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Optimization of CNC Turning Parameters for Surface Roughness on EN 354 Steel using Taguchi Method

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Abstract—*The aim of this research paper is to optimize the CNC turning parameters to get the minimum surface roughness on EN 354 alloy steel using Taguchi method. Taguchi optimization methodology is applied to optimize cutting parameters i.e. cutting speed, feed rate and depth of cut and results are analyzed using Analysis of Variance (ANOVA). The main purpose of this technique is to produce high quality products with maximum productivity in short time at low cost. Number of experiments have been conducted with suitable combination of input parameters which affects the surface roughness. The experiments have been conducted using L9 orthogonal array on STALLION 100HS CNC machine and MINITAB-17 software is used. In the present research work, a single characteristic response optimization model based on Taguchi Technique is developed to optimize process parameters, such as feed rate, cutting speed and depth of cut using single point cutting tool. Taguchi method shows that the cutting speed has been the most significant factor followed by feed rate as far as surface roughness is concerned and the depth of cut has least effect on surface roughness.*

Keywords*: Surface Roughness, ANOVA, EN 354 Steel, MINITAB - 17Software, CNC Turning, Taguchi Method.*

1. INTRODUCTION

Metal cutting is one of the most important and widely used manufacturing processes in engineering industries and in today's manufacturing scenario, optimization of metal cutting process is essential for a manufacturing unit to respond effectively to severe competitiveness and increasing demand of quality which has to be achieved at minimal cost [1]. Machining is an essential finishing process by which jobs of desired dimensions and surface finish are produced by gradually removing the excess material from the performed blank in the form of chips with the help of cutting tools moved past the work surfaces [2]. Based on the literature review it was conclude that the factors that highly influences the process efficiency and output characteristics in a CNC machine tool are tool geometry, spindle speed, feed rate and depth of cut. Surface finish is an important parameter in manufacturing engineering. Surface roughness which is used to determine and to evaluate the quality of a product, is one of the major quality attributes of a turning product. This study helpful in evaluating optimum machining parameter like tool geometry, tool material, cutting speed, feed rate and depth of cut for turning of EN 354 alloy steel on CNC Lathe machine. The selection of optimal cutting parameter like the spindle speed, depth of cut for each pass, feed rate and cutting tool is a very critical issue for every machining process. The three primary process parameter in any basic Turning operation are cutting speed, feed rate, and depth of cut. Speed always refers to the spindle and the work piece. Feed is the rate at which the tool advances along its cutting path. Depth of cut is the thickness of the material that is removed by one pass of the cutting tool over the work piece. After experimentally turning sample work pieces using the selected orthogonal array and parameters, this study produced a verified combination of controlled factors and a predictive equation for determining surface roughness with a given set of parameters.

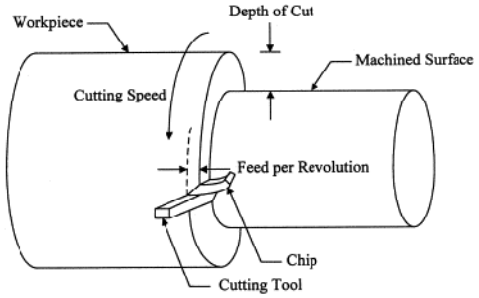


Fig. 1: Representation of turning process

2. TAGUCHI TECHNIQUE

The Taguchi experimental design method, by Genichi Taguchi is a well-known, unique and powerful technique for product or process quality improvement. It is widely used for analysis of experiment and product or process optimization. Taguchi method is a powerful tool for the design of high quality

systems. It provides simple, efficient and systematic approach to optimize designs for performance, quality and cost [3]. Taguchi method is efficient method for designing process that operates consistently and optimally over a variety of conditions.

Step of Taguchi method follows as:

1. Selection of the factors to be evaluated.
2. Selection of the number of levels.
3. Selection of the appropriate orthogonal array.
4. Assignment of factors to the columns.
5. Conduct the experiment.
6. Analyze the result.
7. Carry out the experiment.

