VALIDATE THE OPTIMUM TURNING PROCESS PARAMETER ON ALUMINIUM ALLOY 6061 FOR SURFACE ROUGHNESS AND MRR

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Abstract: This examine discusses an investigation to validate the optimum turning process parameters on Aluminium Alloy 6061 for Surface Roughness and material Removal Rate (MRR). Turning process parameter included spindle speed, feed rate, depth of cut, tool nose radius and cutting condition. A total number of 27 experiment runs were conducted with an orthogonal array, and the ideal mixture of cutting parameter levels. In this study cutting conditions are used to comparison, which condition is best for Surface Roughness and MRR. After validation shows that MRR is influenced by tool nose radius and also shows that Surface Roughness is also influenced by spindle speed.

***Key Words* – CNC Turning Process, Tool Nose Radius, Cutting Condition, Taguchi Method, Validation.**

I. INTRODUCTION

Turning operation is one kind of material removal process in which work piece or tool rotated and among of them one is stationary or axially moved and other is rotated at a time. Turning operation is shown in figure 1. This figure shows the work piece is rotated and tool is axially moved to the work piece to remove the excess metal from the work piece and determined desired output. In past conventional lathe is used to perform the turning operation to get required output. But it is long time consuming process and other draw back also such as surface finish is poor than non conventional lath, to overcome this problem used computer numerical control lathe, in this machine turning operation are speedy as compare to the conventional lathe and give better surface finish as compare conventional[1]. But this type of machine required trial and error method to find the cutting parameter value which can give best output. Many parameter are affect the turning process among of them Feed Rate, Depth of Cut and Spindle Speed generally taken.

Optimization of turning process can be completed by various optimization techniques. Here Taguchi method is used to optimize the turning process. Taguchi technique includes an orthogonal array for experimental work. Thus the combination of DOE with optimization of control parameters to acquire finest outcome is achieved in the Taguchi technique [2]. Dr. Taguchi has developed a method to achieve desirable product quality and also help to overcome the experimental work and overcome the consumable time. He recommends a three stage process 1) system Design, 2) parameter design, 3) tolerance design. In system design prototype development are included. In process and tolerance design consist to define numerical value of the input parameter and state the target value and tolerance range around the target which is defined by the technical person to get required output. This method is also used to determine the optimum values of the process parameter. He also found three basic concept 1) quality of the product should be improve at the beginning stage. 2) To minimize the deviation from target value for achieving the best quality of the product. 3) In deviation function also consist the quality cost and should be measured & losses should be measured system. This method included orthogonal array, use of this array makes the experiment very easy and consist.

After the optimum parameter is determined to require the complete analysis, he suggested two rout to carry out analysis. First one ANOVA analysis and second is signal to noise ratio. For this study smaller the better and larger the best S/N ratio is used to find out the influence of the process parameter on Surface Roughness and MRR respectively [3].

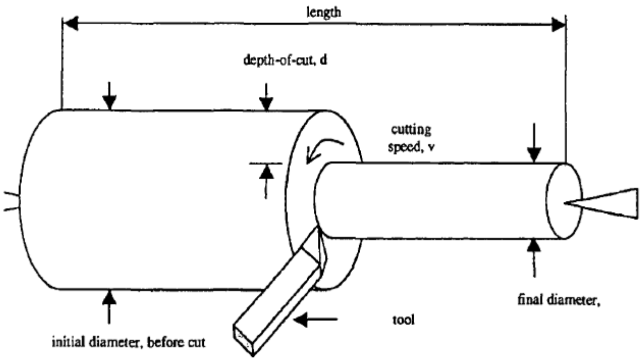

Figure: 1 Turning Process

II. Experimental work

Taguchi has developed this method to achieve best product quality. Taguchi define steps to perform this method, First of all define the process parameter and their level & response parameter, second define experiment of design, third perform the experiment, forth one data collection and last analysis of the collected data and conclusion. Level of the process parameters are shown in the table 1and table 2 shows the design of experiment which can be used to performed the experiment.

