OPTIMIZATION OF TURNING PARAMETERS BASED ON SURFACE ROUGHNESS USING OPTIMIZATION TECHNIQUE

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ABSTRACT

Surface roughness determines how a real object interacts with its environment. Rough surfaces usually wear more quickly and have high friction coefficient than smooth surfaces. Roughness is often a good predictor of the performance of mechanical components, since irregularities in the surface may form nucleation sites for cracks or corrosion. In this work attention is given to investigate, the effect of cutting parameters mainly Feed, Depth of Cut, Tool nose radius on Surface Roughness by keeping cutting speed constant in CNC turning operation. The experiments were performed on SS304 Using Taguchi method. A three level, three Factor design of experiment prepared according to Taguchi orthogonal array L_9 using Minitab 16 software. The Analysis of Variance (ANOVA) and Signal to Noise (S/N) Ratio was carried to find out the most significant factor and percentage contribution of individual factor for Surface Roughness and Material Removal Rate. The all experiments were performed at dry condition. From result it is found that optimum level of cutting parameters for Surface Roughness are obtained at feed of 0.15 mm/rev, depth of cut of 0.2 mm, tool nose radius of 0.8 mm.

Keyword: - *CNC Turning, Taguchi method, Surface Roughness, ANOVA, Minitab 16.*

1. INTRODUCTION

Now a day's customer demands better quality product with minimum cost in the manufacturing field. The Surface finish is the important parameter at the point of view quality of the product and better surface finish can be achieved that using optimization technique. Material removal rate decides the productivity of the manufacturing component. So the Surface roughness and Material removal rate plays an important role in manufacturing industry. Surface roughness and material removal rate is one of the important quality control parameter for evaluating of production process.

Now a day, the fulfillment of customer's satisfaction in terms of low cost, high quality, easily deliverable is a key to stand strongly in the field of manufacturing market. This can be achieved effectively by application of optimization technique [22]. Now a day's turning operations become important subject in industries and also in research & development. These are mostly used in automobile, die, gear and bearing industries [27].

Fig -1: CNC Turning Operation

In recent times, modern machining industries are trying to achieve high quality, dimensional accuracy, surface finish, high production rate and cost saving along with reduced environmental impact. In the machining process, turning can be carried out on variety of machines like lathe, special purpose machine or CNC machine. The quality of turning is measured in terms of tolerances and roughness of surface. Surface finish is a quality specified by customer for machined parts [31].

Turning produces three cutting force components,(the main cutting force i.e. thrust force, (FZ), which produces in the cutting speed direction, feed force, (FX), which produces in the feed rate direction and the radial force, (FY), which produces in radial direction and which is normal to the cutting speed) [9]. In a turning activity, it is a significant errand to choose cutting parameters for accomplishing high cutting execution. For the most part, the ideal cutting parameters are resolved dependent on experience or by utilization of a handbook. To choose the cutting parameters appropriately, a few numerical models dependent on factual relapse procedures or neural figuring have been built to set up the connection between the cutting execution and the cutting parameters. [1]

In the present study, the Taguchi method is used as an efficient approach to determine the optimal machining parameters for CNC turned parts for optimization of surface roughness (SR), material removal rate (MRR). In experimental design orthogonal array L_9 is used for three controllable factors (Feed, depth of cut & Tool nose radius) to find the optimum setting of process parameters for CNC turning of SS304 steel. Finally, the analysis of variance (ANOVA) is used to find out the most influential CNC turning parameter.

2. EXPERIMENTAL METHODOLOGY

2.1 Specimen material and cutting tool material

CNC Turning operation was performed on SS 304 steel of dimension 30mm diameter & 50mm length and its chemical composition is shown in Table 1. The specimen material is shown in fig. 1. AISI 304 stainless steel is austenitic grade. The three different Cutting Insert material used for this experimentation (TNMG160404, TNMG160408 & TNMG160412)

Table -1: Chemical composition of SS304 Steel

Content	C	Si	Mn	P	Cr	Ni
%	0.06	0.29	0.90	0.03	18.3	8.3

In this work three control factors with three levels of each were investigated. The control factors (Cutting speed, Feed, Depth of cut, Tool nose radius) along with their levels as shown in Table 2.

