Optimization of Process Parameter for Surface Roughness and Material Removal Rate on CNC Turning Machine for MS Material

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Abstract— Quality and productivity play a major role in today's manufacturing market. In the present work a single characteristic response optimization model based on Taguchi Technique is developed to optimize process parameters such as spindle speed, feed and depth of cut. Taguchi's L9 orthogonal array is selected for experimental planning. The Analysis of experimental result showed that the combination of optimum levels of cutting speed, feed and depth of cut is essential to achieve simultaneous maximization of material removal rate and minimization of surface roughness. In cutting process, optimization of cutting parameter is considered to be a vital tool for improvement in output quality of a product as well as reducing the overall production time.

Key words: Surface Roughness, MRR, Optimization

I. INTRODUCTION

Taguchi method is a powerful statistical tool [11] that yields optimized values of process parameters for the design response characteristics. Meticulous experimental design using Orthogonal array coupled with standard or S/N analysis of results using Taguchi techniques gives optimum levels of parameters with minimum amount of experimentation [6]. Literature shows that work has been explored on various aspects of experimentation and process in CNC turning process. In this study, detailed analysis has been made to establish relationships between input parameters and output parameters with quality leading to an optimal process.

K.Saravanakumar, M.R.Pratheesh Kumar, and Dr.A.K.Shaik Dawood [12] have studied the Influence of surface roughness & material removal rate on CNC turning machine. Milon D. Selvam, had studied the influence of the use of Taguchi technique and Genetic Algorithm (GA) for minimizing the surface roughness in machining mild steel with three zinc coated carbide tools inserted into a face miller of 25 mm diameter. The experimental study was carried out in a FANUC series CNC vertical machining center (VMC). [1]

II. EXPERIMENTATION

In this investigation an attempt was made to find out the optimum process parameters of CNC lathe on mild steel rods. Process parameters considered are cutting speed, depth of cut and feed rate. Each process parameter is considered at three levels (with one trial on each specimen). Trails are conducted and the response characteristics are studied, for surface finish

Mild steel Brite was the target material used in this investigation. Table 2 shows the material related properties. Experiments were performed using a cnc lathe machine machine. Figure 1 shows the experimental set-up. A cylindrical mild steel rod of size100*25mm in machine for performing step turning operation.

The present study is aimed to optimize cnc lathe machine process parameter on MS Brite rods. Steel is the most commonly used alloy for structural applications.

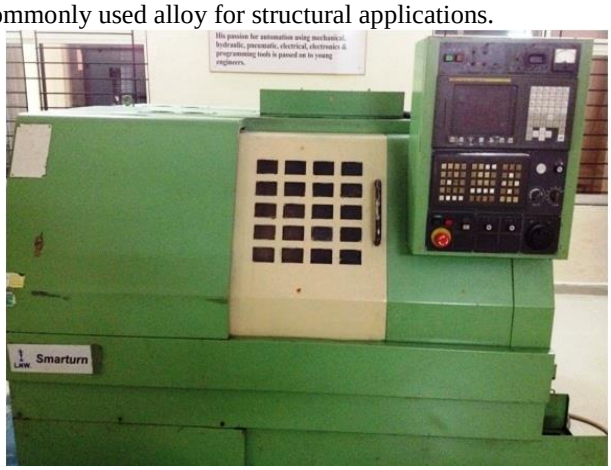

Fig. 1: CNC Lathe Machine


Fig. 2: Tool Bit Cnmg432 – Ha

Step turning operation was performed on lathe machine for MS Brite material of dimension 100 mm×83mm×20mm diameter as shown in Figure 2 and Figure 3.

In this operation material removal rate and surface roughness was the output parameters and to identify the optimum process parameters.

Fig. 3: Ms Brite Rod

III. RESULTS AND DISCUSSIONS

Mild steel plates are prepared as per the experimental plan given in Table 1. For each of the plates made the responses are the surface roughness and material removal rate which are experimentally determined. After getting the experimental results, the results are analyzed to arrive at optimum values of process parameters. Experimental results are given in Table 2.