Table 1: Level of Process Parameter

Parameter	Code	Level1	Level2	Level3
Spindle Speed (rpm)	P	1000	1500	2000
Feed Rate (mm/rev)	Q	0.05	0.1	0.15
Depth of Cut (mm)	R	0.2	0.4	0.6
Tool Nose Radius (mm)	S	0.4	0.8	1.2

Table 2: Orthogonal Array (L_{27})

Experiment No	P	Q	R	S
1	1000	0.05	0.2	0.4
2	1000	0.05	0.4	0.8
3	1000	0.05	0.6	1.2
4	1000	0.10	0.2	0.8
5	1000	0.10	0.4	1.2
6	1000	0.10	0.6	0.4
7	1000	0.15	0.2	1.2
8	1000	0.15	0.4	0.4
9	1000	0.15	0.6	0.8
10	1500	0.05	0.2	0.4
11	1500	0.05	0.4	0.8
12	1500	0.05	0.6	1.2
13	1500	0.10	0.2	0.8
14	1500	0.10	0.4	1.2
15	1500	0.10	0.6	0.4
16	1500	0.15	0.2	1.2
17	1500	0.15	0.4	0.4
18	1500	0.15	0.6	0.8
19	2000	0.05	0.2	0.4
20	2000	0.05	0.4	0.8
21	2000	0.05	0.6	1.2
22	2000	0.10	0.2	0.8
23	2000	0.10	0.4	1.2
24	2000	0.10	0.6	0.4
25	2000	0.15	0.2	1.2
26	2000	0.15	0.4	0.4
27	2000	0.15	0.6	0.8

III. Experimental Set Up

For this study material Aluminium Alloy 6061 is used to optimize the process parameter of MRR and Surface Roughness. The material diameter is 25mm and length of the work piece is 50mm which is shown in figure 2 and material composition is given in table 3. To perform the experiments Jyoti CNC Dx 200 was used which is shown in figure 3. To calculate the Surface roughness Mahr Federal Pocket Surf mobile Surface Roughness tester is used which is shown in figure 4 and for calculating the MRR weight scale is used which is shown in figure 5.

Table 3: Chemical Composition of al6061

Material	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Al
%	0.4-0.8	0.7	0.15-0.4	0.15	0.8-1.2	0.04-0.35	0.25	0.15	Remainder

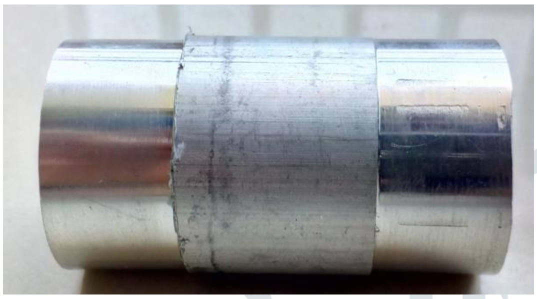

Figure: 2 Work Piece

Figure: 3 CNC Machine

Figure: 4 Roughness Tester

Figure: 5 Weight Scale

IV. RESULT AND DISCUSSION

After the experiment, data is collected based on the SN ratio larger is better and smaller is better and doing complete analysis for the Surface Roughness and MRR which is shown in below table 4. This analysis is usefully to define the influence of the process parameter. Cutting condition is not affect the MRR but it is affecting on Surface roughness. In dry cutting condition, achieve better surface finish with compare the wet cutting condition. The most significant parameter for MRR is tool nose radius following feed rate. Spindle speed and depth of cut are less significant and for Surface Roughness feed rate is most significant parameter following tool nose radius. Spindle speed and depth of cut are less significant. Cutting Conditions are not significant for Material Removal Rate but significant for Surface Roughness, dry cutting condition is better than wet cutting condition. Spindle speed and Depth of cut is less significant parameter for both MRR and Surface Roughness in both Condition Feed rate is more significant parameter following tool nose radius for the Surface Roughness. Tool nose radius is more significant parameter following feed rate for the material Removal Rate.

Table 4: Experimental Results

Experiment No	Control Factors				Dry Condition		Wet Condition	
	P	Q	R	S	MRR (gm/sec)	Ra (μm)	MRR (gm/sec)	Ra (μm)
1	1000	0.05	0.2	0.4	0.115	0.60	0.115	0.90
2	1000	0.05	0.4	0.8	0.077	0.60	0.077	0.70