Fig -1: Specimen Material

2.2 Process Parameters

Three factors (Feed, Depth of cut & Tool nose radius) at 3 levels each are as follows

Table -2: Taguchi L_9 Orthogonal array

Control Factors	Units	Level I	Level II	Level III
Feed	mm/rev	0.05	0.10	0.15
Depth of cut	mm	0.2	0.4	0.6
Tool nose radius	mm	0.4	0.8	1.2

2.2 Taguchi Method

The Orthogonal array L_9 is shown in Table 3. For surface roughness quality characteristics Smaller the better is selected.

Table -3: Taguchi L_9 Orthogonal array

Run	Factor 1 Feed (mm/rev)	Factor 2 Depth of Cut (mm)	Factor 3 Tool nose radius (mm)
1	0.05	0.2	0.4
2	0.05	0.4	0.8
3	0.05	0.6	1.2
4	0.10	0.2	0.8
5	0.10	0.4	1.2
6	0.10	0.6	0.4
7	0.15	0.2	1.2
8	0.15	0.4	0.4
9	0.15	0.6	0.8

2.3 Experimental Setup

The experiments are conducted on Jyoti Dx 200 Year2013/6 (chuck dia. 200mm, Turning dia. 250mm and maximum turning length 600mm) CNC lathe machine. The photograph of experimental set up as shown in fig. 3.3. The all experiments were performed at dry condition.

Fig -2: Photograph of experimental set up

Table -4: Experimental result for Tensile strength

Run	Factor 1 Feed (mm/rev)	Factor 2 Depth of Cut (mm)	Factor 3 Tool nose radius (mm)	Response 1 Surface Roughness (μ_m)
1	0.05	0.2	0.4	0.90
2	0.05	0.4	0.8	0.94
3	0.05	0.6	1.2	1.07
4	0.10	0.2	0.8	0.81
5	0.10	0.4	1.2	1.01
6	0.10	0.6	0.4	1.10
7	0.15	0.2	1.2	0.92
8	0.15	0.4	0.4	1.00
9	0.15	0.6	0.8	0.97

2.4 S/N ratio

The signal-to-noise (S/N) ratio is calculated for each factor level combination. The formula for the Smaller-is-better S/N ratio using base 10 log is:

$S/N = -10 * \log (\Sigma (Y^2)/n)$ --------------- (1)

Where Y = responses for the given factor level combination and n = number of responses in the factor level combination.

Table -5: Experimental result for Tensile strength

Run	Factor 1 Feed (mm/rev)	Factor 2 Depth of Cut (mm)	Factor 3 Tool nose radius (mm)	S/N Ratio Surface Roughness
1	0.05	0.2	0.4	0.91
2	0.05	0.4	0.8	0.54
3	0.05	0.6	1.2	-0.59
4	0.10	0.2	0.8	1.83
5	0.10	0.4	1.2	-0.086
6	0.10	0.6	0.4	-0.83
7	0.15	0.2	1.2	0.72
8	0.15	0.4	0.4	0.00
9	0.15	0.6	0.8	0.26

3. RESULT & DISCUSSION

3.1 ANOVA Analysis of Surface roughness

ANOVA is similar to regression in that it is used to investigate and model the relationship between a response variable and one or more predictor variables. ANOVA of the overall grade is done to show the significant parameters. If the P value for a factor becomes less than 0.05 then that factor is considered as significant factor at 95% confidence level. Statistical software with an analytical tool of ANOVA is used to determine which parameter significantly affects the performance characteristics.

