

Optimization of CNC Turning Parameters on EN36B Steel Using Taguchi Method

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ABSTRACT: The main objective of today's manufacturing industries is to produce low cost, high quality products in short time. The selection of optimal cutting parameters is a very important issue for every machining process in order to enhance the quality of machining products and reduce the machining costs. This paper investigates the machining of EN36B steel to find optimal parameters for CNC turning process. The Taguchi's L₉ Orthogonal array is used to formulate the experimental layout, to analysis the effect of each parameter on the machining characteristics and to predict the optimal choice for each turning parameters such as Speed, Feed and Depth of cut. It is found that these parameters have a significant influence on machining characteristics such as Material removal rate (MRR) and Surface roughness (SR). The Analysis of Variance (ANOVA) and Signal-to-Noise ratio are used to study the performance characteristics in turning operation.

KEYWORDS: CNC Turning, EN36B Steel, ANOVA, Material removal rate, Surface roughness

I. INTRODUCTION

Machining by turning involves the use of a lathe and is used primarily to produce cylindrical or conical parts. It is valuable to increase tool life, to improve surface roughness, to reduce cutting force and material removal rate in turning operations through an optimization study. Among these four characteristics, surface roughness and material removal rate play the most important roles in the performance of a turning process. Cutting speed, feed rate, depth of cut, tool-work piece material, tool geometry, and coolant conditions are the turning parameters which highly affect the performance measures. In order to improve machining efficiency, reduce the machining cost, and improve the quality of machined parts, it is necessary to select the most appropriate machining conditions. The setting of turning parameters relies strongly on the experience of operators. It is difficult to achieve the highest performance of a machine because there are too many adjustable machining parameters. In order to minimize these machining problems, there is a need to develop scientific methods to select cutting conditions for free machining of metals.

II. LITERATURE REVIEW

Paramasivam et al.[1]. They investigated the optimization of turning process parameters for EN24 steel based on Regression analysis. The L₉ orthogonal is used for the experiment cutting speed, feed rate and depth of cut are considered as input parameters and material removal rate and surface roughness are output parameters. From the experiment study it can be seen that cutting speed has the significant effect on MRR and surface roughness when compared to feed rate.Narayanareddy et al. [2].The machining parameters of 20MnCr5 steel were analyzed in CNC horizontal lathe. The Taguchi method is used for optimization. The L₉ orthogonal array, signal to ratio and Analysis of variance were employed to study the performance characteristics in turning operation. In this study they have used four input parameter like cutting speed, feed rate, depth of cut and hardness of the cutting tool for identifying the output parameters like surface roughness and MRR.Shunmugesh et al. [3].They have made attempt to search for a set of optimal process parameter value that leads to minimize the value of machining performance. This study aimed at optimizing machining performance and the input parameters for 11sMn30. The input parameters considered for the study were speed, feed and depth of cut. The Taguchi analysis is used for optimizing the machining parameter.

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Aravindkumar. [4]. He has optimized the turning parameters for mild steel 1018. He used three cutting parameters to find out the maximum metal removal rate from the manufactured component. The CNC turning machine was used for this study. For the optimization purpose the Taguchi approach with L_{27} orthogonal array is used. He revealed, that the feed rate influences the material removal rate. Anand S. Shirade et al. [5]. The experiment was conducted to determine the optimum cutting parameters setting for minimizing surface roughness when turning of EN8 steel material. The L_9 orthogonal array design is used for design the experiments. The analysis of variance (ANOVA) employed to analyze the influence of performance parameters during turning.

Shreemoykumarnayaket al. [6]. The investigation was carried out the effect of machining parameters during dry turning of AISI 304 austenitic stainless steel. For this study HMT heavy duty lathe machine was used. They have adopted L_{27} orthogonal array with three machining parameters like cutting speed, feed rate and depth of cut and three importance characteristics of machinability such as material removal rate (MRR), cutting force and surface roughness (R_a) were measured. For the optimization of machining parameters, Grey relational analysis was used.

