Parametric Optimization of Heat Treated SS202 Alloy Steel in Turning Operation Using Taguchi Method

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Abstract - In many machining operations surface finish is one of the most important factor, as it helps in maintaining close tolerance. It also applies to the turning operations. So it is very essential to get desired surface finish and to attain it optimized machining conditions are required. In this experiment we have selected four parameters (spindle speed, depth of cut, feed rate and flow rate of lubricant) for optimization. We have also studied the effect of fourth parameter on machining. The material selected for the experiment is SS202 alloy steel(0.1% c).In this work turning operations has been done on SS202 alloy steel by carbide tip cutting tool in wet condition and the combinations of factors were obtained to get optimum condition for minimum surface roughness. Taguchi method is used to study the performance of turning operations. The predicted and measured values are fairly closed and this model can be effectively used to predict the surface roughness in turning operation.

Keywords: Surface Roughness, Heat Treatment, Orthogonal L9 Array.

I. INTRODUCTION

One of the important measures of product quality is surface roughness that greatly influences the performance of mechanical parts as well as production cost. The machinability of materials is determined by surface finish and dimensional accuracy are the important factors required to predict machining parameters of any machining operations, optimization of machining parameters not only increases the utility for machining economics, but also the product quality increases to a great extent. Since Turning is the primary operation in most of the production process in the industry, surface finish of turned components has greater influence on the quality of the product. During turning, cutting tools remove material from the component to achieve the required shape, dimension and surface roughness (finish). However, wear occurs during the cutting action, and it will ultimately result in the failure of the cutting tool. The criterion for the end of tool life is varied, either the tool is reground or replaced when it fails to cut and ceases out, when the dimensions or surface finish of the work-piece change, or when the temperature begins to rise and fumes are generated. The symptoms of the end of tool life should be detected to avoid damage caused by total tool failure. Surface finish and tool life in turning operation have been found to be influenced in varying amounts by a number of factors such as feed rate, work material characteristics, work hardness, unstable built up edge, cutting speed, depth of cut, cutting time, tool nose radius and tool cutting edge angle, use of cutting fluids etc. In this context, efforts can be made to estimate the surface roughness using experimental data.

II. SYSTEM MODEL

Heat treatment of SS-202 Steel is done to reduce the hardness of the material in the furnace to about 730^{o} to 850^{o} for one hour and cooled in the furnace itself. To perform turning operation L9 Taguchi orthogonal array method has been used in order to study the effect of four different process parameters (spindle speed, Depth of cut, Feed rate and Flow rate) on the surface roughness of SS202 Alloy steel in turning operations by Carbide P-30 cutting tool and surface roughness was measured. Therefore for the following research, SS202 steel with carbon (0.1%), silicon (0.75), Chromium (16%) and Manganese (10%) Nickel (0.25%), phosphorous (0.1), Sulphur (0.01) was chosen for specimen material.

Fig. 2.1 Name of Figure(9pt, Normal)

III. PREVIOUS WORK

Roughness measurement in turning operation is already been done by using different parameters and different conditions By Mr Vishal Francis to find the surface roughness of the material using Anova. [1]

In the second paper [2] five different parameters have been taken and surface roughness of the material is measured using Taguchi method. In this article [3] an analytical equation is used to calculate surface roughness, Ra value. The deviation that often occurs between the expected and the obtained surface roughness during these machining operations is investigated.

IV. PROPOSED METHODOLOGY

Taguchi Uses Design of experiment which reduces complex Algebra in simpler form and minimize the number of experiments, Taguchi proposed L9 orthogonal array for four different parameters and three different levels.

Table No.1 Control Parameters at their various Levels

Factors	Level 1	Level 2	Level 3
Depth of cut (mm)	0.3	0.6	0.2
Feed (mm/rev)	0.2	0.4	0.6
Spindle speed (rpm)	500	350	225
Flow rate (ml/s)	3.12	1.66	4.54

V. SIMULATION/EXPERIMENTAL RESULTS

Table No 2: Results of Experimental Trial Runs for Turning Operation

S.no	Spindlespeed (rpm)	Depth of cut (mm)	Feed (mm/rev)	Flow rate (ml/s)	Surface roughness (µm)	SNRA	Me-an
1	500	0.3	0.2	3.12	43	-32.6694	43
2	500	0.6	0.4	1.66	68.8	-36.7518	68
3	500	0.2	0.6	4.54	25	-27.9588	25
4	350	0.3	0.4	4.54	64	-36.1236	64
5	350	0.6	0.6	3.12	46	-33.2552	46
6	350	0.2	0.2	1.66	52	-34.3201	52
7	225	0.3	0.6	1.66	38	-31.5957	38
8	225	0.6	0.2	4.54	39	-31.8213	39
9	225	0.2	0.4	3.12	28	-28.9432	28

Table No. 3 Response Table for Signal to Noise Ratios

Smaller is better

Level	Spindle speed A	Depth of cut B	Feed rate C	Flow rate of lubricant D
1	-30.79	-30.41	-32.94	-34.22
2	-34.57	-33.46	-33.94	-31.62
3	-32.46	-33.94	-30.94	-31.97
Delta	3.78	3.54	3.00	2.60
Rank	1	2	3	4

From the table no. 4 optimum parameters for turning operations were A2, B3, C2 and D1.