3. LITERATURE REVIEW

Mr.Manoj Kumar Sahoo [4] reported the optimization of turning process by the effects of machining parameters applying Taguchi methods. Three machining parameters i.e., Spindle speed, Feed rate and Depth of cut. Experiments were done by varying one parameter and keeping other two fixed so maximum value of each parameter was obtained. Taguchi orthogonal array is designed with three levels of turning parameters with the help of software Minitab 16**. Dr.S.S.Chaudhari et.al [5]** investigated a single characteristic response optimization model based on Taguchi Technique was developed to optimize process parameters, such as speed, feed, depth of cut, and nose radius of single point cutting tool. Taguchi's L9 orthogonal array is selected for experimental planning. The experimental result analysis showed that the combination of higher levels of cutting speed, depth of cut and lower level of feed is essential to achieve simultaneous maximization of material removal rate and minimization of surface roughness. **Ajay Mishra and Dr. Anshul Gangele[6]** used Taguchi techniques to find out the optimum tool flank wear width in turning operation of AISI 1045 Steel. A L9 orthogonal array, S/N ratios and ANOVA are used to study the performance characteristics of cutting speed, feed rate and depth of cut as turning parameters with tool flank wear width as response variable. **Harsimran Singh Sodhi and Harjot Singh [7]** Discusses an investigation into the use of Taguchi Parameter Design for optimizing surface roughness generated by a conventional lathe. Control parameters being consider in this paper are cutting speed, feed rate and depth of cut. After experimentally turning sample work piece using the selected orthogonal array and parameters, this study expected to produce an optimum combination of controlled parameter for the surface roughness. **Prof. Atul dhale and Fahim khan [8**] proposed three cutting conditions dry cut, cutting with water as coolant and normal coolant were used. The material used in study is EN8. Three cutting parameters namely feed rate, depth of cut, cutting speed are optimized with consideration with surface roughness. Taguchi method is used find optimal cutting parameters for surface roughness (Ra) in turning. **R.K Suresh & G.Krishnaiah [9]** investigated an optimal setting of process parameters in turning for maximizing material removal rate. In this work En 41B alloy steel has been taken as work material and cermet as tool. A number of experiments have been conducted as Taguchi DOE. By Taguchi analysis process parameters such as spindle speed, feed and depth of cut has been optimized for maximum MRR and by ANOVA. **MeenuSahu and KomeshSahu[10]** presents an optimization method of cutting parameters (cutting speed, depth of cut and feed) in dry turning of AISID2 steel to achieve minimum tool wear, low work piece surface temperature and maximum material removal rate. The experimental layout was designed based on Taguchi OA technique and ANOVA was performed to identify the effect of cutting parameters on the response variables. The results showed that depth of cut and cutting speed are the most important parameters influencing wear.

4. WORK MATERIAL & CUTTING TOOL

The experimental investigation presented here was carried out on a HMT STALLION 100 HS CNC lathe with 5.5 kW power rating. The work material selected in this investigation was EN354 alloy steel. The chemical composition of the EN354 alloy steel includes:

Material	C	Mn	Si	S	Cr	Ni	Mo
EN 354	0.20	05.-1.0	.35	.40	.75-1.25	1.5-2.0	.10-.20

Commercially available EN354 round bar of dia. 40 mm was used as work piece material. A commercially available single point CNMG 120408 GT cutting tool was used as cutting tool material.

Fig. 2: HMT STALLION 100 HS CNC lathe

The work piece material which is turned on CNC machine shows as:

Fig. 3: Shows the workpiece material after machining

The surface roughness (Ra) was measured using Digital Portable Surface Roughness Tester or SRT 6210. It is small in size, light in weight, easy to use.

Fig. 4: SRT 6210

5. DESIGN OF EXPERIMENTS

In this study, Taguchi method is used for single characteristics optimization has been used to establish correlation between the independent variables therefore; the experiments were performed according to a Taguchi design of experiments. To perform the experimental design, a total of three parameters namely cutting speed, feed rate and depth of cut were chosen for the controlling factor, and each parameter is designed to have three level.

Table 1: Process parameters and their levels

Symbol	Factor	Unit	Level1	Level2	Level3
A	Speed	mm/min	125	175	225
B	Feed	mm	0.05	0.10	.15
C	DOC	mm	0.8	1.0	1.2

6. RESULTS AND DISCUSSION

The surface roughness Ra was measured using the input factors namely cutting speed, feed rate and depth of cut. The response, surface roughness was measured by varying the machining parameters and the corresponding values is shown in table 2. The statistical analysis is done using MINITAB (version17) software for obtaining the main effect, interaction effect and graphs. The surface roughness plots for means and signal to noise ratio are given in table 3 and 4.

Experimental details:

Table 2: L9 Orthogonal Array.

