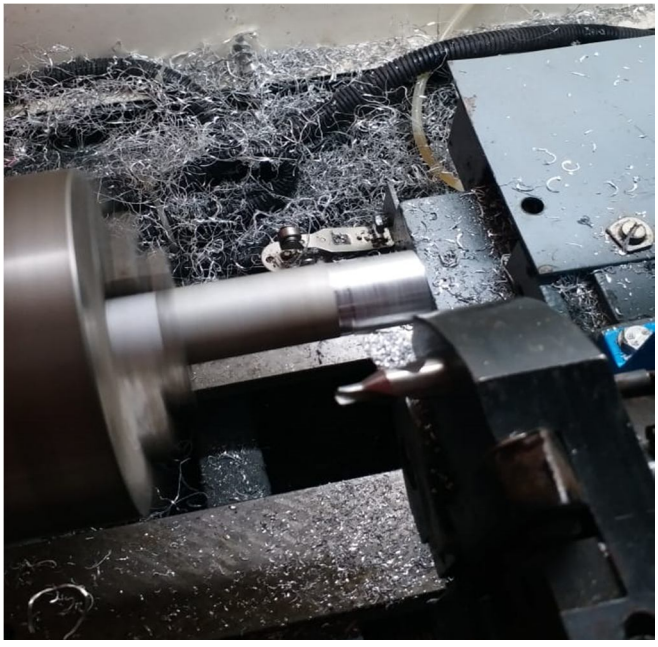

Figure 1: Aluminium Shaft during turning

The turning operation is performed in Aluminium Alloy 6063 with various process parameter like spindle speed, feed rate and depth of cut using carbide insert. In this paper turning experiments are designed with the help of Taguchi's DOE. Turning operation has been performed on the work piece as shown in figure-1 with considering three process parameters and calculate maximum MRR and minimum the surface roughness values are measured.
The results are collected and responses are analyze with help of Taguchi method and ANOVA in minitab 19. Statistical analysis will used for getting the optimum result with considering all the corresponding responses.

II. EXPERIMENTAL SETUP

The machine tool employed for turning operation in CNC MCL-12 with selection of cutting parameters like Spindle Speed (N), feed rate (f) and depth of cut (d). Table 1 is shows three levels of cutting parameters for this experiment.

Table 1: Parameters and their levels for experiments

S.No.	Parameter	A	B	C
1	Spindle Speed (N) rpm	1000	1500	2000
2	Feed Rate (f) mm/rev.	0.2	0.4	0.6
3	Depth of Cut (d) mm	0.3	0.6	0.9

The Aluminum alloy 6063 material used for this turning operation because it's widely used in aerospace industries and have high corrosion resistance. The experiment have been performed based on L_9 Orthogonal array designed with three level of different combination of process parameter and 9 work piece machined in CNC lathe machine by selected machining parameter then the MRR is too calculated and surface roughness is measured by tester TIME 3100.

Table 2: Observation Table for MRR and SR

Experiment No.	Spindle Speed (N) rpm	Feed Rate (f) mm/rev.	Depth of Cut (d) mm	MRR cm^3/min	Surface Roughness(Ra) µm
1	1000	0.2	0.3	4.465	1.49
2	1000	0.4	0.6	17.634	1.2
3	1000	0.6	0.9	39.168	0.81
4	1500	0.2	0.6	13.225	0.72
5	1500	0.4	0.9	36.168	0.9
6	1500	0.6	0.3	20.092	0.82
7	2000	0.2	0.9	26.112	0.72
8	2000	0.4	0.3	17.860	1.28
9	2000	0.6	0.6	52.902	0.6

III. RESULT AND DISCUSSION

The turning parameter have been optimize for maximum MRR by "larger-the-better" concept and to obtained minimum Surface roughness the "smaller-the-better" concept by Taguchi method where experimental data have been analyzed.

Table 3: Experimental values using L_9 orthogonal array

Exp. No.	Spindle Speed (N) rpm	Feed Rate (f) mm/rev.	Depth of Cut (d) mm	MRR cm^3/min	S/N Ratio (db)	Ra µm	S/N Ratio (db)
1	1000	0.2	0.3	4.465	12.99642926	1.49	-3.46373
2	1000	0.4	0.6	17.634	24.92701673	1.2	-1.58362
3	1000	0.6	0.9	39.168	31.85862792	0.81	1.8303
4	1500	0.2	0.6	13.225	22.42791361	0.72	2.85335
5	1500	0.4	0.9	36.168	31.16648988	0.9	0.91515
6	1500	0.6	0.3	20.092	26.06046339	0.82	1.723723
7	2000	0.2	0.9	26.112	28.33680274	0.72	2.85335
8	2000	0.4	0.3	17.860	25.03762909	1.28	-2.1442
9	2000	0.6	0.6	52.902	34.46944182	0.6	4.436975

The plot of average response at each level of a parameter indicate the trends. It is a graphic representation of effect of parameter on the response. The change in levels of parameter can easily be visualized from these curves. The S/N ratio is treated as a response of the experiment which is measure of the variation within a trial when noise factor are present.

