Optimization of Material Removal Rate of Mild Steel Bar using Taguchi Method

Sorabh Kasara
Indore Institute of Science & Technology, Indore M.P.

Abstract— In this paper, we will optimize the turning parameters by the Taguchi method. Here we are selecting material removal rate as output characteristic and spindle speed, feed and depth of cut as input control parameters. And taking three levels of each input control parameters. For the experimental work we are selecting the Conventional Center lathe machine. After finding the optimum parameter, we have created the ANOVA table which shows the percentage contribution of the input parameter to improve the material removal rate.

Key words: Material Removal Rate, Spindle Speed, Depth of Cut, Taguchi Method, ANOVA, Optimization, Signal to Noise Ratio

I. INTRODUCTION

To produce more and more in today's era is a big challenge because more and more production decreases the value of the item and meets market requirements in a fair price. The lathe machine is a very useful machine that works to make machine components. Lathe machine is also known by name mother of machine tools. Lathe machine is also known by name mother of all machine tools. Material Removal Rate is a very noticeable output characteristic that by controlling we can achieve good production. The rate of substance removal per minute is called the Material Removal Rate and its unit is mm^3 / minute. Our task in this work is to increase the material removal rate and for this purpose we will use the Taguchi method. This method helps us to find optimum parameters.

II. TAGUCHI METHOD

The Taguchi method is a very useful method for managing the quality. The Taguchi method gives an easy, effective and systematic approach to designing the design and optimization of cost performance in an experimental way. The main purpose of the Taguchi method is to reduce the change in process through strong design of the experiment.

Its broad form was given by Dr. Genichi Taguchi of Japan. A method was designed to design experiments by Dr. Genichi Taguchi in which the performance of the process is checked. In the Taguchi method, the use of orthogonal arrays by Dr. Taguchi is used to organize the parameters and their different levels affecting the result in experimental work. By using it we can save resources and time.

III. SET UP OF EXPERIMENT AND CUTTING CONDITIONS

(3.1) Experiments:-Experiment set up is shown in fig.1. For the experimental work, we are using mild steel as a substance of the work segment and using High Speed Steel as a substitute for cutting tools. We have done the entire experimental work on Conventional Type Center lathe machine. We are using three cutting parameters which have spindle speed, feed and depth of cut and with this, three levels of each parameter have been taken. The cutting parameters with their levels are shown in table 1 with their level and chemical composition of wokpiece are shown in table 2.

Fig. 1: Experiment St up

Sr. No.	Control Parameters	Level-1	Level-2	Level-3
1	Spindle Speed(rpm)	200	600	800
2	Feed (mm/rev.)	0.05	0.1	0.15
3	Depth of Cut(mm)	0.5	1.0	1.5

Table 1: Cutting Parameters

Component	C	Si	MN	S	P
Wt%	0.16-0.25	Max.0.4	0.7-0.9	Max 0.04	Max 0.04

Table 2: Chemical Composition of Mild Steel

To find the material removal rate, we have used a formula that is written below

$$\text{Material removal rate} = \frac{\frac{\pi}{4}(D^2-d^2)\times l}{N}\ mm^3/\text{minute} \qquad (1)$$

Where D= Diameter of workpiece before machining,
d= Diameter of workpiece before machining,
l= Length of workpiece,
N=Time taken for turning of l length of workpiece.

From equation 1 it is clear that we are using the volume reduction system. We have chosen the L_9 orthogonal array for the experiment.

A. Process of Turning:

The process of removing metal from the surface of the workpiece in the form of chips by turning the work cut into a certain axis by cutting it on a certain axis is called turning. After turning, the work segment can be found in cylindrical, conical forms according to our requirement. If we have a parallel cut of the rotating axis of the work segment on the work segment by cutting tools, then in this process we get cylindrical surface and this process is known simple turning. And if we cut the angle at the angle of the working axis by the cutting tool, then we get the conical surface and this process is called taper turning. Our three cutting parameters are spindle speed, feed and depth of cut which affect the

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material removal rate. The number of revolutions placed in a minute by spindle of the head stock of the lathe machine is called spindle speed and it is displayed by RPM. The distance covered by a tool in one revolution of spindle is called feed and its unit is mm/revolution. The amount of tool that is inserted inside the work segment to remove the substance is called the depth of cut. For the combination of cutting parameters in the experiment, we are taking the L9 orthogonal array, which is shown in table 3. For the experiment we have selected Mild Steel Bar of 50 mm diameter and 102 mm length, which we will later make 48 mm diameter and 100 mm length by machining. So that it comes in the right shape and the black surface and the rolling defect get out and after this we will start the experiment according to the L9 orthogonal array. The material removal rate received after use on each orthogonal array is shown in Table 3.

