ANALYSIS OF SURFACE ROUGHNESS DURING TURNING OPERATION OF ALUMINIUM-6063 USING TAGUCHI APPROACH

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ABSTRACT

In any machining process, apart from obtaining the accurate dimensions, achieving a good surface quality is also desirable. A machining process involves many process parameters which directly or indirectly influence the surface roughness of the product in common. Surface roughness may be influenced due to various parameters involved in the operation. This study aims at analysis of cutting parameters spindle speed, feed, depth of cut in CNC machine of Aluminium 6063. An L_{27} orthogonal array is used to study the analysis of variance (ANOVA) and the signal-to-noise (S/N) ratio. This paper discusses the use of Taguchi's technique for minimizing required surface roughness in machining Aluminium Alloy 6063. Experiments were conducted based on the established Taguchi's technique L_{27}orthogonal array and Minitab-16 statistical software is used to generate the array. Optimal values of process parameters for desired performance characteristics are obtained by Taguchi design of experiment. The mathematical model is also obtained as a result of regression analysis can be reliable to predict surface roughness Ra.

I. INTRODUCTION

In this developing era of engineering optimum operating conditions are required for the every developing country. In conventional machining processes turning is the most widely used among all the cutting processes. In this process parts of round shape are produce by a single point tool on lathes. The tool is fed either parallel linear in the direction or perpendicular to the axis of in which workpiece rotating, or along to specified path for producing complex rotational shapes. The rotation of the workpiece considered as primary motion in turning and is the, and feed motion is considered as the secondary motion of cutting. The desired quality of the product is one of the most desirable output. Surface finish has been considered a method to measure the quality of product and also an important parameter of machining process. It is one of the prime requirements of customer for machined parts. For any production it is necessary to fulfill the demand of end user. To achieve desire quality of product and productivity should be high. In order to achieve these desired performance measures in any machining operation, proper selections of machining parameters is essential.

Taguchi method is statistical method developed by Professor Genichi for the production of robust products. According to Taguchi, quality of a manufactured product has total loss generated by that product to society from the time has shipped. Taguchi developed a method based on orthogonal array experiments, which reduced "variance" for the experiment with "optimum settings" of control parameters. Thus the combination of Design of Experiments (DOE) with optimization of control parameters to obtain best results have achieved in the

Taguchi Method. Signal to noise (S/N), ratio and orthogonal array are two major tools used in robust design. Signal to noise ratio, which are log functions of desired output measures quality with emphasis on variation, and orthogonal arrays, provide a set of well-balanced experiments to accommodate many design factors simultaneously.

The objective of this work is to obtain the optimum process parameters spindle speed, feed and depth of cut used in CNC machining on Aluminum 6063 workpiece. The optimal parametric combination using signal to noise ratio have been found.

II. EXPERIMENTAL DETAILS

2.1. Work Material

The turning of Aluminium 6063 was done during designed experiments .Aluminium has good machining characteristics such as light weight and good surface finish can be achieved. Table-1 gives the mechanical properties and composition of Aluminium 6063.

Table 1: Chemical Composition and Mechanical Properties of Aluminium-6063

Chemical		Mechanical Properties	
Component	Amount (wt. %)		
Aluminum	97.5	Ultimate Tensile strength (Mpa)	241
Magnesium	0.45-0.9	0.2% Proof Stress (MPa)	240-276
Silicon	0.2 – 0.6	Brinell Hardness (500g load, 10mm ball)	73
Iron	Max. 0.35	Elongation 50mm dia (%)	9-13
Copper	Max 0.1	Density: g/cm^3	2.7
Zinc	Max. 0.1	Melting Point: Approx	616-654°C
Titanium	Max. 0.15	Modulus of Elasticity:	68.9 GPa
Manganese	Max. 0.1	Poissons Ratio	0.33
Chromium	0.1	Co-Efficient of Thermal Expansion (20-300°C) m/min.°C	23.5x10-6
Others	0.05	Thermal Conductivity W/m.K	200

2.2 Physical Properties

- Density: 2.7 g/cm^3
- bbMelting Point: Approx 616-654°C
- Modulus of Elasticity: 68.9 GPa
- Poissons Ratio: 0.33