The aim is to minimize the S/N ratio whatever may be the nature of quality characteristics. The average value of all S/N ratios when parameters are at the same distinct level is used to describe the effect of parameter or factor of quality characteristics at that level, such that analysis of means. The means of S/N ratio refers to the average value of performance characteristics for each parameter at different levels. A parameter level corresponding to the minimize average S/N ratio is called the optimal level that parameter.

Table 4: S/N Ratio Response Table for MRR (Larger is better)

Level	Spindle Speed	feed rate	Depth of cut
1	23.26	21.25	21.36
2	26.55	27.04	27.27
3	29.28	30.80	30.45
Delta	6.02	9.54	9.09
Rank	3	1	2

Figure 2: Effects of process parameter for MRR

Table 5: Table S/N Ratio Response Table for Surface Roughness (Smaller is better)

Level	Spindle Speed	Feed Rate	Depth of Cut
1	-1.0724	0.7477	-1.2947
2	1.8307	-0.9376	1.9022
3	1.7154	2.6637	1.8663
Delta	2.9031	3.6012	3.1970
Rank	3	1	2

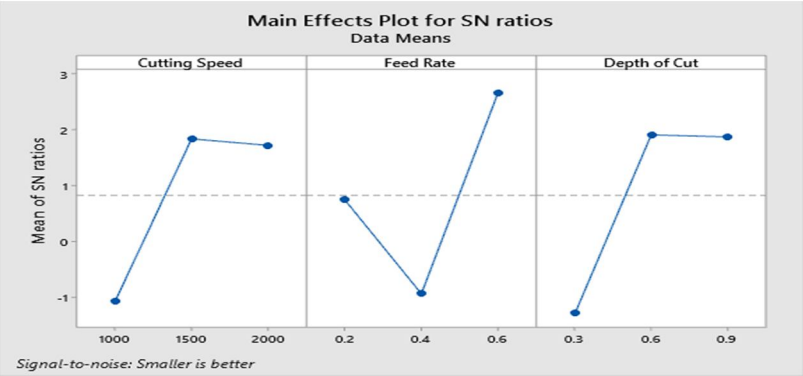

Figure 2: Effects of process parameter for SR

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IV. RESULT AND DISCUSSION

Table 6: ANOVA results for MRR

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
Spindle Speed	2	0.002285	16.71%	0.002285	0.001142	21838.12	0.000
Feed rate	2	0.005941	43.44%	0.005941	0.002971	56785.30	0.000
Depth of cut	2	0.005451	39.85%	0.005451	0.002725	52097.90	0.000
Error	2	0.000000	0.00%	0.000000	0.000000		
Total	8	0.013677	100.00%				

From ANOVA table no. 6 it was observed that for maximum MRR the feed rate is given maximum contribution for a better result. The percentage contribution for MRR the feed rate 43.44%, depth of cut 39.85% and Spindle Speed 16.71% from the analysis of variance and S/N Ratio.

Table 7: ANOVA results for Surface Roughness

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
Spindle Speed	2	0.242240	28.17%	0.242240	0.121120	645.52	0.002
Feed rate	2	0.324509	37.74%	0.324509	0.162254	864.75	0.001
depth of cut	2	0.292681	34.04%	0.292681	0.146340	779.94	0.001
Error	2	0.000375	0.04%	0.000375	0.000188		
Total	8	0.859805	100.00%				

From ANOVA table no.7 it was observed that for minimum SR the feed rate is given maximum contribution for a better result. The percentage contribution for SR is feed rate 37.74%, depth of cut 34.04% and Spindle Speed 28.17% from the analysis of variance and S/N Ratio.

V. MATHEMATICAL MODEL (REGRESSION ANALYSIS)

Mathematical model has been developed in any machining process to be better resulting output to be machined parameter then other developed model can be used for prediction process control and optimization in order to evaluate the machining parameters of CNC turning process in term of machining performance such as MRR and SR. the regression is carried out stabilized the relation between factors and results while performing the regression analysis it has been assume that factors and the response are linearly relate to each other. Taking into consideration linearity of response, a linear polynomial is equation is filled to experimental results. The response function which represent the MRR and SR can be expressed as given below.

$Y=b_0+b_{1+}\ b_2….$

Here Y = performance output term (MRR/ SR)

b= b_i (i=0,1,2,3,….) are the model constants the value of these constants can be calculated by using nonlinear regression analysis method with the help of Minitab 19 software.