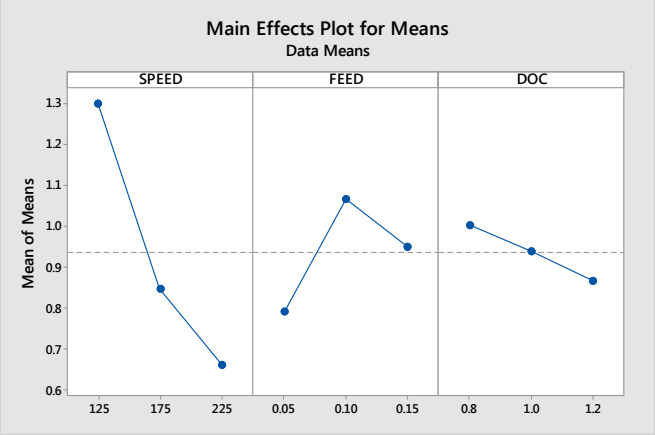
Sr. No	Cutting speed	Feed rate	Depth of cut	Surface roughness	S/N Ratio for Ra
1.	125	0.05	0.8	1.19	-1.510
2.	125	0.10	1.0	1.48	-3.405
3.	125	0.15	1.2	1.23	-1.798
4.	175	0.05	1.2	0.68	3.349
5.	175	0.10	0.8	1.03	-0.256
6.	175	0.15	1.0	0.83	1.618
7.	225	0.05	1.0	0.51	5.848
8.	225	0.10	1.2	0.69	3.223
9.	225	0.15	0.8	0.79	2.047

Table 3: Response table for means (Smaller is better)

Level	Cutting Speed	Feed Rate	Depth of Cut
1.	1.3000	0.7933	1.0033
2.	0.8467	1.0667	0.9400
3.	0.6633	0.9500	0.8667
Delta	0.6367	0.2733	0.1367
Rank	1	2	3

Table 4: Response table for Signal to Noise ratios (Smaller is better)

Level	Cutting Speed	Feed Rate	Depth of Cut
1.	-2.23809	2.56249	0.09326
2.	1.57051	-0.14632	1.35393
3.	3.70636	0.62260	1.59158
Delta	5.94445	2.70881	1.49832
Rank	1	2	3



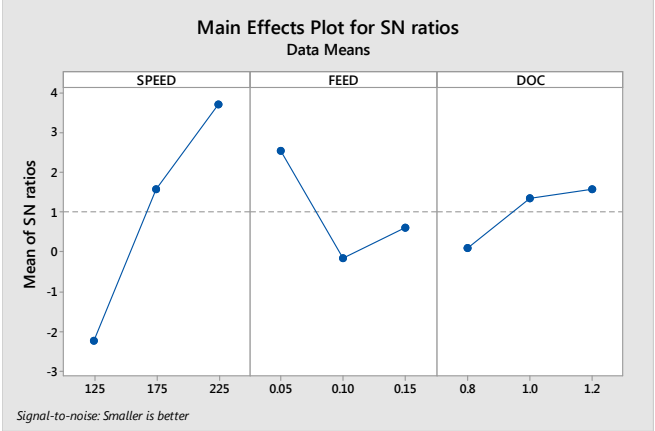


Fig. 5: Effect of turning parameters on Surface Roughness.

Table 5: Result of ANOVA for Surface Roughness contribution

Source	DF	SeqSS	AdjSS	F	P	%C
Speed	2	54.40	27.20	93.2	0.011	77.09
Feed	2	11.69	11.69	20.04	0.048	16.5

DOC	2	3.89	3.89	6.67	0.13	5.5
Residual error	2	0.583	0.583			0.08
Total	8	70.57				

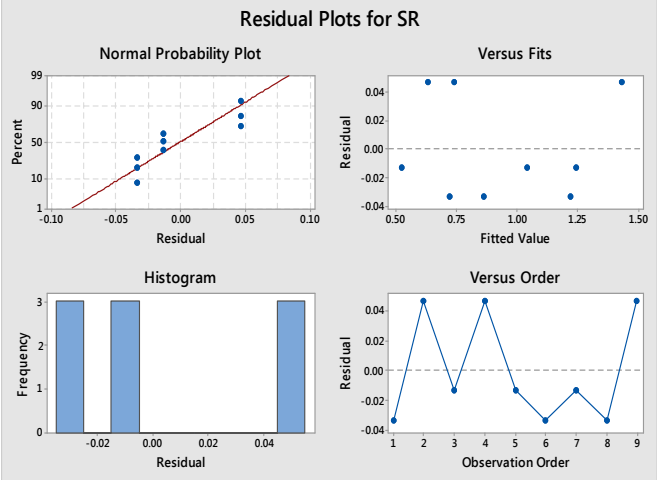


Fig. 6: Residual analysis of Surface Roughness

Interaction plot for S/N ratios of the surface roughness for data means is shown in fig. Signal to Noise ratio of common interest for optimization for surface roughness is smaller the better.

