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Performance analysis of surface roughness in al alloy using different cutting parameters

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Abstract

The Quality and productivity play very important role in manufacturing technology. The quality of any product influences the extent or degree of satisfaction of the shoppers throughout its usage & therefore quality becomes a significant concern for every manufacturing unit. Today's manufacturing business should manufacture product among lesser time with no compromise shown on quality; thus on tackle these a pair of totally different criteria; it's a necessity to examine the quality level of the merchandise either offline or on-line. In associate passing manufacturing unit, one of customers most like demand is surface roughness that's associate indicator of the surface quality. Throughout this gift work associate offline estimation of surface roughness and its variation with reference to projectile cutting parameters in turning of element alloy is applied. Taguchi DOE and ANOVA unit of measurement used for locating out the foremost acceptable cutting parameters for minimizing surface roughness. This paper shows the impact of machining parameters on surface roughness throughout step turning of Al alloy with inorganic compound tools underneath dry conditions. Experimental setup determined by victimization Taguchi style methodology. The assorted machining parameter combination was non in heritable by victimization quantitative relation signal/noise (S/N) ratio analysis. In keeping with the experimental results, surface roughness enlarged with a rise in feed rate, whereas small with increase in cutting speed. Optimum machining conditions for the surface roughness (Ra) were obtained by victimization the L9 orthogonal array and analysis of variance.

Keywords: Al Alloy, Step turning, Surface Roughness, Taguchi methodology, Anova

1. Introduction

CNC Turning is that the one among the foremost wide used machine for manufacturing rounded form work piece in shorter time at affordable prize with smart surface end. Metallic element is widely accustomed manufacture the elements of the vehicles by turning method due its light-weight weight. It's extremely desired that product having smart surface quality area unit factory-made in short time. The surface quality of product is usually determined in terms of the measured surface roughness. Surface roughness usually depend upon the cutting parameters such as: cutting speed, feed rate and depth of cut. Proper choice of the management factors for the experiment is very important so as to supply the parts with smart surface end and high tolerance in brief time. Within the previous few decades, lots of labor has been dole out to boost the standard of the merchandise and potency in machining. Still varied aspects associated with this paper area unit however to be explored. Ravindra Thamma [1] has found completely different models to obtain optimal machining parameters for needed surface roughness for an aluminium 6061 work items. He complete that Spindle speed, feed rate, and nose radius have significant control factors for surface roughness. Sander surfaces will be created once machined with a bigger spindle speed, smaller feed rate, and nose radius Depth of cut has a significant influence on surface roughness. H. M. Somashekara *et al*. [2] used management factors e.g. cutting speed, feed rate and depth of move optimize Surface Roughness. While machining Al 6351-T6 alloy with uncoated Carbide tool. They used Taguchi Technique to optimize the process parameters and confirmation take a look at were additionally performed for locating main factors influencing Surface Roughness. They complete that Speed includes a larger influence on the Surface Roughness. Gaurav Vohra *et al*. [3] have optimized the machining parameters for boring of aluminium material on CNC turning centre e.g. cutting speed, feed rate and depth of cut, to get optimum material removal rate and minimum surface roughness by exploitation the Taguchi - method.

II. Research Methodology

In this study, performance analysis of the machining parameters using Taguchi design by step turning of Al Alloy under dry cutting condition with carbide tipped tools was investigated. The standard grade for the cutting tool is shown on fig1.Signal-to-noise ratio (S/N) analysis, analysis of variance (ANOVA) and regression analysis were carried out to determine the effects of each machining parameters on the surface roughness and optimal factor settings by using MINITAB software. Finally, Taguchi & ANOVA method analyze the machining parameters performance with sufficient accuracy.

Fig 1: Cutting tool (carbide tipped tool CNMG120408TM-T9125)

Taguchi Method Analysis (Doe)

Taguchi method is used to improve the Product quality. DOE is a powerful tool for analyzing the influence of control parameters on response. The conventional experiment design is complex to be used especially when large number of experiments are conducted and when the no. of machining factors are increasing. Taguchi method was proposed by Dr. G. Taguchi in the year 1950. The 1st step in Taguchi's is the selection of control factors. Parameter design is select the proper orthogonal array (OA) according to the control factors. Then, observation runs are based on control factors which form an orthogonal array and the experimental values are analyzed to find the optimum condition. When optimum conditions are found, then analysis of variance (ANOVA) is used to identified the optimum levels of all the factors. SIGNAL TO NOISE RATIO is the major part in Taguchi design. Signal defines the effect on the average response while the noise represents the influence on the deviation from the average response. The S/N ratio helps to find the performance level of process parameters. The mathematical equation for calculating S/N ratios for surface roughness is smaller-the-better type because we need surface roughness as low as possible.

$$\frac{S}{N} smaller = -10 \log_{10} \left[\frac{1}{n}\sum_{i=1}^{n} Y_i^2\right]$$

Where yi = ith experimental value
n = no. Of observations

III. Experimental Conditions and Procedure

The experiment was done to analyze the effect of control parameters such as feed rate, speed and depth of cut on surface roughness. The design parameters were studied at three levels & three factors. The design of experiments is based on Taguchi method of selection of orthogonal array L9. The experiment was carried out in dry condition on two-axis CNC lathe machine (ACE Super Jobber) which has a maximum spindle speed of 3500 rpm. Experimental conditions are shown in Table.1.