2.3. Process Variables and There Parameters

In this study, cutting experiments are planned using Taguchi design of experiments approach. Cutting experiments are conducted considering three cutting parameters: spindle speed (rpm), Feed rate (mm/rev), Depth of Cut (mm) and Overall 27 experiments were carried out. More number of experiments were chosen to determine the effect of interaction. Following table indicates the values of various parameters used for experiments:

Table 2: Input Variables

Parameters and their symbols	1	2	3
A: Spindle Speed (X1, rpm)	1500	2500	3500
B: Feed (X2, mm/rev)	0.15	0.25	0.35
C: Depth of cut (X3, mm)	0.1	0.3	0.6

2.4. Output Variable

This experimental study was carried out to investigate the effect of process parameters (input variables) surface roughness (output).

2.5. CNC Lathe Machine Specifications

Type- Jobber XLCNC Lathe

Controller-Fanuc

Spindle Power-400V, 3.4Amp

Speed Range- 50-4500 Rpm

Insert spe 7cification- CNMG 120408 EN-TM

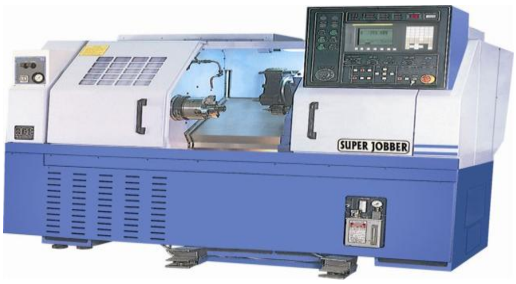

Figure 1: CNC Experimental setup

Figure 2: Picture of machined workpiece

2.6 Experimental Conditions

After design of experiment the CNC machine was prepared for experimentation the experimental conditions are given below in table-3.

Table 3:Experimental Conditions for Turning.

Workpiece material	Aluminum 6063 (T6)
Insert designation	CNMG 120408 EN- TM (H20TI)
Spindle speed (rpm)	1500,2500,3500
Feed(mm/rev)	0.15,0.25,0.35
Depth of cut(mm)	0.1,0.3,0.6
Environment	Dry

III. DESIGN OF EXPERIMENT AND EXPERIMENTAL PLANNING

3.1 Orthogonal Array Selection

An orthogonal array has been selected using Taguchi orthogonal array selection technique. The orthogonal array selected should have greater degree of freedom as compare to degree of freedom required. In this analysis an interaction analysis was also done to get the significance of interaction of two variables on output. So L_{27} was selected as design of experiment.

3.2 Experimentation and Process Followed

To perform experimentation 27 pieces were cut from an Aluminium 6063 rod each of length 55 mm. Then the naming of sample was done according to design of experiments. The prepared samples were machined using CNC machine. The machining time in each sample turning case was noted carefully. After completion of machining the surface roughness was measured usingMitutoyo SJ-201P surface tester. An analysis of S/N Ratio and ANOVA was performed using MINITAB 16.

IV. RESULTS

A series of experiments have been carried out with variation of different parameters. After completing the experiments according to design of experiment a statistical analysis was done for the experimental data obtained which are shown in table from the L_{27} experiments. The average performance and S/N ratio were calculated for surface roughness. Analysis of variance (ANOVA) was performed to identify the most significant control parameter and to quantify their effects on surface roughness.

Table 4: Surface Roughness and S/N ratio according to Design of Experiment

Speed (rpm)	Feed (mm/rev)	Depth of Cut (mm)	Ra (µm)	S/N Ratio
1500	0.15	0.1	2.4954	-7.9428
1500	0.15	0.3	1.0507	-0.4296
1500	0.15	0.6	1.1099	-0.9057
1500	0.25	0.1	2.4307	-7.7146
1500	0.25	0.3	2.4440	-7.7620
1500	0.25	0.6	2.4327	-7.7218
1500	0.35	0.1	4.1620	-12.3860
1500	0.35	0.3	4.2046	-12.4745
1500	0.35	0.6	1.0907	-6.5800
2500	0.15	0.1	1.4533	-3.2471
2500	0.15	0.3	1.3452	-2.5757
2500	0.15	0.6	1.4678	-3.3333
2500	0.25	0.1	2.5976	-8.2914
2500	0.25	0.3	2.8151	-8.9899
2500	0.25	0.6	2.9234	-9.3178
2500	0.35	0.1	2.8042	-8.9562
2500	0.35	0.3	2.9378	-9.3604