Table -6: ANOVA for Tensile strength

Source	DF	Seq SS	Adj MS	F	P	% Contribution
F	2	0.00258	0.00129	0.02	0.980	0.049%
DOC	2	3.66991	1.83496	29.72	0.033	69.81%
TNR	2	1.46067	0.73034	11.83	0.078	27.78%
Residual Error	2	0.12348	0.06174			2.35%
Total	8	5.25665				100

The Analysis of variance result for surface roughness as shown in Table 6. From the result of ANOVA for Surface roughness the depth of cut shows more contribution of 69.81%, Feed shows contribution of 0.049% and tool nose radius shows 27.78% contribution here the residual error was found as 2.35%.

3.2 Main effect plot for S/N Ratio

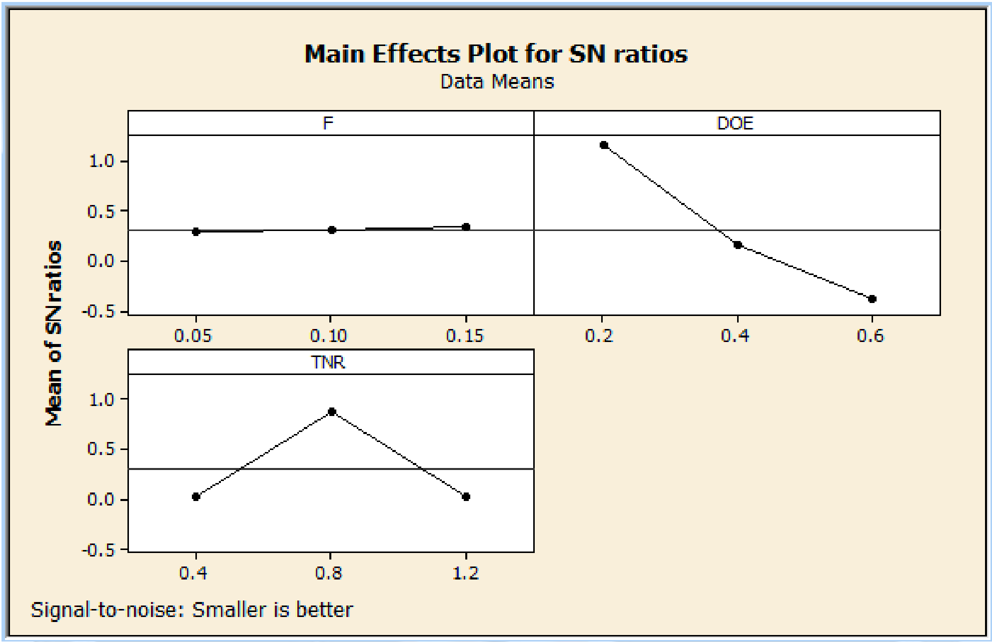

Fig -3: Main Effect Plot for S/N ratio of Surface Roughness

Figure 2 shows the main effect for S/N Ratio of Surface roughness. From Figure 3 the optimum level of cutting parameters are obtained at feed of 0.15 mm/rev and depth of cut of 0.2 mm & tool nose radius of 0.8 mm. From analysis it is also found that depth of cut is the most influencing parameter for surface roughness followed by feed & tool nose radius.

3.3 Confirmation test

Confirmation test were carried out on parameters of feed of 0.15 mm/rev and depth of cut of 0.2 mm & tool nose radius of 0.8 mm.. The result of confirmation test as shown in Table 7.

Table -7: Confirmation test for Tensile strength

Verification experiment No.	Verification experiment for	Predicted value	Experimental value
1	Minimum Surface roughness	0.81	0.8088

4. CONCLUSIONS

In this work nine experiments were conducted with three levels of cutting parameters on SS 30 Steel material. Influence of feed, depth of cut & tool nose radius investigated by using taguchi and ANOVA analysis. From analysis the following conclusions are drawn:

1. From ANOVA analysis it is found that depth of cut is most significant factor for surface roughness followed by feed & tool nose radius.
2. For Surface roughness the depth of cut shows more contribution of 69.81% followed by feed and tool nose radius.
3. The optimum level of cutting parameters are obtained for Surface roughness at feed of 0.15 mm/rev, depth of cut of 0.2 mm, tool nose radius of 0.8 mm.
4. Feed rate has very negligible effect on surface roughness.

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