Table 1: Conditions for experimental setup

Machine Tool	**Ace Super Jobber Cnc Lathe(2-Axes)**
Work piece material	Al alloy, 28 mm dia
Work piece length	78 mm
Tool material	Carbide tipped tool

The machined Aluminium alloys were examined in surface roughness tester to determine the average surface roughness. Surface roughness (Ra) was measured by using Talysruf with a cut of length of 0.8mm and evaluation length of 4 mm. Each measurement was repeated three to four times at different positions on the surface and an arithmetical mean was taken into consideration. After the study and analysis of observed parameters we define levels for each parameter. In this study, three control factors (spindle speed, feed rate, and depth of cut) with different levels (Table-2) which are experimentally constructed for the step turning operation. The levels of spindle speed, feed & depth of cut are shown in Table .2.

Table 2: Control factors for Experimental set up

Machining parameters	**Level 1**	**Level 2**	**Level 3**
Cutting speed, v(rpm)	425	625	825
Feed rate, f(mm/rev)	0.1	0.2	0.4
Depth of cut (mm)	0.4	0.8	1.2

Fig 2: Job material (step turned Al)

L9 Orthogonal Array is shown in Table 3. Each run will having 3 values which are collected for surface finish. Therefore, a (3*3) =9 data values were collected for better surface finish, which are conducted for analysis in the experiment.

Fig 3: Machining Set Up (Super Jobber CNC Turning)

Fig 4: Shows the Talysruf surface roughness testing device for measurement of surface roughness (Ra)

Table 3: L_9 orthogonal array with factors and responses

Exp No.	Speed (V) Rpm	Feed (F) Mm/Rev	Depth Of Cut (D) Mm	Surface Roughness (Ra) µm	Signal to Noise Ratio
1	425	0.1	0.4	1.690	-4.5577
2	425	0.2	0.8	4.260	-12.5881
3	425	0.4	1.2	6.825	-16.6820
4	625	0.1	0.8	2.154	-6.6649
5	625	0.2	1.2	3.614	-11.1597
6	625	0.4	0.4	4.223	-12.5124
7	825	0.1	1.2	1.111	-0.91428
8	825	0.2	0.4	1.467	-3.3286
9	825	0.4	0.8	3.524	-10.9407

The S/N ratio is calculated using Taguchi method. The most effective need is to analyze the response variable surface roughness (Ra).smaller-the-better types Signal to Noise ratio was applied for transforming the input data for surface roughness as smaller values of Ra as suitable.

Evaluation of Surface Roughness

surface roughness depends on several factors, such as cutting speed, feed rate, & depth of cut etc. In this study, the effect of cutting speed (V) and feed rate (f) on average surface roughness (R_a) were investigated. Effect of Surface roughness variations according to the cutting speed and Feed rate are shown in Fig. 5

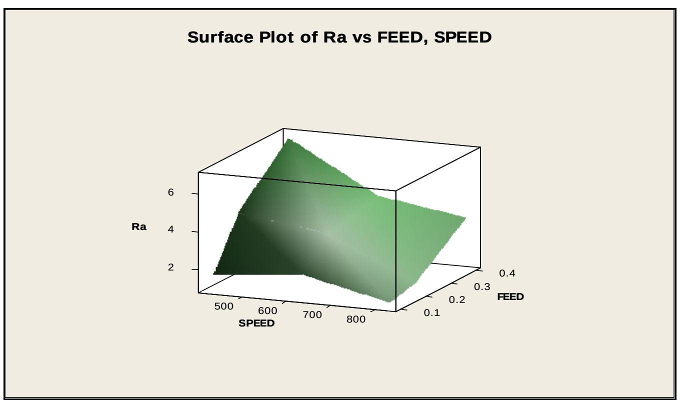

Fig 5: Effect of cutting parameters on surface roughness

From Figure 5. the surface roughness value will decreasing with increasing in cutting speed. This shows a positive effect of the increase value of cutting speed on surface roughness. It can be seen from Fig. 5 that when cutting speed is increased to 825 rpm from 425 rpm at the feed rate of 0.1 mm/rev., the average surface roughness will also decreased. At lower level of cutting speed 425 rpm & higher level of feed rate 0.4 mm/rev the roughness value is more.

