IJMTST is UGC Approved Journal with Journal Id: 43137

International Journal for Modern Trends in Science and Technology, 8(S06): 146-151, 2022

ISSN: 2455-3778 online
DOI: https://doi.org/10.46501/IJMTST08S0721
Available online at: https://www.ijmtst.com/vol8si07.html

Optimization of Cutting Parameters in Turning of EN24 Steel by Using Taguchi's Method

Rajnishkumar Singh, M. Sivaramakrishna, B. Prasanth, K. Sai Surya Hemanth, K. Sai Teja

Department of Mechanical Engineering, Godavari Institute of Engineering and Technology(A), JNTUK, Kakinada.

To Cite this Article
Rajnishkumar Singh, M. Sivaramakrishna, B. Prasanth, K. Sai Surya Hemanth and K. Sai Teja. Optimization of Cutting Parameters in Turning of EN24 Steel by Using Taguchi's Method. International Journal for Modern Trends in Science and Technology 2022, 8(S06), pp. 146-151. https://doi.org/10.46501/IJMTST08S0721

Article Info
Received: 26 April 2022; Accepted: 24 May 2022; Published: 30 May 2022.

ABSTRACT

The purpose of this research is to investigate EN24 steel utilizing the Taguchi optimization approach for optimum material removal rate and minimal surface roughness when turning EN24 steel with an HSS tool on an Engine lathe machine. Randomly selecting cutting parameters has a significant impact on final output reactions such as surface roughness, tool life, and other workpiece and tool attributes. Three various turning process parameters, such as Cutting Speed, Feed Rate, and Depth of cut, are investigated for optimization in this work by altering them on three levels. Because it decreases the number of tests, the Taguchi technique is a suitable approach for optimizing various machining settings. As a result, an appropriate orthogonal array was chosen, and experiments were conducted. The MRR and surface roughness were assessed and the signal to noise ratio estimated once the trials were completed. Optimal values and confirmation experiments were determined using graphs. To identify the ideal settings and examine the influence of the cutting parameters on maximum material removal rate and minimal surface roughness, a further analysis is done.

KEYWORDS: Optimization, CNC Turning, Taguchi's Method, L9 Orthogonal Array, Spindle speed, depth of cut, Feed Rate

1. INTRODUCTION

Manufacturing is a phrase used to describe the process of turning a finalized design into physical real-world goods or components. A manufacturing process with numerous factors is studied, and each parameter chosen for manufacturing the product determines the degree of acceptability and rejection of the finished product. Identifying the optimal mix of factors involved in a manufacturing process is a necessary step before starting the process.The key problems of the metal-based sector are increasing productivity and improving the quality of machined products; there has been a greater interest in monitoring all elements of the machining process.Turning is a type of machining that involves cutting away undesirable material in order to generate rotatable pieces. A turning machine or lathe, a work piece, a fixture, and a cutting tool are all necessary for the turning process. The work piece is a pre-shaped piece of material that is fixed to the fixture, which is then attached to the turning machine and rotated at high speeds. The cutter is usually a single-point cutting tool that is locked into the machine.

EN24 is a medium-carbon low-alloy steel that is commonly used in the production of automotive and machine tool parts. Large cutting pressures, high cutting tool temperatures, poor surface smoothness, and built-up edge development are all issues in EN24 steel machining due to its low specific heat and tendency to strain-harden and diffuse between tool and work material. As a result, this material is tough to process.The nose radius is one of the most essential elements in tool geometry. It strengthens the tool point by thinning the chip near the tool's point and spreading it over a larger area of the point. It also gives a superior polish since the tool markings aren't as deep as sharp tool marks [4].For machining parameter optimization, various techniques such as Taguchi's Experimental Design, Response Surface Methodology, Definitive Screening Design, and Genetic Algorithm are commonly used. [10,12]. The Taguchi technique appears to be the best way for determining the best cutting parameters for turning operations of different materials in a machine shop [8,11].

Dr. Taguchi of the Nippon Telephone and Telegraph Company in Japan created a method based on "ORTHOGONAL ARRAY" experiments that results in a considerably lower "variance" for the experiment with" optimal settings" of control parameters. The Taguchi Method therefore combines Design of Experiments with optimization of control settings to provide the best results. Dr. Taguchi's Signal-to-Noise ratios (S/N), which are log functions of desired output, serve as objective functions for optimization, aid in data analysis, and prediction of optimal outcomes.[9]

The goal of this project is to use the Taguchi technique to observe cutting parameters in turning and determine the optimum value of the parameters in order to optimize surface roughness and Material Removal Rate. The statistical analysis will be carried out in order to improve machining operations and quality control of machined components.