2500	0.35	0.6	2.8125	-8.9819
3500	0.15	0.1	1.1039	-0.8586
3500	0.15	0.3	1.5186	-3.6289
3500	0.15	0.6	1.2072	-1.6356
3500	0.25	0.1	0.9787	0.1870
3500	0.25	0.3	3.0095	-9.5699
3500	0.25	0.6	4.8894	-13.7851
3500	0.35	0.1	4.7984	-13.6219
3500	0.35	0.3	4.8763	-13.7618
3500	0.35	0.6	4.7394	-13.5145

Table 5: ANOVA for surface roughness

Source	DOF	Seq SS	Adj SS	Adj MS	F	P	% contribution
Speed	2	2.9651	2.6682	1.3341	2.71	0.126	6.66376
Feed	2	22.6838	21.1463	10.57315	21.48	0.001	50.97953
Doc	2	0.1115	0.1067	0.05335	0.11	0.899	0.250585
speed*feed	4	7.4175	5.6740	1.4185	2.88	0.095	16.67008
speed*doc	4	3.2074	3.6386	0.90965	1.85	0.213	7.208305
feed*doc	4	4.1731	4.1731	1.043275	2.12	0.170	9.378617
Error	8	3.9375	3.9375	0.492188			8.84913
Total	26	44.4959					100.00

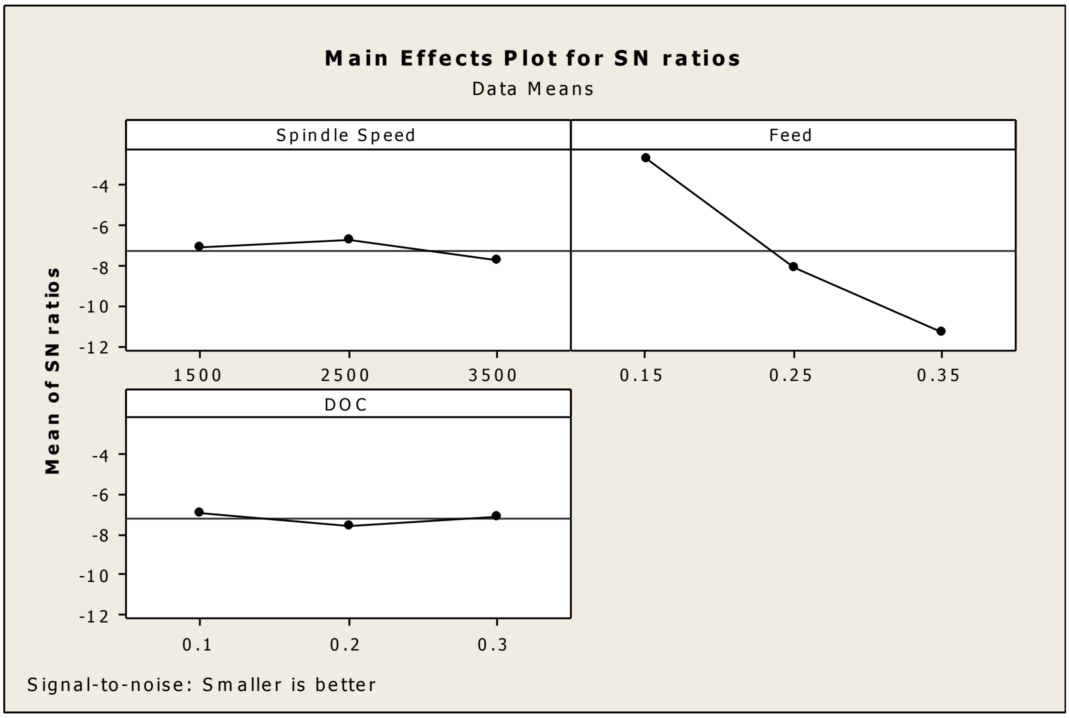

Figure 3: S/N Response Graphs for Surface Roughness

V. MATHEMATICAL MODEL AND COMPARISON GRAPH FOR SURFACE ROUGHNESS

The mathematical model is developed by means of multiple linear regression analysis for optimal selection of machining parameters for minimum surface roughness during machining of Aluminium-6063. Equation (1) shows the mathematical model obtained from the multiple regression analysis.

