Effect of Process Parameters on MRR and Surface Roughness for Machining Aluminium 6061 Alloy

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Abstract— **The present investigation deals with the effect of input process parameters in CNC turning of Aluminium 6061. Speed, depth of cut, and feed are the input process parameters that has been considered. Surface Roughness SR and MRR are considered as the response output variables. Taguchi method has been employed using L9 orthogonal array to find out the effective process parameters. Experimental runs have been conducted as per L9 orthogonal array. Stylus profile meter has been used to measure surface roughness after completing the experiment. Factor effects have been also studied. To obtain maximum MRR and minimum SR suitable optimum value of the input parameters has been selected to perform the experiment.**

Keywords— CNC Turning, Taguchi, MRR, Surface Roughness

I. INTRODUCTION

In industrial applications the uses of Aluminium 6061is widely preferred. Al alloys are generally light weight, easily formable, ductile in nature, high mechanical strength, and highly corrosion resistive [1,2,3]. Al 6061alloy is an alloy having excellent and unique combination properties. The uses of Al alloy in industry is rapidly increasing day by day. Various manufacturing processes are used to create Al 6060 alloy. To obtain proper dimension, size and shape: several other machining processes are involved. To upgrade the machine parts; the influence of input parameters like feed, spindle speed, depth of penetration as well as implementation of cutting fluid etc. are preferred [4,5]. In research area the upgradation qualities of surface have been preferred for Al 6061 alloy.

To acquire proper geometrical shape as well as high quality surface finish; the machining operations are usually carried out with the cutting tool which provide the best performance [6]. Various input parameters like material properties, vibration, cutting forces etc. affect the machining operations [4]. Cutting variables are considered to be the input parameters which play a vital role to obtain best quality surface finish. Every manufacturing industry prefer minimization of SR. Automation plays an important role in manufacturing industry. Machining with CNC lathe helps to achieve good quality products along with an increased amount of production. CNC lathe has lot of advantages due to its versatility and thus it is preferred by modern automated industries. Performing turning operation in CNC lathe helps to obtain a high quality surface finish product. Optimization of process parameters can be obtained from CNC lathe. Surface roughness is considered as one of the standard parameter to obtain a high quality product. Machined parts performance along its uses are the factors that always affect the quality as well as the manufacturing cost [9]. It always states about the surface textures along with geometrical structure. Various performance parameters such as heat transfer and coating characteristics, corrosion resistance, wire resistance, fatigue strength etc. all effect the surface finish [10,11]. Figure 1 describes the effect of process parameter in surface roughness with the help of fishbone diagram.

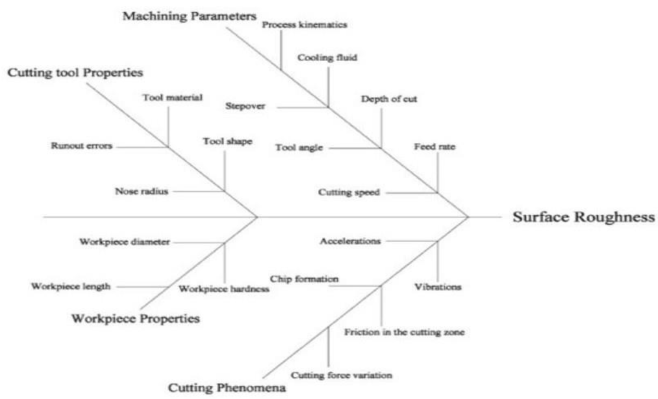

Figure 1. Diagram of Fishbone representing the parameters that influence SR [5]

Several factors or parameters can also effect surface roughness as discussed above. Various trial runs have been implemented to obtain the desired output by many of the manufacturing industry. Trial and error method is not an appropriate process because the consumption time is more. Various experimental techniques and effective theoretical procedure has been proposed as well as implemented by various researchers. Various investigations have concluded the best optimization of process parameters is obtained by CNC lathe while performing turning operation. MRR, roundness and surface roughness are the desired output for Al 6061 alloy which has been obtained by optimizing input parameters while performing turning operation [5]. Prominent factors like feed, depth of cut effect the characteristics quality of Al 6061alloy while implementing turning operation. Machine tool vibration and cutting parameters are used as input parameters to generate [13]. While performing turning operation; vibration signals have been implemented to predict surface roughness for alloy Ti-6Al-4V [14]. To minimize roughness quality and to increase the production turning operation can be performed by two types-by using tool made up of diamond [1]. Mathematical model has been formed with respect to speed, feed rate and depth of penetration to obtain maximum MRR and minimum Surface roughness [10].