2. REALATED WORK

The perspectives of many writers on optimising cutting parameters in turning of various materials using the Taguchi technique were studied. Many researchers have studied various aspects of plain turning, the majority of which are focused on cutting speed, feed rate, and depth of cut [1]. Various other parameters are also considered for the optimization of the turning performance, measured mainly in form of surface roughness, tool wear etc. [2, 6]. Many of the works combined ANOVA with Taguchi orthogonal array to get a perspective of impact of various parameters that influences the turning operation [3, 7]. Comparative studies has also been done to establish the most effective parameter that affects surface finish of turned workpiece [5].

This paper explores the influence of machining parameters such as Spindle speed, feed rate and depth of cut on the surface roughness as well as material removal rate for the turning operation. The paper is aimed find the optimal set of parameters for minimum surface roughness and maximum MRR, an effort has been made to also rank the effect of different parameters on both using MINITAB-19.

3. PROPOSED WORK

The present work is aimed to optimise the cutting parameters for the turning of EN24 Steelbars to obtain maximum MRR and minimum Surface roughness. The cutting parametersevaluated are feed rate, cutting speed and depth of cut. The optimization technique used isTaguchi's experimental design method, which is a reliable, cost effective and efficient way tooptimize design for performance, quality etc.Orthogonal arrays of Taguchi are employed to find the optimal levels and to analyse theeffect of the cutting parameters on maximum material removal rate and minimum surfaceroughness. To design the orthogonal arrays for different parameter levels and for the analysisof the experimental work Minitab – 19 statistical software was used.

4. EXPERIMENTAL SETUP AND PROCEDURE

A. CNC Lathe

An Emco Turn 105 CNC lathe was used to perform the turning operation. The table no. 1 following are the specification of the CNC Lathe.

Figure 1: Cnc turning machine

B. Cutting Tool

The turning tool is a CNC turning tool with a cutting component. In CNC milling, turning tools are one of the most commonly utilised tools. The cutting edge, the structure for breaking or rolling up the chips, the space for chip removal or storage, and the passage of cutting fluid are all parts of the turning tool that generate and handle chips.

Table 1: Specifications of cnc turning machine

CNC Machine Make	LT2 XL
Chuck size	200/250 mm
max turning dia	290 mm
Max swing over carriage	290 mm
Max turning length	400/500 mm
Spindle power (KW)	11 KW
Axis motor N/M	8 N/M

Weight of machine	4000 kg
Cast bad	Yes
Type of spindle	A2-6
Spindle RPM	4000

In this Experiment we are using Carbide cutting tool. Cast iron, non-ferrous metals, plastics, chemical fibres, graphite, glass, stone, and conventional steel are all cut with this blade, which is made of cemented carbide. It can also be used to cut materials including heat-resistant steel, stainless steel, high-speed steel, and tool steel that are tough to process.

Figure 2: Cnc carbide turning tool

Table 2: Chemical composition of carbide cutting tool

Tool	Tungsten	Chromium	Vanadium	Carbon	Cobalt	Iron
Carbide	13 %	4.75 %	6 %	2.15 %	10 %	64.1 %

C. Work piece material

Long Rods of EN24 Steel of diameter 24mm were used for turning operation, which were cut by power hacksaw into pieces of equal length of 60mm. The turning operation was performed on the length of 40mm. The composition and properties for EN24 are given in table no. 3.


Figure 3: EN24 turned workpieces

D. Machining parameters and levels

Three cutting parameters namely Spindle speed, Feed rate and Depth of cut were considered to perform the experiment. The table no: 4 shows the three different levels of each parameters used.

Table 3: Chemical composition of EN24 steel

Alloyant	Percentage
Carbon	0.36-0.44
Silicon	0.1-0.35
Manganese	0.45-0.70
Sulphur	0.04 max
Phosphorous	0.035 max
Chromium	1-1.40
Molybdenum	0.2-0.35
Nickel	1.3-1.7

Table 4: Machine Parameters and Levels

S. No	Parameters	Units	Levels		
			L1	L2	L3
1	Spindle Speed	m/min	1000	1200	1400
2	Feed Rate	mm/rev	0.1	0.2	0.3
3	Depth of Cut	mm	0.5	0.7	1

E. Selection of orthogonal array

The degree of freedom for 3 parameters, each at 3 levels, can be calculated by equation 1,

DOF = P(L-1) ………. (1)

Where, P = number of factors = 3

L = number of levels = 3

DoF calculate for the experiment is 6. The orthogonal Array selected should have DoFgreater than or equal to DoF for experiment, so L9 array is selected and following OA isgenerated using Minitab.

Table 5: Orthogonal Array

SPINDLE SPEED (rpm)	FEED(mm/rev)	DEPTH OFCUT (mm)
1000	0.1	0.5
1000	0.2	0.7
1000	0.3	1
1200	0.1	0.7
1200	0.2	1
1200	0.3	0.5
1400	0.1	1
1400	0.2	0.5
1400	0.3	0.7

9 experiment runs of turning operation on EN24 steel are performed as per the orthogonal array adopted. The details of turning operation and the tools used is already mentioned in previous section. After all, 9 runs were performed.