The predict equation is written as:-

A. Regression Equation for MRR

MRR=-35+0.01187SS+57.0FR+32.79DC

Table 8: The coefficient of regression model for MRR

Term	Coef.	SE Coef.	T-Value	P-Value	VIF
Constant	-35.0	11.5	-3.05	0.028	
Spindle Speed	0.01187	0.00545	2.18	0.082	1.00
Feed Rate	57.0	13.6	4.18	0.009	1.00
Depth of Cut	32.79	9.09	3.61	0.015	1.00

B. Regression Equation for SR

SR=2.019-0.000300SS-0.583FR-0.644DC

Table 8: The coefficient of regression model for SR

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	2.019	0.413	4.89	0.005	
Spindle Speed	-0.000300	0.000196	-1.53	0.187	1.00
Feed Rate	-0.583	0.491	-1.19	0.288	1.00
Depth of Cut	-0.644	0.327	-1.97	0.106	1.00

VI. CONCLUSION

This work demonstrates the uses of L_9 orthogonal array (Taguchi method) for optimize the process parameter during turning operation.

A. The effect of process parameter- Spindle Speed (N), feed rate (f) and depth of cut (d) have been analyzed and it has been found that all the factors contribute in obtaining maximum MRR and minimum SR, but feed rate plays an important role out of all three variables.

B. The maximum MRR value (52.90 cm^3/min) and minimum SR value (0.6 µm) declared with 2000 rpm Spindle Speed, 0.6 mm/rev. feed rate and 0.6 mm depth of cut.

C. This paper provides machining parameters to optimize surface roughness and MRR.

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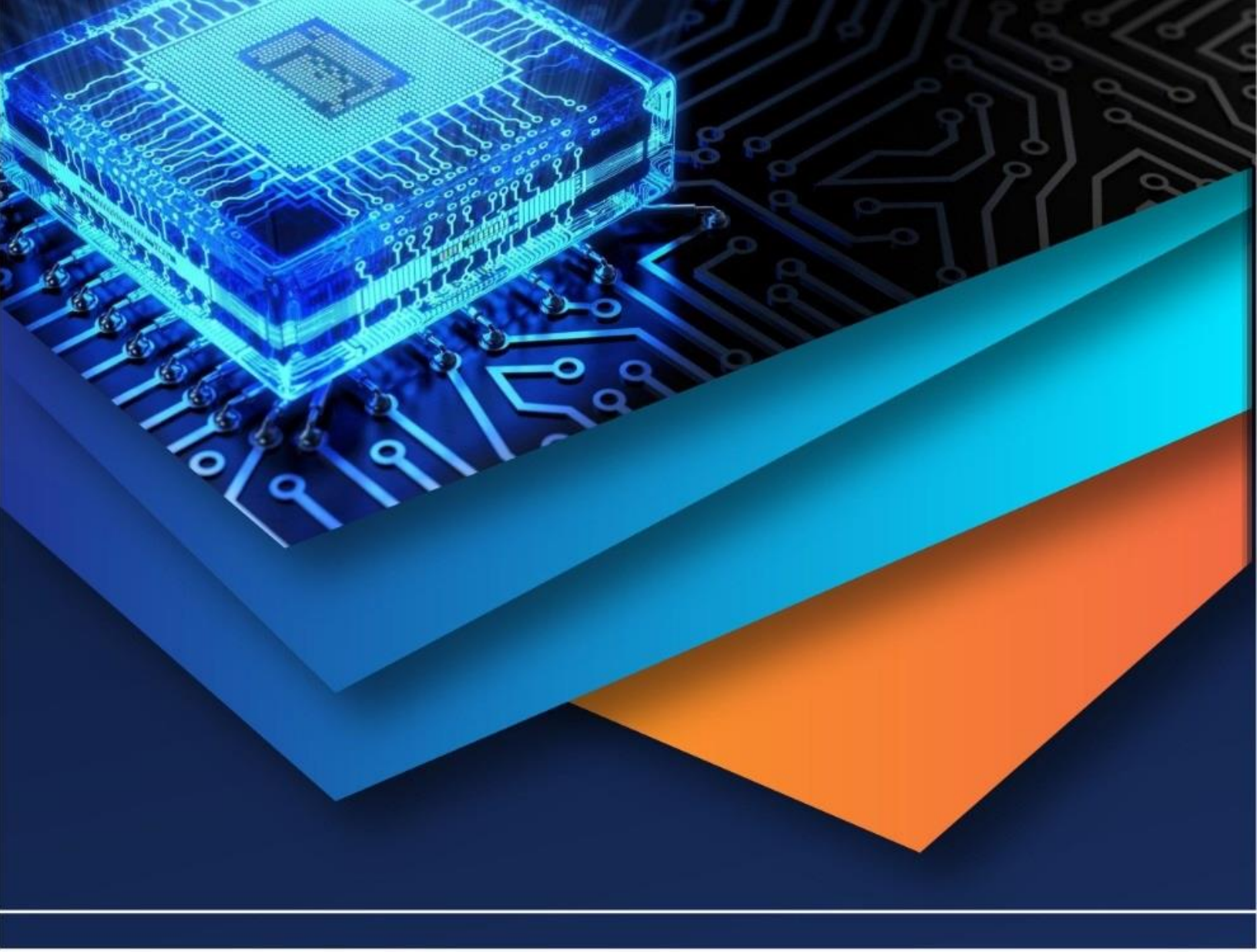

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