"OPTIMIZATION OF TURNING PARAMETERS TO IMPROVE SURFACE ROUGHNES & MRR OF 2024-T3 ALUMINIUM"

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Abstract

Surface roughness determines how a real object interacts with its environment. Rough surfaces usually wear more quickly and have high friction coefficient than smooth surfaces. Roughness is often a good predictor of the performance of mechanical components, since irregularities in the surface may form nucleation sites for cracks or corrosion. Although roughness is usually undesirable, it is difficult and expensive to control in manufacturing. Decreasing the roughness of surface will usually increase its metal cutting costs exponentially. In this work attention is given to investigate, the effect of cutting parameters mainly cutting speed, Feed, Depth of Cut on Surface Roughness and Material Removal Rate in CNC turning operation. The experiments were performed on 2024-T3 Aluminium Using Taguchi method. A three level, three Factor design of experiment prepared according to Taguchi orthogonal array L_9 using Minitab 16 software. The Analysis of Variance (ANOVA) and Signal to Noise (S/N) Ratio was carried to find out the most significant factor and percentage contribution of individual factor for Surface Roughness and Material Removal Rate.

Keywords— *Turning, Production, MRR, Speed, Feed, Depth of cut, etc.*

I. INTRODUCTION

Turning is one of the important operations generally performed on lathe to remove the material from rotating work piece in order to obtain desired size. The machining parameters required for turning are spindle speed, feed rate and depth of cut. All these three parameters have equal importance in describing a material removal rate. In order to understand the behavior of these parameters on MRR author proposed a theory of turning parameters optimization for improved MRR. For experimental work, author selected 2024-T3 aluminum alloy as this alloy is widely used in automotive and industrial application. The nine set of work piece of same size is produced and turning is performed using CNC lathe as a machine tool. During this experimental trials the parameters such as spindle speed, feed rate and depth of cut are varied to have different MRR rate and the optimum values of such parameters is proposed which gives maximum MRR. The following table 1 shows the material properties of 2024-T3 aluminum.

And the figure 1 shows the nine sample of work piece before machining.

Table 1 Material Properties of 2024-T3 Aluminum

Parameter	Value
Density	$2.78e^{-3}$g/mm^3
Poisson's Ratio	0.33
Young's Modulus	73 GPa
Tensile Yield Strength	345 MPa
Fatigue Strength	138 MPa
Shear Strength	283 MPa

II. EXPERIMENTAL ANALYSIS:-

2.1 Selection of Parameters for Machining

The following table 2 shows the values of parameters like spindle speed, feed rate and depth of cut categorized in level 1, 2 and 3 in order to form nine set of parameters which are to be fed to the machine tool.

Parameter	Code	Level 1	Level 2	Level 3
Cutting Speed, S (rpm)	A	800	900	1000
Feed Rate, f (mm/min)	B	80	100	120
Depth of Cut, d (mm)	C	0.5	0.8	1.0

And the table 3 shows the orthogonal array of set of parameters produced by the table 2.

Table 3. Orthogonal Array of Experimental Machining Parameters

Job No.	Spindle Speed (Rpm)	Feed Rate (mm/ min)	Depth of Cut (mm)	Length of Cut (mm)
1	800	80	0.5	25
2	800	100	0.8	
3	800	120	1	
4	900	80	0.8	
5	900	100	1	
6	900	120	0.5	
7	1000	80	1	
8	1000	100	0.5	
9	1000	120	0.8	

Once the parameters are evaluate then the work piece are directly fed to the CNC machine tool to measure the MRR using the listed parameters. To measure the MRR it is necessary to measure the weight of work piece before and after machining. The figure 2 shows the nine work piece after machining.

Figure 2. Work Piece Sample After Machining

III. MRR & SURFACE ROUGHNESS MEASUREMENT

After collecting the machined work piece and the machining data including machining time, the weight of the work piece is measured and tabulated in table 4 to have the material removal rate (MRR).

Table 4. MRR of Nine Work Piece

Sr. No	Run	Weight Before Machining(gm)	Weight After Machining(gm)	Machining Time(min)	MRR (mm3/ min)
1	1	106.553	103.258	2.083	598.67
2	2	106.071	102.258	1.8	784.57
3	3	106.818	98.132	1.1	2924.58
4	4	106.576	100.861	2.35	900.71
5	5	106.810	98.975	0.516	5623.74
6	6	106.745	105.040	0.483	1307.42
7	7	106.750	98.995	0.416	6904.38
8	8	106.965	102.427	0.416	3149.93
9	9	106.769	100.246	0.333	7255.03

Table 5. Surface Roughness Measurement

Sr.No	Run	Factor 1 Cutting Speed (rpm)	Factor 2 Feed (mm/min)	Factor 3 Depth of Cut (mm)	Response 1 Surface Roughness (μ_m)
1	1	800	80	0.5	1.874
2	2	800	100	0.8	1.600
3	3	800	120	1.0	1.853
4	4	900	80	0.8	2.465
5	5	900	100	1.0	2.512
6	6	900	120	0.5	2.755
7	7	1000	80	1.0	2.602
8	8	1000	100	0.5	2.822
9	9	1000	120	0.8	2.973

III RESULTS & DISCUSSION

3.1Analysis of Surface Roughness

3.1.1S/N Ratio for Surface Roughness

The Signal to Noise (S/N) Ratio for Surface roughness is calculated by using Smaller the Better characteristic.