F. Measurement of Surface roughness

A stylus type surface roughness measuring machine was used to measure surface roughness of all 9-work material after turning. Two readings of the surface roughness (Ra) at different points were taken for each work piece and were noted from the digital display. The average of two readings for each workpiece is mentioned in the table no: 6, along with the corresponding Signal to Noise ratio (S/N ratio). The cut off length was 2.5 mm and all readings were takes in mm.

Figure 4: Surface Roughness Test

The surface roughness is transformed to the S/N ratio using Minitab statistical tool tomeasure the quality characteristics deviated from desired values. The desired characteristic for surface roughness is "smaller is better". Following formulae was used to calculate the S/N ratios

S/N ratio (η) $=-10\log_{10}[\frac{1}{n}\sum y_i^2]$

Where n is number of tests in trial (no. of repetitions regardless of noise levels) and is the ith observation of the quality characteristic.

Table 6: Surface roughness values along with S/N ratio

Experiment No.	SPINDLE SPEED (rpm)	FEED (mm/rev)	DEPTH OF CUT (mm)	SURFACE ROUGHNESS (um)	S/N Ratio
1	1000	0.1	0.5	0.66	3.609
2	1000	0.2	0.7	1.07	-0.587
3	1000	0.3	1	1.01	-0.086
4	1200	0.1	0.7	0.76	2.383
5	1200	0.2	1	0.78	2.158
6	1200	0.3	0.5	0.76	2.383
7	1400	0.1	1	1.14	-1.138
8	1400	0.2	0.5	0.69	3.223
9	1400	0.3	0.7	1.36	-2.670

G. Measurement of material removal rate

Following formulae was used for calculation of material removal rate (MRR) for all the 9 runs,

$$MRR = (V_i - V_f) f N$$

Where, are initial and final volumes (/min) of workpiece during turning. f is the feed rate (mm/ rev) and N is spindle speed (rpm). The MRR calculated by above formulae are tabulated and transformed into S/N ratio using Minitab (Table no. 7). The desired characteristic for surface roughness is "larger is better".

Following formulae was used to calculate the S/N ratios

S/N ratio (η) $=-10\log_{10}[\frac{1}{n}\sum \frac{1}{y_i^2}$

Where n is number of tests in trial (no. of repetitions regardless of noise levels) and is the ith observation of the quality characteristic.

Table 7: MRR values along with S/N ratio

Ex No	Spindle Speed	Feed Rate	Depth of Cut	MRR	S/N Ratio
1	1000	0.1	0.5	0.785	-2.102
2	1000	0.2	0.7	3.927	11.881
3	1000	0.3	1	9.425	19.485
4	1200	0.1	0.7	2.356	7.443
5	1200	0.2	1	7.539	17.546
6	1200	0.3	0.5	2.827	9.026
7	1400	0.1	1	4.398	12.865
8	1400	0.2	0.5	2.199	6.844
9	1400	0.3	0.7	8.247	18.325

5. RESULT AND DISCUSSION

The use of both Taguchi method and S/N ratio approach makes it easy to obtain the optimal set of parameters for optimum surface roughness and Material removal rate. To obtain optimal set of parameters the average value of S/N ratio has been calculated at each different level for each parameter. The S/N ratio for each value can be taken easily from Minitab – 19, by analysing the taguchi design for given set of orthogonal arrays and its results.

Optimization of surface roughness

Table no. 8 shows the response sheet for the surface roughness shows the S/N ratio of the individual level of each parameter.The S/N ratio for different levels of parameters are also plotted in figure 5.

Table 8:Response table for S/N ratio for surface roughness

Smaller is better			
Level	Spindle Speed	Feed rate	Depth of Cut
1	0.9783	**1.6183**	**3.072**
2	**2.3085**	1.5978	-0.2916
3	-0.1953	-0.1245	0.3112
Delta	2.5038	1.7427	3.3635
Rank	2	3	1

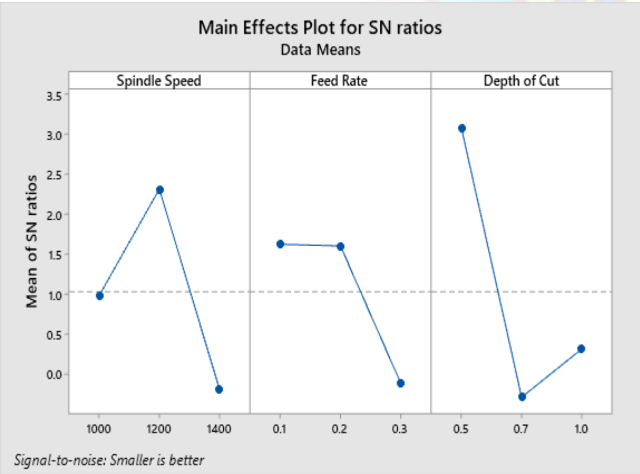

Figure 5: Plot for SN ratios of Surface Roughness

The levels with highest S/N ratio are selected from each parameter as the optimal values of parameters for minimum surface roughness. Table no. 9 lists the optimal values of parameters.