Signal to noise ratio is utilized to measure the deviation of quality characteristics from the target. In this experiment the response in the surface roughness which should be minimized so the desired SNR characteristics are in the category of smaller is better. The difference of SNR between level 1, 2, 3 indicates that spindle speed contributes highest effect (Δmax-Δmin=3.78),Depth of cut (Δmax-Δmin=3.54), Feed rate(Δmax-Δmin=3.00) and Flow rate(Δmax-Δmin)=2.60

Therefore the predicted value of S/N ratio for turning operation

$\eta_{p\ (Surface\ Roughness)}$

$$= -32.60+ [-30.79-(-32.60)] + [-30.41-(-32.60)] + [-30.94-(-32.60)] + [-31.62-(- 32.60)] = \mathbf{25.96\ \mu m}$$

Table No. 4: Response Table for Means

Level	Spindle speed(rpm)	Depth of cut(mm)	Feed rate(mm/rev)	Lubrication rate(ml/s)
1	35.00	35.00	44.67	52.93
2	54.00	48.33	53.60	39.00
3	45.60	51.27	36.33	42.67
Delta	19.00	16.27	17.27	13.93
Rank	1	3	2	4

From Table 5 Optimal Parameters for Surface Roughness were A1, B1, C3 and D2 table shows the SNR of the surface roughness for each level of the factors. The difference between level 1, 2 and 3 indicates Spindle Speed contributes the highest effect (Δmax-min = 19.00) on the surface roughness followed by Feed rate (Δmax-min = 17.27), Depth of cut (Δmax-min = 16.27), Lubrication rate (Δmax-min = 13.93).

Therefore the Predicted optimal value of Surface Roughness

$\beta_{p\ (Surface\ Roughness)}$

= 44.66+[35.00-44.66]+[35.0-44.66] + [36.33-44.66]+[39.00-46.66]= **9.35 µm**

Fig 01. Main effects for Surface Roughness

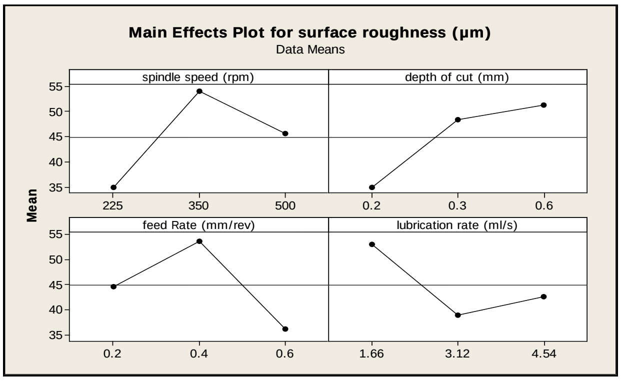

Fig 02. Interaction plot for surface Roughness

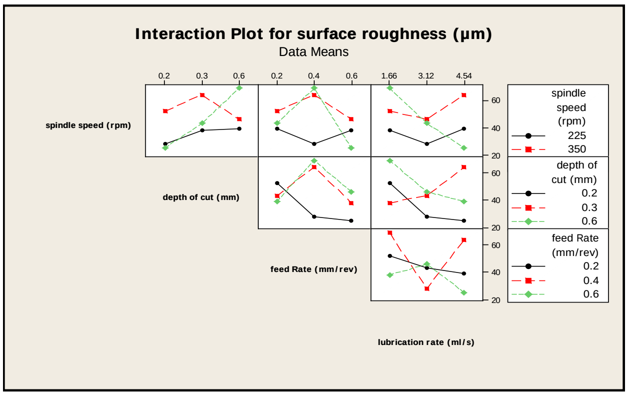

Fig 03. Main Effects plots for SN ratios

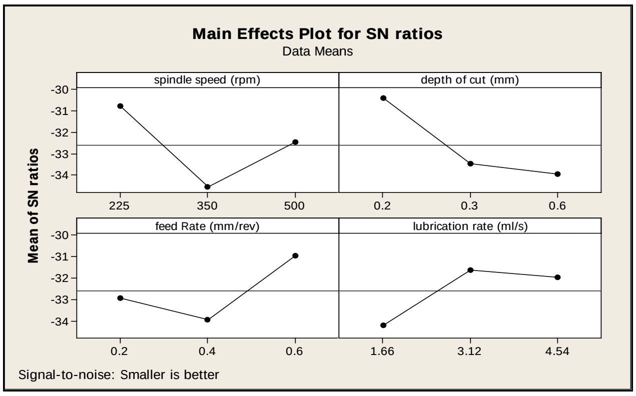

TABLE NO. 5

Chemical Composition of SS-202 Alloy Steel Specimen

Material	C%	Si%	Cr%	Ni %	P%	Mn
SS-202	0.1	0.75	16	10	0.1	10

VI. CONCLUSION

- The use of a standard L9 orthogonal array, with four control parameters required the workpieces to conduct the experimental portion
- Minimum Surface Roughness can be obtained at the second level of Spindle Speed (350 rpm), third level of Depth of Cut (0.2 mm),second level of Feed (0.4 mm/rev) and first level of lubrication rate(3.12 ml/s). Therefore it is recommended that the above results can be used to get lowest surface roughness.
- A confirmation test was then performed, which indicated that the selected parameter and predictive equation were accurate to within the limits of the measurement instrument.

VII. FUTURE SCOPES

- In this work, the material used is SS-202 Alloy steel with 0.1% carbon. The experimentation can also be done for other materials also having high hardness to see the effect of parameters on Surface Roughness.
- In DOE the number of trails can be repeated with the same combinations of factors and their interactions can be obtained to obtain more than one response and effects.
- The research can be extended by using tool nose radius rake angles, different lubricants, material hardness etc. as factors.

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