Sr. no	Spindle Speed (A)	Feed (B)	Depth of Cut (C)	Material Removal Rate (mm3/Min.)
1	1	1	1	742.4
2	1	2	2	2918
3	1	3	3	6521.6
4	2	1	2	4394.5
5	2	2	3	12739.88
6	2	3	1	6603
7	3	1	3	8661.1
8	3	2	1	5829.1
9	3	3	2	17169.1

Table 3:

IV. Result & Discussion

A. *Optimum Parameter:*

From Fig.2, it is clear that optimum parameter is $A_3B_3C_3$that means spindle speed of 800 rpm, feed of 0.15 mm/rev., and 1.5 mm depth of cut will get the best results. Fig. 2 shows the optimization of the material removal rate and Fig. 3 shows the optimization of mean of signal to noise ratios of material removal rate. That is the same thing as the Fig. 2, $A_3B_3C_3$.

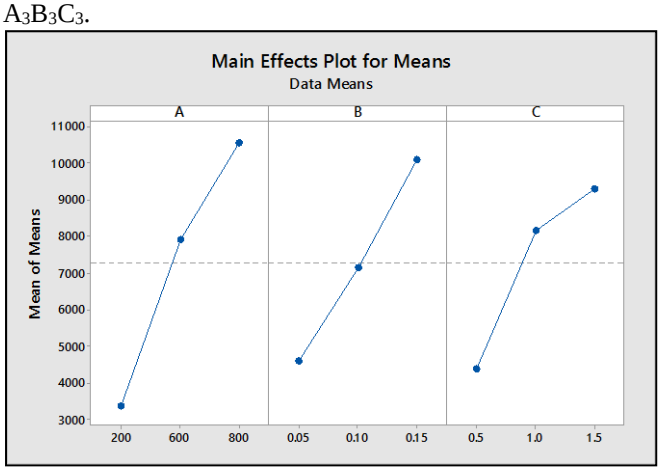

Fig. 2: Variation of Mean of Material Removal Rate

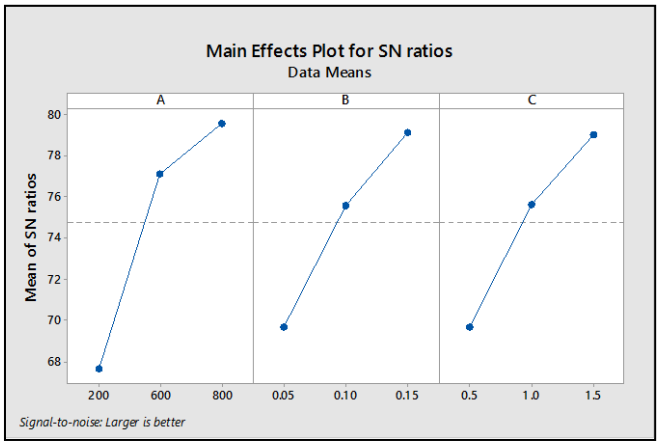

Fig. 3: Variation of Mean of S/N Ratios of Material Removal Rate

B. *Analysis of Variance (ANOVA):*

ANOVA table shows us the percentage contribution of all the parameters. ANOVA table is show in the table No. 3. It is clear from ANOVA table that spindle speed is the most important parameter for high material removal rate, which contributes 38.79%. After that feed is on the second number which contributes 22.4%. And finally, the least important parameter is depth of cut, which is 19.88%.

Table No. 3: Analysis of Variance

Source	DF	Seq SS	% Contribution	Adj MS	F-Value
A	2	78642173	38.79%	39321087	2.02
B	2	45420761	22.40%	22710381	1.16
C	2	39688524	19.58%	19844262	1.02
Error	2	38992163	19.23%	19496082	
Total	8	202743621	100%		

V. Conclusion

In the process of finding optimal parameters by the Taguchi method, we got the combination of $A_3B_3C_3$ levels, i.e. $A_3B_3C_3$ will get higher Material Removal rate. The most important parameter spindle speed contributes 38.79% and then the feed contributes 22.40%, the depth of cut is the lowest critical parameter with 19.58%. The percentage of error is 19.23, which means that there is a need to control the noise factor.

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