S. No.	Control Factors	Units	Factors Notation	Factor Levels		
				Level-1	Level-2	Level-3
1	Spindle Speed	rpm	N	1000	1250	1500
2	Feed Rate	mm/min	F	100	150	200
3	Depth of Cut	mm	DC	0.25	0.50	0.75

Table 1: CNC Lathe Parameters and their Levels

Trail no	Spindle speed 'rpm'	Feed rate 'mm/min'	Depth of cut 'mm'	Surface roughness 'Ra'	Material Removal Rate 'g/min'
1	1000	100	0.25	3.14	0.34
2	1000	150	0.50	4.71	1.14
3	1000	200	0.75	6.28	0.7
4	1250	100	0.75	2.512	1.02
5	1250	150	0.25	3.768	1.26
6	1250	200	0.50	5.024	0.82
7	1500	100	0.50	2.093	0.78
8	1500	150	0.75	3.14	1.74
9	1500	200	0.25	4.18	0.7

Table 2: Experimental Results for the CNC Lathe

A. Optimization of Process Parameters for Surface Roughness

Source	DOF	Seq ss	Adj ms	% contribution
Spindle speed	2	0.2158	0.108	14.79
Feed rate	2	0.8548	0.427	58.57
Depth of cut	2	0.1326	0.066	9.09
Error	2	0.2563	0.128	17.56
Total	**8**	1.4595		**100**

Table 3: Analysis of Variance (ANOVA) for Surface Roughness

1) Surface Roughness Values at Optimum Condition

Grand Average of standard value of surface roughness $(\overline{T})$ =0.94

Expected surface roughness at optimum condition

$$Y_{Optimum} = \overline{T} + \left[\overline{N_1} - \overline{T}\right] + \left[\overline{F_1} - \overline{T}\right] + \left[\overline{DC_3} - \overline{T}\right]$$

= 0.94+ (0.73-0.94) + (0.71-0.94) + (0.83-0.94) = 0.39

By the experiment results it was found that the surface roughness quality characteristic is smaller the better but the experimental value is 0.94 i.e., at parameters S_3, F_2, D_3 from the Taguchi prediction values 0.39 parameters levels at S_1, F_1, D_3.

2) Material Removal Rate Values at Optimum Condition

Source	DOF	Seq ss	Adj ms	% contribution
Spindle speed	2	8.90	4.45	28.86
Feed rate	2	10.14	5.07	32.88

Depth of cut	2	6.90	3.45	22.37
Error	2	4.90	2.45	15.89
Total	**8**	30.84		**100**

Table 4 analysis of variance (ANOVO)

Grand Average of standard value of material removal rate $(\overline{T})$ =3.87
Expected material removal rate at optimum condition

$$Y\ Optimum = \overline{T} + \left[\overline{N_1} - \overline{T}\right] + \left[\overline{F_3} - \overline{T}\right] + \left[\overline{DC_2} - \overline{T}\right] = 3.87 + (4.17-3.87) + (5.17-3.87) + (4.64-3.87)$$

By the experiment results it was found that the Material Removal Rate quality characteristic is bigger the better but the experimental value is 6.28 i.e., at parameters S_1, F_3, D_2 from the Taguchi prediction values 6.78 parameters levels at S_3, F_2, D_3.

IV. CONCLUSIONS

As per L_9 orthogonal array, we have 3^3=27 combinations. Instead of 27 experiments, nine numbers of trials were conducted. The optimum values of turning geometry, combinations of parameters and their levels are also predicted by Taguchi method.

By ANOVA techniques, influence of each turning parameter is studied and the prediction of the geometry is done. Analysis of turning parameters such as surface roughness, Material removal rate against variations in spindle speed, feed rate and depth of cut in CNC turning were done.

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