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TAGUCHI BASED OPTIMIZATION OF CNC TURNING MACHINE PARAMETERS

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ABSTRACT

To predict the effect of various machining parameters on the machining characteristics e.g. material removal rate, surface roughness, a series of experiments are carried out using variation of different parameters. This chapter explain briefly the plan of experiment i.e. work-piece materials, experimental design, input parameter setting, instrument used for experimentation and measurement. Few trial experiments are conducted to decide the range of input parameters. On the basis of performance of the trail experiments parametric levels are set up for further experimentation. Then specific numbers of experiments are carried out according to the Taguchi method based design of experiments to investigate the parametric effect during machining Aluminium 6061.

1.0. INTRODUCTION

The data obtained from this study will provide a better understanding of the effect of process parameters on material removal rate and surface roughness developed in the work piece and during turning of Al 6061. The results obtained will enrich the existing database and may be helpful in selecting the optimum values of process parameters during machining of different grades of Aluminium.

Organizations involved in some kind of machining activity on machine tools will be benefited by this study. Further, information about relationship between cutting parameters and machining variables if obtained on-line or off-line could be used to establish economic optimization of machining operations. The study will help the users of Al 6061 material to use the tailor made optimized cutting parameters to improve the quality of their product and enhance the surface integrity and moreover to reduce the time and cost of production.

There are several factors which are affecting the machining performance during turning operation, it was found that assessment, modeling and optimization of machining variables such as material removal rate, surface roughness by varying cutting parameters like spindle speed, feed and depth of cut are the prominent factors which need to be investigated.

2.0. OBJECTIVES OF PRESENT WORK

The objective of this dissertation is given below:

1. To study the influence/effect of machining parameters viz. speed, feed and depth of cut, on the material removal rate of Aluminium 6061.
2. To study the influence/effect of machining parameters viz. speed, feed and depth of cut, on the surface roughness of Aluminium 6061.
3. To determine optimum machining parameter settings for the chosen tool/work combination so as to minimize the surface roughness using Taguchi method.
4. To develop mathematical model for the Surface Roughness and the material removal rate for the chosen tool/work combination within the specified domain of parameters.

3.0. METHODOLOGY

Keeping in view the proposed objectives, the following methodology have been adopted to meet the set objectives in turning of Al 6061.

1. Turning of Al 6061rod has been performed on a CNC machine using CNMG 120408 EN-TM insert for various combinations of cutting parameters.
2. Taguchi based Design of experiments have been used to find out optimum number of experiments to be conducted to achieve the said objectives.
3. Surface roughness of machined surface has been measured using a surfaceanalyzer during experimentation.
4. Material removal rate has been evaluated using high precision balance by weighing samples before and after experimentation.
5. Analysis has been carried out using analysis of variance (ANOVA). The significance of the regression model and significant model term i.e spindle speed, feed and depth of cut are clearly highlighted

Table 1.1: Details of experimental conditions

Work piece material	Aluminum 6061 (T6)
Insert designation	CNMG 120408 EN- TM (H20TI)
Cutting velocity (m/min)	1000,2000,3000
Feed(mm/rev)	0.20,0.30,0.40
Depth of cut(mm)	0.1,0.3,0.5
Environment	Dry

Table 1.2: Developed machining parameters and their levels

Parameters, their symbols and units	1	2	3
A: Speed (X_1,rpm)	1000	2000	3000
B: Feed (X_2, mm/rev)	0.20	0.30	0.40
C:Depth of Cut (X_3, mm)	0.1	0.3	0.50

Table 1.3: Experimental conditions

Workpiece material	Aluminum 6063 (T6)
Insert designation	CNMG 120408 EN- TM (H20TI)
Spindle speed (rpm)	1000,2000,3000
Feed(mm/rev)	0.20,0.30,0.40
Depth of cut(mm)	0.1,0.3,0.5
Environment	Dry

Table 1.4: Composition of the Aluminium 6061 alloy

Component	Amount (wt. %)
Aluminum	Balance
Magnesium	0.8-1.2
Silicon	0.4 – 0.8
Iron	Max. 0.7
Copper	0.15-0.40
Zinc	Max. 0.25
Titanium	Max. 0.15
Manganese	Max. 0.15
Chromium	0.04-0.35
Others	0.05

4.0. MATHEMATICAL MODELS

4.1. Mathematical Model and Comparison Graph for Material Removal Rate

$$Y_{MRR} = 881.707 - 1.74424\ X_1 - 9895.86\ X_2 + 416.781\ X_3 - 2.27037e\text{-}005\ X_1^2 - 2521\ X_2^2 - 65.9168\ X_3^2 + 16.6701\ X_1 \times X_2 - 0.0268944\ X_1 \times X_3 + 461.195\ X_3 \times X_2$$

----------Eqn. 1.1

Where, X_1 = Speed (rpm), X_2 = Feed (mm/rev) and X_3= Depth of Cut (mm)

Fig. 1.1 shows the graphical representation of the mathematical model(1.1) and experimental results obtained from 27 sets of experimental investigation. From the Fig., it is concluded that the mathematical modelhas a good agreement with the experimental values.