3	1000	0.05	0.6	1.2	0.182	0.32	0.182	0.36
4	1000	0.10	0.2	0.8	0.071	0.50	0.071	0.70
5	1000	0.10	0.4	1.2	0.231	0.38	0.308	0.41
6	1000	0.10	0.6	0.4	0.143	0.90	0.143	0.70
7	1000	0.15	0.2	1.2	0.349	0.63	0.300	0.63
8	1000	0.15	0.4	0.4	0.182	1.75	0.182	1.75
9	1000	0.15	0.6	0.8	0.182	0.90	0.182	0.90
10	1500	0.05	0.2	0.4	0.100	0.30	0.100	0.40
11	1500	0.05	0.4	0.8	0.100	0.74	0.100	0.76
12	1500	0.05	0.6	1.2	0.188	0.18	0.188	0.19
13	1500	0.10	0.2	0.8	0.167	0.80	0.167	0.89
14	1500	0.10	0.4	1.2	0.300	0.33	0.300	0.35
15	1500	0.10	0.6	0.4	0.167	0.94	0.167	0.85
16	1500	0.15	0.2	1.2	0.317	0.63	0.375	0.59
17	1500	0.15	0.4	0.4	0.111	1.76	0.111	1.71
18	1500	0.15	0.6	0.8	0.222	0.93	0.222	0.89
19	2000	0.05	0.2	0.4	0.176	0.38	0.176	0.26
20	2000	0.05	0.4	0.8	0.176	0.32	0.176	0.35
21	2000	0.05	0.6	1.2	0.278	0.15	0.308	0.18
22	2000	0.10	0.2	0.8	0.182	0.52	0.182	0.72
23	2000	0.10	0.4	1.2	0.331	0.36	0.331	0.39
24	2000	0.10	0.6	0.4	0.182	0.89	0.182	0.86
25	2000	0.15	0.2	1.2	0.286	0.69	0.429	0.69
26	2000	0.15	0.4	0.4	0.222	1.70	0.222	1.70
27	2000	0.15	0.6	0.8	0.222	0.94	0.222	1.05

V. VALIDATION

Validation is define as the process of establishing documentary evidence demonstrating that a procedure, process, or activity carried out in testing and then production maintains the desired level of compliance at all stages. Table 5 shows the result of actual and theoretical comparison. Theoretical MRR and Surface Roughness are calculated as per below the equation & actual value was taken from the experimentation data and compare it.

$$MRR = vfd \; cc/min$$

$$Ra = \frac{f^2}{32\,r} \quad mm$$

Where; v = cutting speed m/min

f = feed rate mm/rev

d = depth of cut mm

r = tool nose radius mm

Ra = Surface roughness value mm

Table 5 shows the result of validation from that the optimum process parameters for Material Removal Rate are spindle speed 2000 rpm, feed 0.15 mm/rev, depth of cut is 0.2mm, and tool nose radius is 1.2mm and MRR is 0.429 gm/sec in actual &

theoretical is 0.636 gm/sec. The optimum parameter for Surface Roughness 2000 rpm spindle speed, 0.05 mm/rev feed rate, 1.2 mm nose radius and 0.6 mm depth of cut and Ra is 0.15 µm and theoretical 0.07 µm. Mean effect plot for SN ration was shown in figure 6 & 7 for theoretical MRR and actual MRR respectively. Mean effect plot for SN ratio was shown in figure 8 & 9 for theoretical Surface roughness and actual surface roughness respectively

Table 5: Validation Result

Experiment No	Control Factors				MRR (gm/sec) (wet)		Ra (µm) (Dry)	
	P	Q	R	S	Actual	Theoretical	Actual	Theoretical
1	1000	0.05	0.2	0.4	0.115	0.035	0.60	0.20
2	1000	0.05	0.4	0.8	0.077	0.071	0.60	0.10
3	1000	0.05	0.6	1.2	0.182	0.106	0.32	0.07
4	1000	0.10	0.2	0.8	0.071	0.071	0.50	0.39
5	1000	0.10	0.4	1.2	0.308	0.141	0.38	0.26
6	1000	0.10	0.6	0.4	0.143	0.212	0.90	0.78
7	1000	0.15	0.2	1.2	0.300	0.106	0.63	0.59
8	1000	0.15	0.4	0.4	0.182	0.212	1.75	1.76
9	1000	0.15	0.6	0.8	0.182	0.318	0.90	0.88
10	1500	0.05	0.2	0.4	0.100	0.053	0.30	0.20
11	1500	0.05	0.4	0.8	0.100	0.106	0.74	0.10
12	1500	0.05	0.6	1.2	0.188	0.159	0.18	0.07
13	1500	0.10	0.2	0.8	0.167	0.106	0.80	0.39
14	1500	0.10	0.4	1.2	0.300	0.212	0.33	0.26
15	1500	0.10	0.6	0.4	0.167	0.318	0.94	0.78
16	1500	0.15	0.2	1.2	0.375	0.159	0.63	0.59
17	1500	0.15	0.4	0.4	0.111	0.318	1.76	1.76
18	1500	0.15	0.6	0.8	0.222	0.477	0.93	0.88
19	2000	0.05	0.2	0.4	0.176	0.071	0.38	0.20
20	2000	0.05	0.4	0.8	0.176	0.141	0.32	0.10
21	2000	0.05	0.6	1.2	0.308	0.212	0.15	0.07
22	2000	0.10	0.2	0.8	0.182	0.141	0.52	0.39
23	2000	0.10	0.4	1.2	0.331	0.283	0.36	0.26
24	2000	0.10	0.6	0.4	0.182	0.424	0.89	0.78
25	2000	0.15	0.2	1.2	0.429	0.212	0.69	0.59
26	2000	0.15	0.4	0.4	0.222	0.424	1.70	1.76
27	2000	0.15	0.6	0.8	0.222	0.636	0.94	0.88