II. METHOD IMPLEMENTED:

TAGUCHI Taguchi's method involves below mentioned procedure:

a. Determination of Quality Performance and optimization.
b. Identification of Factors and to obtain test results
c. To obtain various levels of Control Factor.
d. To get Experimental Design to obtain procedure for Analysis of Data.
e. To perform Experimental Design.
f. To determine the optimum Input Factors.
g. Prediction the level of performance.

A. Taguchi Design of Experiment (DOE) in MINITAB

While performing the experiments following steps should be followed:

i. Before starting MINITAB, some trial runs has to be performed.
ii. Selection of input process parameters and their various levels.
iii. Create Design of Experiment to perform experiments.
iv. Output results are used for analysis purpose.
v. Optimal parameters are obtained to get the best desired output.

Signal-to-noise ratio	Experimental Goal	Characteristics Data
Better : Large Value	The response is maximized	Obtained Positive Data
Best is Nominal	Response is consider on the bases of Noise to Signal ratios	Either Positive or zero or negative
Best is Nominal (default)	Response is consider on the bases of Noise to Signal ratios	Positive and zero where the standard deviation= 0 and the mean = 0
Best: Smaller Value	Minimum Response	Positive and having a target value= 0

III. EXPERIMENTAL DETAILS

A. EXPERIMENTAL SETUP

To carry out the experiment this machine set up has been used. It's an automated CNC Lathe machine tool. 6061 Aluminum Alloy has been used as work piece material.

Figure 2. Experimental Setup

B. WORK PIECE DETAILS

In this experiment AA6061 alloy has been used as raw material. Aluminium alloy 6061 is an alloy having medium strength and very commonly used as an architectural alloy. In extrusions processes they are implemented.

C. SELECTION OF PROCESSES PARAMETERS

3 levels of three different parameters has been used to carry out the experiment. Table 2 shows the L_9 orthogonal array for the experiment.

Table 1: Input Parameters

Sl. No.	Parameters	Level 1	Level 2	Level 3
01	Spindle Speed (rpm)	100	125	150
02	Feed (mm/min)	0.20	0.25	0.30
03	Depth of Cut (mm)	0.5	1	1.5

Table 2: DOE using Orthogonal Array (L_9)

Sl. No	Spindle Speed (rpm)	Feed (mm/min)	h of Cut (mm)
1	100	0.20	.5
2	100	0.25	1.0
3	100	0.30	1.5
4	125	0.20	1.0
5	125	0.25	1.5
6	125	0.30	.5
7	150	0.20	1.5
8	150	0.25	.5
9	150	0.30	1.0

D. WORKPIECE AFTER MACHINING

Figure 2 Workpieces after Machining

IV. RESULTS AND DISCUSSION

A. CALCULATION OF MATERIAL REMOVAL RATE

Materials Removal Rate = (Weight of unfinished bar − Weight of finished bar) /Time Taken

Table 3: List of MRR Values

Sl. No	Spindle Speed (rpm)	Feed (mm/min)	Depth of Cut (mm)	MRR (mm^3/min)
1	100	0.20	0.5	0.0000020
2	100	0.25	1.0	0.0000029
3	100	0.30	1.5	0.0000030
4	125	0.20	1.0	0.0000028
5	125	0.25	1.5	0.0000045
6	125	0.30	0.5	0.0000032
7	150	0.20	1.5	0.0000048
8	150	0.25	0.5	0.0000039
9	150	0.30	1.0	0.0000042