Schin C Borse. [7]. He was focused on optimizing turning parameters based on the Taguchi method to minimize the surface roughness and maximize the metal removal rate by using SAE 52100 steel with carbide inserts. Results of this study indicate that the feed rate is mostly influencing the surface roughness of the machined surface.

Neerajsaraswat et al. [8]. They determined the optimal cutting parameters for EN9 steel in turning operation. The analysis of variance (ANOVA) and signal to noise ratio (S/N ratio) were used to study the performance characteristics in turning operation. The cutting speed, feed rate and depth of cut were selected as input parameters to optimize the surface roughness.

Balaraju et al. [9]. The research was analyzed the effect of cutting parameters on surface roughness and cutting force in turning of mild steel and aluminium material. They have used factorial technique to optimize the cutting parameters. For this study they have used universal lathe machine. For this study they have concluded that cutting forces increase with feed rate keeping other parameters constant, cutting forces decrease with spindle speed keeping other parameters constant, cutting forces increase with spindle speed keeping other parameters constant. Jakhaleprashant et al. [10]. They have used L_9 orthogonal array, signal to noise ratio and ANOVA for optimizing the surface roughness value of alloy steel in turning operation. Four input parameters were selected for finding the surface roughness value for reducing the cost of product. Vikas B. Magdum et al. [11]. The experiment was conducted for evaluation and optimization of machining parameter for turning of EN8 steel. In this study the conventional lathe is used for turning operation. They were selected tool shape and material, cutting speed, depth of cut and feed rate as process parameters to find out the optimum cutting parameters for minimizing the cutting force. RK Suresh et al. [12] conducted the optimization process for EN41B steel in turning operation by using Taguchi method. In this study L_{27} orthogonal array is used experiment. Three process parameters used for maximizing the material removal rate of the manufactured component.

Rahul Davis et al. [13]. They have used Taguchi method to identify the effect of turning parameters on surface roughness. The work material EN24 steel is selected for this optimization purpose. The ANOVA and signal to noise ratio were employed for study the operation. The depth of cut, cutting speed and feed rate were selected as input parameters. Nirav M. Kamdar et al. [14]. The investigation of machining parameters of EN 36 steel was carried. The surface roughness, cutting speed and feed rate are used as machining parameters and cutting force, feed force and surface roughness are output parameters. The ANOVA was used to obtain optimum cutting parameters. Ashishyadav et al. [15]. The Taguchi method and regression analysis was selected for optimizing the turning parameters for EN8 steel material. In this study the cutting speed, feed rate and depth of cut is selected as process parameters for finding the various process parameters affecting hardness of the work piece material after turning operation was completed. Suleiman Abdulkareem et al. [16]. They have used box behnken experimental design to optimize the turning parameters of mild steel. Kaladhar et al. [17]. They have determined the optimum turning parameters of AISI 202 austenitic stainless steel. The CVD coated tools are used for turning operation. This experiment had been conducted using full factorial design in design of experiment (DOE) on computer Numerical Controlled (CNC) lathe. Four input parameters were used for finding the optimum surface roughness value for the particular work piece. Sudhansu Ranjanjan Das et al. [18]. Have discussed about the cutting parameters of tool wear and work piece surface temperature of AISI D2 steel in turning operation. In this study Taguchi approach and regression analysis used for optimization. The cutting speed and depth of cut were contribute work piece surface temperature.

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III. TAGUCHI METHOD

Taguchi method is a powerful tool for the design of high quality systems. It provides simple, efficient and systematic approach to optimize design for performance, quality and cost. Taguchi method is efficient method for designing process that operates consistently and optimally over a variety of conditions. Taguchi approach to design the experiments easy to adopt and apply for users with limited knowledge of statics, hence gained wide popularity in the engineering and scientific community. The desired cutting parameters determined by handbook. Cutting parameter is reflected on surface roughness, surface texture and dimensional deviation on turned product. Taguchi method is especially suitable for industrial use but can also be used for scientific research.