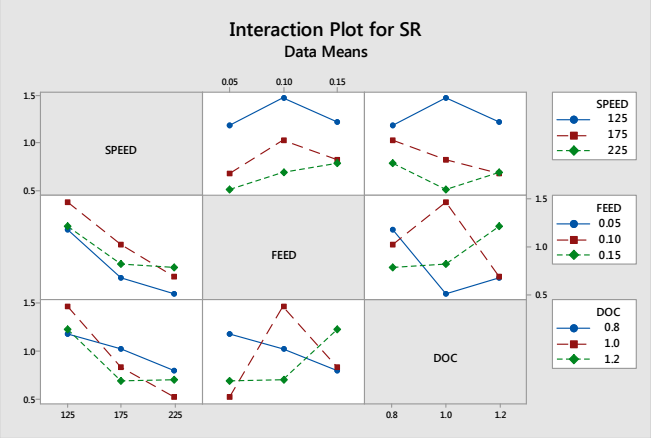


Fig. 7: Interaction plot for S/N Ratios of the Surface Roughness.

Graphs are drawn from the data obtained from the experiments. When Speed increases surface roughness decreases and feed increases surface roughness increases. But in the case of depth of cut, it increases with increase in surface roughness values. In the case of S/N ratios, surface roughness increases with increase in cutting speed. But when Feed rate decreases, the surface roughness value also decreases. Plots for means and SN ratios are shown in figure respectively. From the Taguchi analysis it was found that the speed is the most important significant factor which affects the surface roughness Ra followed by feed rate and depth of cut respectively.

7. CONCLUSION

- The experimental results showed that the Taguchi parameter design is an effective way of determining the optimal cutting parameters for achieving low surface roughness.
- The Machining Parameters namely cutting speed, Feed rate, depth of cut is optimized to meet the objectives. The results reveal that the primary factor affecting the surface roughness is speed, subsequently followed by feed and depth of cut.
- The cutting speed is the most significant factor which contributes to the surface roughness 77.09% subsequently followed by feed which contributes 16.5% and depth of cut has least significant factor contributes 5.5%.
- The optimized factor for minimizing the Surface roughness Ra is Feed rate f1=0.05mm/rev, Cutting speed, V3=225m/min, Depth of Cut d3=1.2mm.

REFERENCES

[1] S.N.NAIK, J.S.Sidhu, S.S.Kulkarni "optimization of cutting parameters of ss316 using different cutting tool on CNC lathe", *IJSRMS* Volume1 Issue 9, pages 275-282.

[2] Shunmugesh K., Panneerselvam K. "Optimization of CNC turning parameters with carbide tool for surface roughness analysis using Taguchi analysis" *Research Journal of Engineering Sciences* vol.3(6), 1-7 June 2014.

[3] W.H. Yang, Y.S. Tang, Design optimization of cutting parameters for turning operations based on Taguchi method, *Journal of Materials Processing Technology*, 84 (1998) 122-129.

[4] Mr. Manoj Kumar Sahoo, 2013. "Parametric Analysis and Optimization of Turning Operation by Using Taguchi Approach", *International Journal of Modern Engineering Research*, Vol.3 (4), 2154-2156.

[5] Dr.S.S.Chaudhari, S.S. Khedkar and N.B. Borkar. "Optimization of process parameters using Taguchi approach with minimum quantity lubrication for turning", *International Journal of Engineering Research*, Vol.1 (4), 1268-1273.

[6] Ajay Mishra and Dr. Anshul Gangele, 2012. "Application of Taguchi Method in Optimization of Tool Flank Wear Width in Turning Operation of AISI 1045 Steel", *Industrial Engineering Letters*, Vol. 2(8), 11-18.

[7] Harsimran Singh Sodhi and Harjot Singh, 2013. "Parametric Analysis of Copper for Cutting Processes Using Turning Operations Based on Taguchi Method", *International Journal of Research in Mechanical Engineering & Technology*, Vol. 3(2), 202-204.

[8] Prof. Atul dhale and Fahim khan, 2013. "Optimization by Taguchi method and In process Monitoring of Cutting Parameters using Acoustic Emission for EN8", *International Journal of Application or Innovation in Engineering & Management*, Vol.2 (11), 465-471.

[9] Meenu Sahu, Komesh Sahu (2014) Optimization of cutting parameters on tool wear, work piece surface temperature and material removal rate in turning of AISI D2 steel, *International Journal of Advanced Mechanical Engineering*, Vol 4, No 3,pp 291-298.

[10] RK.Suresh&G.Krishnaiah (2013) Parametric optimization on single objective dry turning using Taguchi method, *International journal of Innovations of Engineering and Technology*, Vol 2, Issue2, pp 263-269.