B. CALCULATION OF SURFACE ROUGHNESS

Table 4: List of Surface Roughness Values

Sl. No	Spindle Speed (mm)	Feed (mm/min)	Depth of Cut (mm)	Surface Roughness (µm)
1	100	0.20	0.5	2.256
2	100	0.25	1.0	1.718
3	100	0.30	1.5	3.379
4	125	0.20	1.0	1.818
5	125	0.25	1.5	1.781
6	125	0.30	0.5	2.569
7	150	0.20	1.5	0.811
8	150	0.25	0.5	1.601
9	150	0.30	1.0	2.229

C. GRAPHICAL ANALYSIS

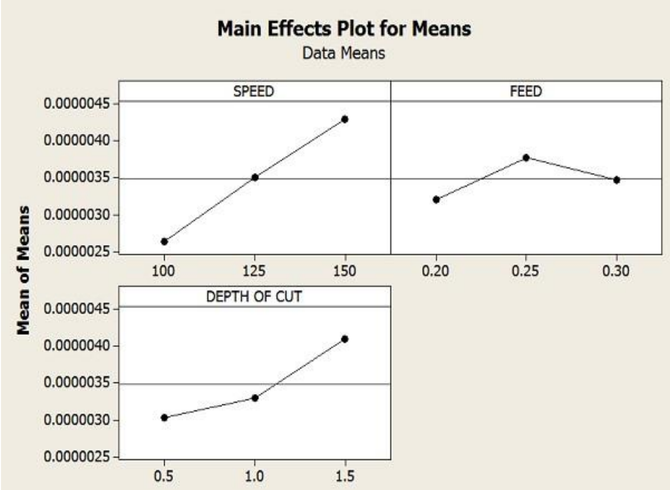

Figure 4: Graphical Analysis for MRR

Figure 4 has depicted the variation of means of Material Removal Rate with the input parameters or process parameters. The plot describes that if the Feed is increased then MRR also increases and then decreases. But if Speed is increased then the MRR also increases. For Depth of Cut MRR gets increases i.e. from 0.5 to 1.0 mm and again it gets increases from 1.0 to 1.5 mm.

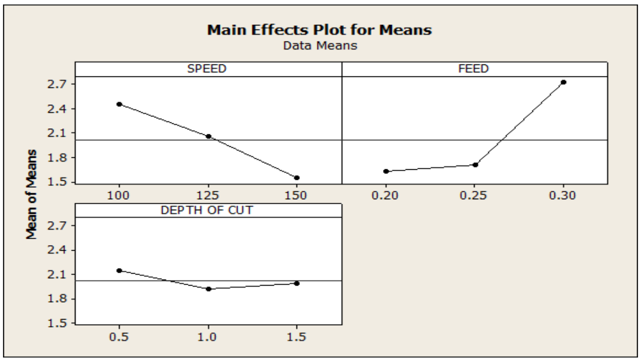

Figure 5: Graphical Analysis for Surface Roughness

Figure 5 has depicted the variation of values of SR with respect to all the input parameters or process parameters. The above mentioned figure describes that the SR always decreases if the speed is increased. But for increased value of Feed, Surface Roughness always increases. But to obtain SR with respect to increase in Depth of Cut initially the value of SR get decreased and then it starts increasing.

V. CONCLUSION

The present investigation focuses for obtaining optimum parameters to obtain the best desired outputs for machining the aluminum alloy 6061 in automated CNC Lathe Machine tool. Experimental results of the preset investigation conclude the following statements:

a. Maximum MRR of 0.0000048 mm^3/ min has been obtained at spindle speed of 150 rpm, Feed of 0.2 mm/min, Depth of cut of 1.5 mm.

b. Minimum Surface Roughness of 0.811 µm has been obtained at spindle speed of 150 rpm, Feed of 0.2 mm/min, Depth of cut of 1.5 mm.

c. Figure 4 has depicted the variation of means of Material Removal Rate with the input parameters or process parameters. The plot describes that if the Feed is increased then MRR also increases and then decreases. But if Speed is increased then the MRR also increases. For Depth of Cut MRR gets increases i.e. from 0.5 to 1.0 mm and again it gets increases from 1.0 to 1.5 mm.

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