Table 9: Optimal values of parameters for minimizing surface roughness

Parameters	Spindle Speed	Feed Rate	Depth of Cut
Unit	rpm	mm/rev	mm
Levels	A2	B1	C1
Values	1200	0.1	0.5

The delta values and rank in the response table suggest that among all the parameters, Depth of cut has highest effect on the surface roughness of turned samples, followed by spindle speed and then depth of cut.

Optimization of MMR

Table 10: Response Table for S/N ratio for MRR

Larger is better			
Level	Spindle Speed	Feed rate	Depth of Cut
1	9.755	6.069	4.589
2	11.339	12.091	12.55
3	12.679	15.613	16.632
Delta	2.924	9.544	12.043
Rank	3	2	1

Table no. 10 shows the response sheet for the MRR shows the S/N ratio of the individual level of each parameter.

The S/N ratio for different levels of parameters are also plotted in figure 6. The levels with highest values of S/N ratio are selected as optimal values for maximizing the MRR.

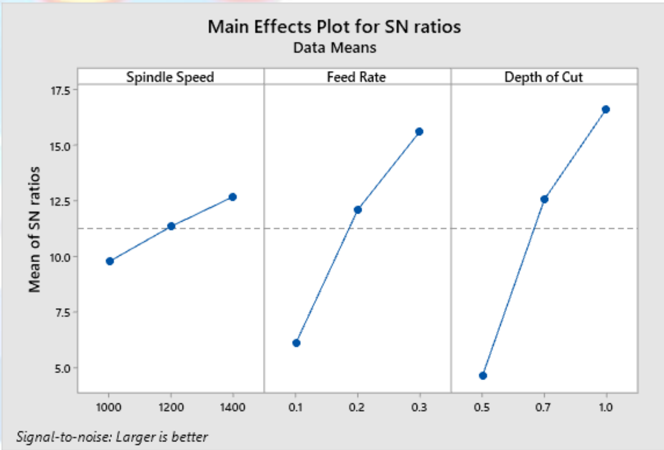

Figure 6: Main effects plot for SN ratios of MRR

The delta values and rank in the response table suggest that among all the parameters, Spindle speed has highest effect on the surface roughness of turned samples, followed by feed rate and then spindle speed.

Table 11: Optimal parameters for maximizing MRR

Parameters	Spindle Speed	Feed Rate	Depth of Cut
Unit	rpm	mm/rev	mm
Levels	A3	B3	C3
Values	1400	0.3	1.0

6. CONCLUSION

The Taguchi method of experimentation offers an economical alternative to conventional research. It can scan dozens of factors in a few experimental runs and give us preliminary data. However, it can also be integrated into the traditional experimentation process. Orthogonal array is very effective for screening factors and performing initial experiments on complex situations.

This study suggests that, when feasible parameters are selected, an efficient turning of EN24 steel can be carried out. The results from the experiment performed here will be useful in similar kind of researches. The same procedure applied here can be applied for optimisation of other turning effects, taking different sets of parameters.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

REFERENCES

[1] Purcar, M., Bortels, L., Bossche and B.V.D. Deconinck, J., (2004). 3D electrochemical machining computer simulations, Journal of Materials Processing Technology, 149, 472–478.

[2] Kozak, J., Chuchro, M., Rusza, A. and Karbowsk, K., (2000). The computer aided simulation of electrochemical process with universal spherical electrodes when machining sculptured surface, Journal of Materials Processing Technology, 107, 283- 287.

[3] Kozak, J., (1998). Mathematical model for computer simulation of electrochemical machining processes, Journal of Material Processing Technology, 76, 170-175.

[4] Sian, S., (2011). CFD analysis of flow pattern in electrochemical machining, B.Tech. Project Report, National Institute of Technology Rourkela, Odhisa, India.

[5] Dabrowski, L., and Paczkowski, T., (2011). Computer simulation of Twodimensional Electrolyte flow in Electrochemical Machining. Russian journal of electrochemistry, 41,102–110.

[6] Wang, G., Yang, Y., Zhang, H and Xia W., (2007). 3-D model of thermo-fluid and electrochemical for planar SOFC, Journal of Power Sources, 167, 398–405V.

[7] Mcclesky, R.B., (2011). Electrical Conductivity of Electrolytes Found In Natural Waters from (5 to 90) °C. Journal of Chemical and Engineering data, 56, 317-327