Table 4: Response table for S/N ratio for R_a

Control Factors	S/N ratio				
	Level 1	Level 2	Level 3	Delta	Rank
Speed	-11.276	-10.112	-5.061	6.215	2
Feed	-4.046	-9.026	-13.378	9.333	1
Depth	-6.800	-10.065	-9.585	3.265	3

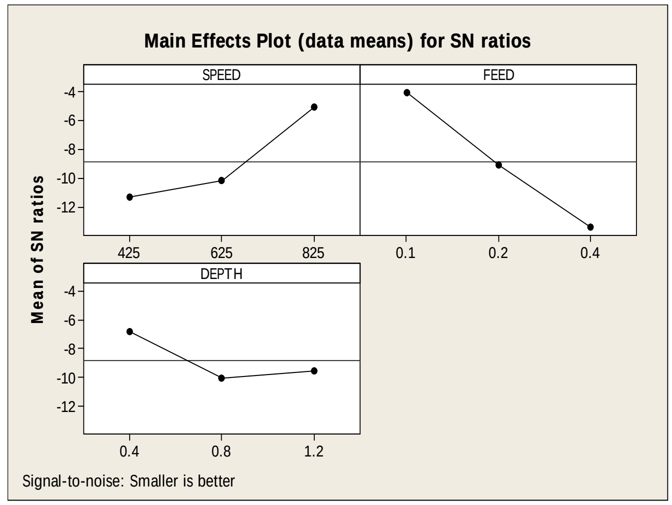

Fig 6: Main effect plot for S/N ratio of R_a

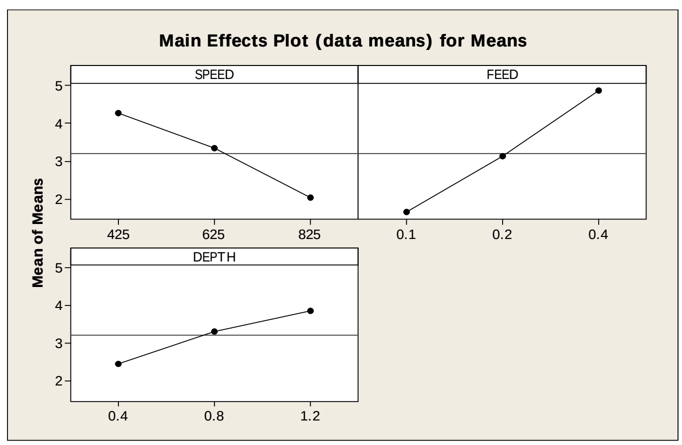

Fig 7: Main effect plot for Mean for Ra

The graph (fig.6, 7) shows the mean of S/N ratio & variation of means with the control parameters speed, feed & depth. From the graph (Fig.6) it would be concluded that the highest level of spindle speed (825 rpm) having maximum value of Signal to Noise Ratio, which gives the minimum variation of surface roughness (Ra). From the graph (fig.7.) the highest level of spindle speed (825 rpm) shows the optimum state in terms of Mean value. For getting better machining performance, the surface roughness value must be lower. So from the graph (fig.6, 7)

The lower level of feed rate (0.1 mm/rev) & also the lower level of depth of cut (0.4 mm) shows the optimum condition for S/N ratio & for the Mean data.

Table 5: Response Table for Means

Level	Speed	Feed	Depth
1	4.258	1.652	3.850
2	3.330	3.114	3.313
3	2.034	4.857	3.850
Delta	2.224	3.206	1.390
Rank	2	1	3

Analysis of Anova Using Adjusted Ss

ANOVA is basically used in this experiment to determine, which cutting factors mostly affect the roughness value.

Basically ANOVA is a collection of statistical models which is used to analyze the variation among the groups. The below table shows the ANOVA analysis result for S/N ratio. From the result the most significant input control factor for surface roughness is feed rate.

In this paper ANOVA & F-Test is used to determine the experimental value shown in Table 6. The %age contribution of feed rate is maximum in this experiment. Here the most important input factor is Feed rate then cutting speed & depth of cut, which are shown in Table.4. rank wise which is obtain from MINITAB 15 software. The value of depth of cut is contribute less effect on surface roughness.

Table 6: ANOVA results for S/N ratios of Ra

Source	Degree Of freedom(DOF)	Sequential Sum of Squares (SS)	Mean Sum of Squares (MS)	F-test	P-Coefficient
Speed	2	7.4893	3.7447	17.15	0.055
Feed	2	15.4541	7.7271	35.39	0.027
Depth Of Cut	2	2.9479	1.4739	6.75	0.129
Error	2	0.4367	0.2184		
Total	8	26.3280			

The regression equation of Ra was as follows:

Ra = 2.87 - 0.00556 Speed + 10.4 Feed+ 1.74 Depth

S = 0.412995 R-Sq = 96.8% R-Sq (adj) = 94.8%

IV. CONCLUSION

In this paper, the effects of the machining parameters were evaluated on surface roughness, when step turning of Al Alloy under dry cutting condition were performed by using Taguchi methodology. The following specific conclusions are achieved based on the results:

- For machining Aluminium alloy feed rate is the most significant control factor.
- Average surface roughness decreased with increasing cutting speed during machining using carbide tipped tool inserts.
- For obtaining better surface finish for machining of material, the control parametric combinations are 3rd level spindle speed (425 rpm), 1st level feed rate (0.1 mm/rev) and 1st level depth of cut (0.4 mm).
- The ANOVA model can determine the surface roughness with accuracy depend on the correlation coefficients R-sq = 96%

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