IV. EXPERIMENTAL RESULTS

A. Material

The work piece used for the concluded experiment was EN 36B steel. It is used in the field of heavy vehicle transmission components, engineering machinery gearbox parts and chuck jaws. The Table I and Table II show the chemical and mechanical properties of EN36B steel.

TABLE I
CHEMICAL COMPOSITION OF EN 36B STEEL

Elements	Percentage (%)
Carbon	0.12 to 0.16
Silicon	0.10 to 0.35
Manganese	0.35 to 0.60
Nickel	3.0 to 3.75
Chromium	0.70 to 1.0
Sulphur	0.035 Max
Phosphorus	0.040 Max

The EN36 is a 3% nickel, chromium, molybdenum grade. Carburized EN36 gives a hard case with a strong core, whilst retaining a remarkable degree of toughness.

TABLE II
MECHANICAL PROPERTIES OF EN36B STEEL

Property	Value
Yield strength	540MPa
Tensile strength	700/770MPa
Elongation	25%
Hardness	255 HB Max

Due its high yield and tensile strength it is suitable for roller and ball bearings of extra light section, aeroplane and motor crankshafts requiring hard surfaces for roller paths, connecting rods with case-hardened ends, as well as highly stressed gudgeon pins, gears and certain types of collets.

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B. Machine Details:



(1)

Fig 1 Horizontal ACE DESIGNER CNC lathe

The ACE Designer lathe is widely used in many of the industry because of this machine convenience and its performance. So that the reason we have selected this machine for our research.

C. Cutting Parameters and Their Levelb

The main cutting parameters are speed, Feed and depth of cut. The factors and the levels are given the Table II.

TABLE III
PARAMETERS AND LEVELS

Sl.No	FACTORS	LEVEL 1	LEVEL 2	LEVEL 3
1	Speed (rpm)-A	500	750	1100
2	Feed (mm/rev)-B	0.1	0.35	0.5
3	Depth of cut (mm)-C	0.5	0.8	1.0

D. Select the Appropriate Orthogonal Array

Selecting an orthogonal array depends on the total degrees of freedom for the corresponding factors. For factor with level of 3, the degree of freedom is 2.

The experimental table is shown in Table IV.

TABLE IV
ORTHOGONAL ARRAY

Experiment No	A	B	C
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	1
9	3	3	2

In this experiment, there are three factors with level number 3 consequently, the total degrees of freedom is 6. In mean time, the interaction between the cutting parameters is neglected here. There by L9 orthogonal array is used.

E. Experimental Data

The turning operation was conducted using the ACE Designers CNC lathe. Experiments were conducted as per the orthogonal array and the results are tabulated in the Table V.

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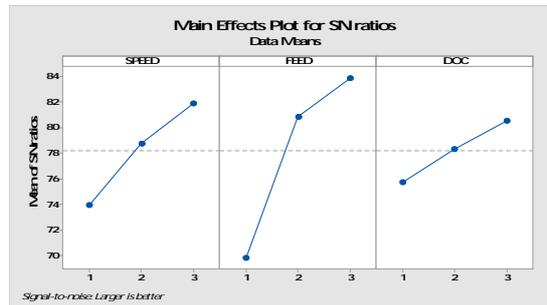
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TABLE V
EXPERIMENTAL RESULTS

Sl.No	Speed (rpm)	Feed (mm/rev)	Depth of cut (mm)	Metal removal rate (mm ³ /min)	Surface roughness, Ra (μm)
1	500	0.1	0.5	1347.50	40.90
2	500	0.35	0.8	7215.13	32.50
3	500	0.5	1.0	12655.49	23.15
4	750	0.1	0.8	3351.21	41.10
5	750	0.35	1.0	14590.29	21.12
6	750	0.5	0.5	13277.16	27.85
7	1100	0.1	1.0	6510.91	35.11
8	1100	0.35	0.5	12894.17	38.12
9	1100	0.5	0.8	22979.70	34.89

I. DATA ANALYSIS BY USING TAGUCHI METHOD



(2)

Fig 2 Effect of Speed, Feed and Depth of Cut on Metal Removal Rate.