Smaller the better,

$$\text{S/N Ratio} = -10\log \left[\frac{1}{n} \sum_{i=1}^{n} (Y_i^2) \right]$$

Table 6. S/N ratio for Surface Roughness

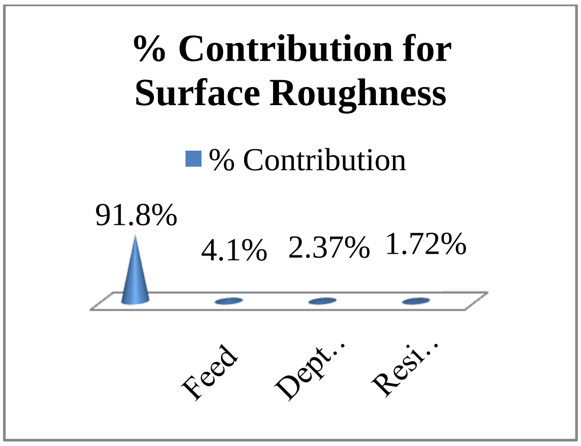
Sr.No	Run	Factor 1 Cutting Speed (rpm)	Factor 2 Feed (mm/rev)	Factor 3 Depth of Cut (mm)	S/N Ratio Surface Roughness
1	1	800	80	0.5	-5.455
2	2	800	100	0.8	-4.082
3	3	800	120	1.0	-5.357
4	4	900	80	0.8	-7.836
5	5	900	100	1.0	-8.000
6	6	900	120	0.5	-8.802
7	7	1000	80	1.0	-8.306
8	8	1000	100	0.5	-9.011
9	9	1000	120	0.8	-9.464

3.1.2 Coefficient for S/N Ratio

Table 7. Estimated Model Coefficients for S/N ratios

Sr.No	Term	Coef	SE Coef	T	P
1	Constant	-7.368	0.167	-44.076	0.001
2	CS 800	2.403	0.236	10.165	0.010
3	CS 900	-0.844	0.236	-3.573	0.070
4	F 80	0.169	0.2364	0.715	0.549
5	F 120	0.337	0.2364	1.426	0.290
6	DOC 0.5	-0.387	0.2364	-1.641	0.243
7	DOC 0.8	0.240	0.2364	1.019	0.415

S = 0.5015 R-Sq = 98.3% R-Sq(adj) = 93.1%



3.2 Analysis of Material Removal Rate (MRR)

3.2.1 S/N Ratio for Material Removal Rate

The Signal to Noise (S/N) Ratio for Material removal rate is calculated by using Larger the Better characteristic.

Larger the better,

$$\text{S/N Ratio} = -10\log \left[\frac{1}{n} \sum_{i=1}^{n} \left(\frac{1}{\text{Yi2}} \right) \right]$$

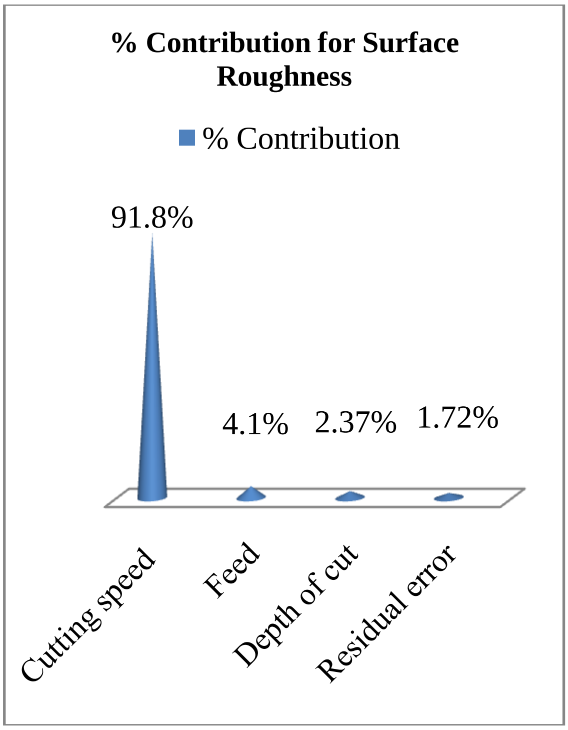
Table 8 S/N ratio for Material Removal Rate

Sr. No	Run	Factor 1 Cutting Speed (rpm)	Factor 2 Feed (mm/rev)	Factor 3 Depth of Cut (mm)	S/N Ratio MRR
1	1	800	80	0.5	55.543
2	2	800	100	0.8	57.892
3	3	800	120	1.0	69.321
4	4	900	80	0.8	60.848
5	5	900	100	1.0	75.000
6	6	900	120	0.5	68.196
7	7	1000	80	1.0	76.782
8	8	1000	100	0.5	69.966
9	9	1000	120	0.8	77.212

3.2.2 Coefficient for S/N Ratio

Sr No	Term	Coef	SE Coef	T	P
1	Constant	67.862	0.7430	91.332	0.000
2	CS 800	-6.943	1.0508	-6.608	0.022
3	CS 900	0.152	1.0508	0.145	0.898
4	F 80	-3.471	1.0508	-3.303	0.081
5	F 120	-0.242	1.0508	-0.231	0.839
6	DOC 0.5	-3.294	1.0508	-3.135	0.088
7	DOC 0.8	-2.544	1.0508	2.422	0.136

S = 2.229 R-Sq = 98.1% R-Sq(adj) = 92.4%



IV. CONCLUSION

4.1 Optimum Machining Parameters

After performing the statistical analysis on the experimental data, it has been observed that there is one particular level for each factor for which the responses are either minimum (in case of Surface roughness) or maximum (in case of MRR). The combination of input factor levels, for which optimum settings will be obtained, is given in Table 6.9.

Table 10 Optimal Parameters Setting for Input Factors

Sr. No	Physical Requirement	Cutting Speed (m/min)	Feed (mm/min)	Depth of Cut (mm)
1	Minimum Surface Roughness	800	100	0.8
2	Maximum Material Removal Rate	1000	120	1.0

ISBN: 978-93-88441-69-8

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