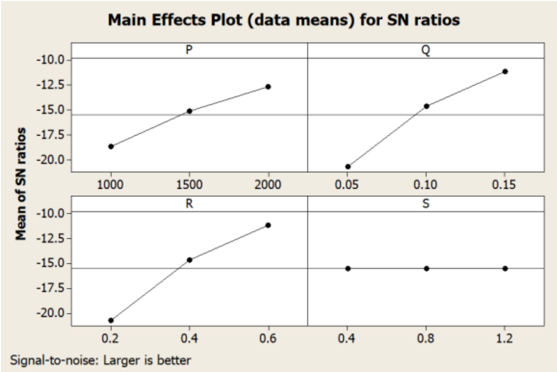

Fig 6: Main Effect Plot for SN Ration (Theoretical)

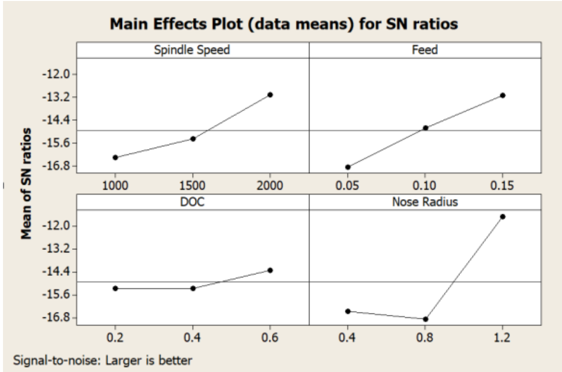

Fig 7: Main Effect Plot for SN Ration (Actual)

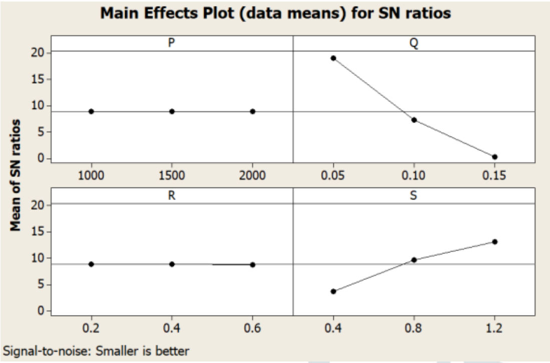

Fig 8: Main Effect Plot for SN Ration (Theoretical)

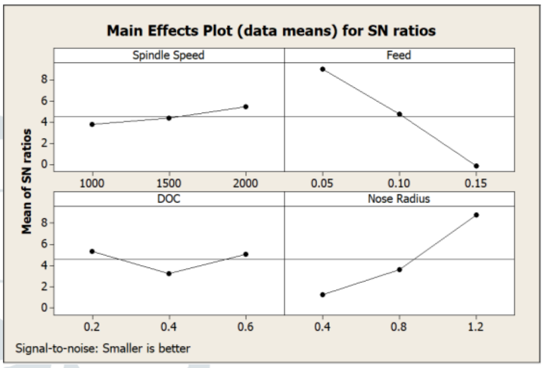

Fig 9: Main Effect Plot for SN Ration (Actual)

VI. CONCLUSION

This study shows that the actual data was completely different form the theoretical data which is shown in table 5. In MRR theoretical graph can be demonstrate that the influence of the nose radius is not significant but in actual it is significant. In surface roughness theoretical graph can be demonstrate that the influence of spindle speed and depth of cut are not significant but in actual manner both are significant. Hence it can be show that tool nose radius has some influence on MRR and speed & depth of cut have influence on surface roughness.

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