The Figure 2 shows that the three parameters were how influencing the material removal rate. From the graph the feed rate is mostly influencing the material removal rate.

1. Taguchi Analysis: MRR versus SPEED, FEED, DOC

TABLE VI
RESPONSE TABLE FOR SIGNAL TO NOISE RATIOS
(LARGER IS BETTER)

LEVEL	SPEED	FEED	DOC
1	73.93	69.79	75.75
2	78.75	80.88	78.30
3	81.90	83.91	80.53
Delta	7.97	14.12	4.78
Rank	2	1	3

This responsible table is created from Minitab 16 software, the table VI shows the ranks created from three input parameters. In MRR we have to select the conditions as larger the better.

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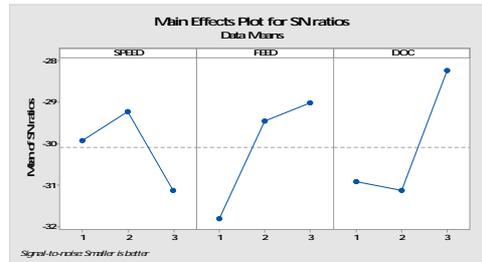
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TABLE VII
ANOVA FOR MATERIAL REMOVAL RATE

Source	DF	Seq SS	Adj SS	Adj MS	% Of Contribution	Rank
Speed (A)	2	74746706	74746706	37373353	21.23	2
Feed (B)	2	241697471	241697471	120848735	68.64	1
Depth of cut(C)	2	8364728	8364728	4182364	2.38	3
Error	2	27320459	27320459	13660230	7.75	
Total	8	329129365			100	

This ANOVA table is used to find out the individual input parameters contribution on material removal rate. From the table feed rate is contributing 68.64% on material removal rate



(3)

Fig 3 Effect of Speed, Feed and Depth of cut on Surface roughness

The Fig 3 shows that the three parameters were how influencing the surface roughness. From the graph depth of cut is mostly influencing the surface roughness.

2. Taguchi Analysis: SR versus SPEED, FEED, DOC

TABLE VIII
RESPONSE TABLE FOR SIGNAL TO NOISE RATIOS
(SMALLER IS BETTER)

Level	SPEED	FEED	DOC
1	-29.92	-31.81	-30.92
2	-29.22	-29.45	-31.12
3	-31.13	-29.01	-28.23
Delta	1.91	2.79	2.89
Rank	3	2	1

This responsible table is created from Minitab 16 software, the table VI shows the ranks created from three input parameters. For SR we have to select the conditions as smaller the better.

TABLE IX
ANOVA FOR SURFACE ROUGHNESS

Source	DF	Seq SS	Adj SS	Adj MS	% Of Contribution	Rank
Speed (A)	2	55.74	55.74	27.87	13.07	3
Feed (B)	2	183.6	183.6	91.81	43.04	1
Depth of cut(C)	2	178.4	178.4	89.21	41.82	2
Error	2	8.851	8.851	4.426	2.07	
Total	8	426.620			100	

This ANOVA table is used to find out the individual input parameters contribution on surface roughness.

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V. CONCLUSION

The present work shows the use of Taguchi method to find out optimal machining parameter. The S/N ratio for the test results were found out using the Taguchi method. The machining parameters namely Speed, Feed rate and Depth of cut is optimized to meet the objectives. As a result of the study the following conclusions are drawn: (i) The results reveal that the primary factor affecting the Material removal rate is feed rate, subsequently followed by speed and depth of cut. (ii) The results reveal that the primary factor affecting the surface roughness is feed rate, subsequently followed by depth of cut and speed

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