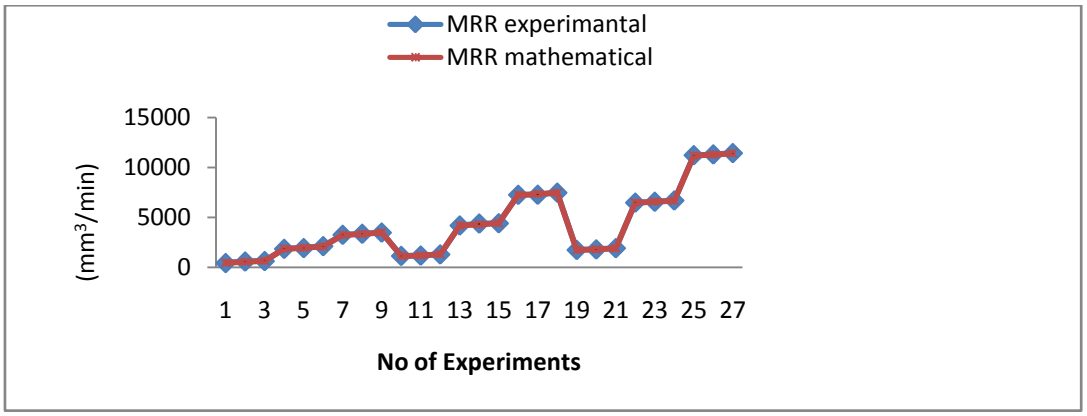

Fig.1.1 Comparison of MRR for aluminum 6063 by experiment and mathematical model

4.2. Mathematical Model and Comparison Graph for Surface Roughness

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 $X_1 \times X_3$ ……Eqn. 1.2

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

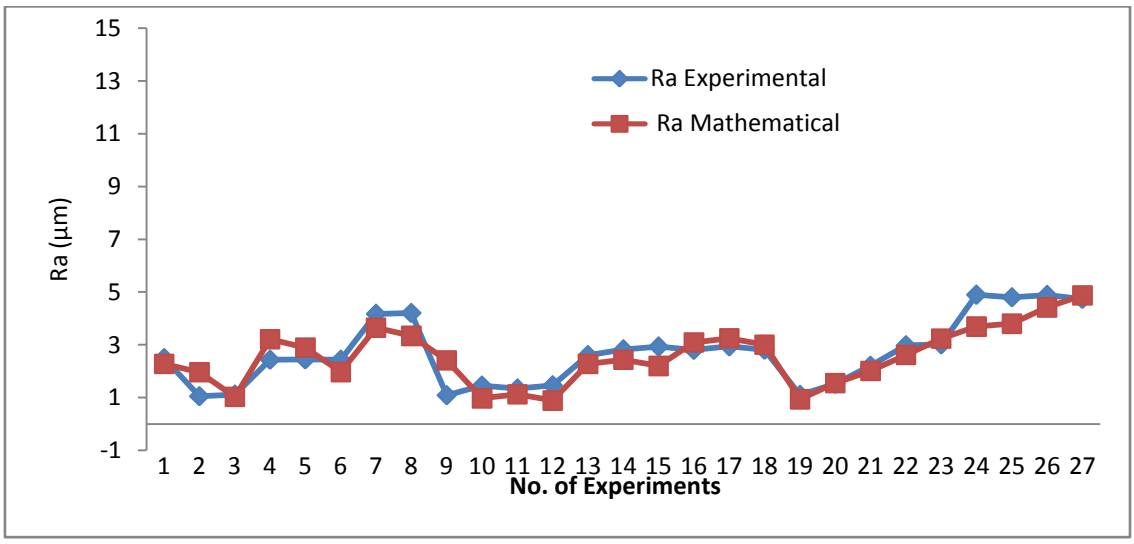

Fig. 1.2 Comparison of surface roughness for aluminum 6063 by experiment and mathematical model

Fig. 1.2 shows the graphical representation of the mathematical model(1.2) and experimental results obtained from 27 sets of experimental investigation. From the Fig., it is concluded that the mathematical modelhas a good agreement with the experimental values.

5.0. CONCLUSIONS

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 65.65 % contribution. The contribution of speed on surface roughness is 28.87 %.
2. The speed has a most significant effect on Material removal rate with 88.176% contribution, feed has 8.41% contribution.
3. For maximum material removal rate, the optimal parametric combination is $A_3B_2C_3$ i.e. material removal rate is maximum at the parametric combination of 3000 rpm spindle speed, .0.4 mm/rev feed and 0.3 mm depth of cut.
4. For minimum surface roughness , the optimal parametric combination is $A_1B_1C_1$ i.e. material removal rate is maximum at the parametric combination of 1000 rpm spindle speed, 0.2 mm/rev feed and 0.1 mm depth of cut.
5. Regression based developed mathematical model shows good agreement with the experimental results obtained for surface roughness and material removal rate.

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