Y_{Ra} = 5.51057 - 0.00462022 X_1+ 13.6935 X_2- 3.78549 X_3+ 6.3209e-007 X_1^2- 24.8125 $X_2^{\ 2}$ - 3.109 X_3^2 + 0.0037233 $X_1 \times X_2$ + 0.00231777 $X_1 \times X_3$ --------------------------------------(1)

Where, X_1 = Speed (rpm) , X_2 = Feed (mm/rev) andX_3= Depth of Cut (mm)

Figure 4 shows the graphical representation of the mathematical model(6.2) and experimental results obtained from 27 sets of experimental investigation. From the figure, it is concluded that the mathematical modelhas a good agreement with the experimental values.

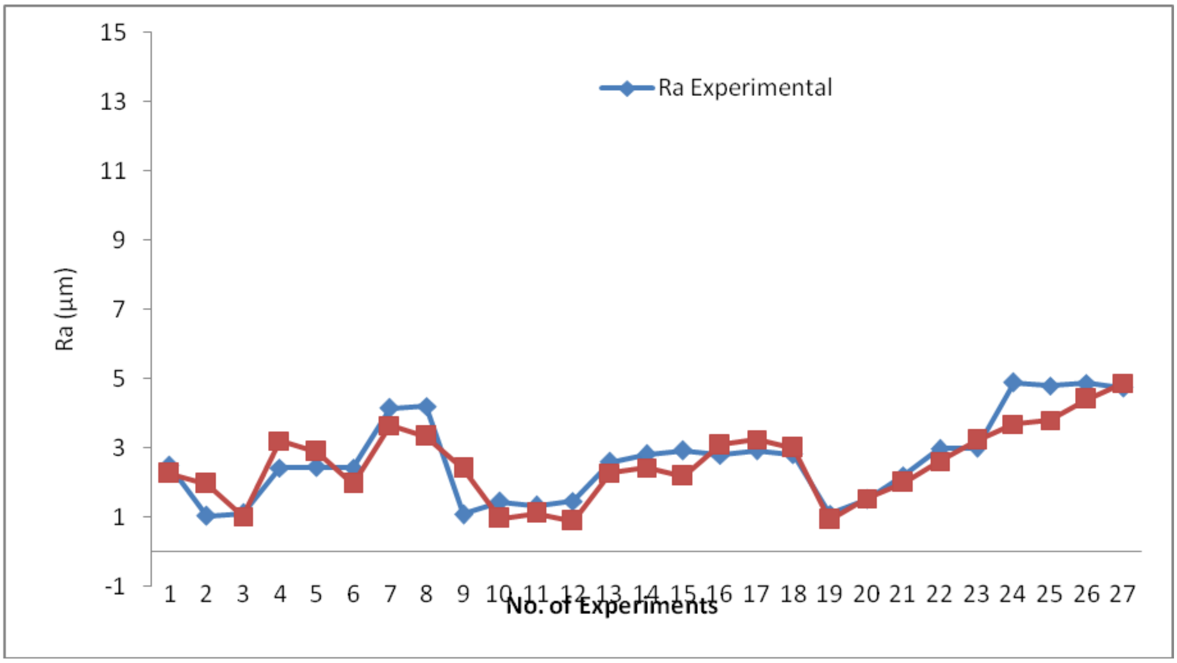

Fig. 4 Comparison of Surface Roughness for Aluminum 6063 by Experiment and Mathematical Model

VI. CONCLUSION

On the basis of the experimental results during machining on Aluminium 6063 utilizing the CNC machine and thereafter discussion on the investigated results, the following conclusions are drawn as listed below.

(1) The feed has a most significant effect on surface roughness with 50.97 % contribution. The contribution of speed on surface roughness is 6.67 %.

(2) Interaction also has significant effect on roughness as the contribution of speed and feed is 16.67%, contribution of speed and depth of cut is 7.21% and contribution of feed and depth of cut is 9.37%.

(3) For minimum surface roughness , the optimal parametric combination is $A_2B_1C_1$ i.e. material removal rate is maximum at the parametric combination of 2500 rpm spindle speed, .15 mm/rev feed and 0.1 mm depth of cut.

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