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Optimization of CNC turning operation parameters for EN32M steel by using TAGUCHI method

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Abstract

The main aim 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 role for every machining process in order to improve the quality of machining products and reduce the machining costs. In this paper investigates the machining of EN32M 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 every parameter on the machining characteristics and to predict the optimal choice for every turning parameter such as Speed, Feed and Depth of cut. These are 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 process.

Keywords— *CNC Turning, EN32M Steel, ANOVA, Material removal rate, Surface roughness*

1. Introduction

The Machining process involves the turning operation of a lathe and is used primarily to produce cylindrical parts. It is valuable to improve tool life, surface roughness, to reduce cutting force and material removal rate in turning operations through an optimization study. Among these 4 characteristics, surface roughness and material removal rate play main 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 very important turning parameters which highly affect the performance measures. In order to improve machining life, the quality of machined parts and to reduce the machining cost. For this it is necessary to select the most appropriate machining conditions. The study of turning parameters are strongly on the experience of operators.. In order to minimize these machining problems, there is a need to develop standard methods to select cutting conditions for any cutting of metals.

2. Literature Review

Paramasivam et al.(2014). The investigation of 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 spindle speed has the significant effect on MRR and surface roughness when compared to feed rate. Narayanareddy et al.(2014).The machining parameters of CNC horizontal lathe for 20MnCr5 steel were analyzed. The L9 orthogonal array, signal to ratio and Analysis of variance were employed to study the performance and characteristics parameters of turning operation. This study they have used 4 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. (2014). They have made to study the search for combination of optimal process parameter value that leads to minimize the value of machining performance. The aim of study at optimizing machining performance and the input parameters for 11sMn30. The input parameters considered for the study were spindle speed, feed

and depth of cut. The Taguchi method analysis is used for optimizing the machining parameter design.

Aravindkumar. (2014). The turning parameters are optimized for mild steel 1018. It is used for three cutting parameters to find out the maximum metal removal rate from the manufactured component. The purpose of optimization used is Taguchi approach with L9 orthogonal arrayed with the feed rate influence the material removal rate. Anand S. Shirade et al. (2014). The experiment was setup to determine the optimum cutting parameters for minimizing surface roughness when turning of EN8 steel material. The L9 orthogonal array design is used for design of experiments. The analysis of variance (ANOVA) employed to analysis the influence of the parameters during turning the operation.

Shreemoykumar nayak et al. (2014). The study was carried out the effect of machining parameters during the turning of AISI 304 austenitic stainless steel. The HMT heavy duty lathe machine was used for this study. it can be adopted L9 orthogonal array with three machining parameters like spindle speed, feed rate and depth of cut and three importance characteristics of machinability such as material removal rate (MRR), cutting tool and surface roughness (Ra) were measured.

Sschin C Borse. (2014). The study 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. This study of results to indicate that the feed rate is mostly influencing the surface roughness of the machined surface. Neerajsaraswat et al. (2014). He 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 influence of characteristics in turning operation. The spindle speed, feed rate and depth of cut were selected as a input parameters to optimize the output parameters of surface roughness.

Balaraju et al. (2013). The research was studied the effect of cutting parameters on surface roughness and cutting force in turning of mild steel and aluminium material. He used factorial technique to optimize the cutting parameters. For this study he have used universal lathe machine and concluded that cutting forces increase with spindle speed keeping other parameters feed rate is degreases. Jakhaleprashant et al. (2012). He was used to analysis L9 orthogonal array, signal to noise ratio and ANOVA for optimizing the surface roughness in alloy steel for turning operation. The four input parameters were selected for finding the surface roughness value for reducing the cost of product.Vikas B.magdum et al. (2013). The experiment was conducted for evaluation and optimization of machining parameter for turning of EN8 steel. In this study the turning lathe is used for turning operation. They are selected tool size and materials cutting speed, depth of cut and feed rate as process parameters to find out the optimum parameters for minimizing the cutting force. RK Suresh et al. (2013) The optimization process for EN41B steel in turning operation by using Taguchi method. In this research L27 orthogonal array is followed the experiment. Three process parameters used for maximizing the material removal rate of the manufactured product.

Rahul davis et al. (2012). He have used Taguchi method to identify the effect of turning parameters on surface roughness. For this optimization purpose EN24 steel work material is selected and the ANOVA and signal to noise ratio was followed by the study of operation. The spindle speed, depth of cut, and feed rate were selected as input parameters .Nirav.M.Kamdar et al. (2012). The investigation of machining parameters of EN 36 steel was carried and analysis the surface roughness, spindle speed and feed rate are used as machining parameters as a input parameters and surface roughness are output parameters. The ANOVA was used to obtain optimum machining parameters. Ashishyadav et al. (2012). The Taguchi method and regression analysis was selected for optimizing the machining parameters for EN8 steel material. In this study the spindle speed, feed rate and depth of cut is selected as input parameters for finding the various other process parameters affecting hardness of the work piece material. After turning operation was completed. Suleiman Abdulkareem et al. (2011). He have used box behnken experimental design to optimize the turning operation of mild steel. Kaladhar et al. (2010). He have analysis 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 CNC lathe. The optimum surface roughnesses were used for finding value of four input parameters for the particular work piece. In this work Taguchi method and regression analysis used for optimization. The spindle speed and depth of cut were contributes work piece surface temperature.

3. Taguchi method

Taguchi method is a powerful tool for design of experiment of the high quality analysis. It provides simple, efficient and systematic which approach to optimize design of performance for quality and cost. Taguchi method is easy method

for designing process that operates consistently and optimally over a variety of conditions. It is easy to adopted and apply for users with limited knowledge of system. Hence its gained a wide popularity in the engineering and scientific community. The machining parameter is reflected on surface roughness, surface texture and dimensional deviation on turning operation. Taguchi method is especially suitable for industrial purpose and scientific research.

4. Experimental Results

4.1 Material

The work piece used for the concluded experiment was EN 32M steel. It is used in the field of heavy vehicle transmission components, engineering machinery gearbox parts and chuck jaws. The Table 1 and Table 2 show the chemical composition and mechanical properties of EN32M steel.

Table 1 Chemical Composition Of En 32M Steel

S.No	Elements	Percentage (%)
1	Carbon	0.10 - 0.18
2	Silicon	0.05 - 0.35
3	Manganese	0.60 - 1.00
4	Sulphur	0.05 - 0.05
5	Phosphorus	0.05-0.05

Table 2 Mechanical Properties of EN32M Steel

S.No	**Property**	**Value**
1	Yield strength	240MP
2	Tensile strength	350-450MPa
3	Elongation	25%
4	Hardness	255 HB Max

Due its high yield and tensile strength it is suitable for roller and ball bearings of extra light section, aero plane 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.

4.2. Cutting Parameters and Their Level

The main cutting parameters are speed, Feed and depth of cut. The factors and the levels are given the Table 3.

4.3. Machine Details:

Fig 1 NEWTON CNC Lathe

Table 3 Parameters and Levels

S.No	Factors	Level 1	Level 2	Level 3
1	Speed (rpm)-A	1000	1500	2000
2	Feed (mm/rev)-B	0.2	0.35	0.5
3	Depth of cut (mm)-C	0.5	0.8	1.0

4.4 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 4.

Table 4 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.

4.5. 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 5.

Table 5 Experimental Results

Sl.No	Speed (Rpm)	Feed (Mm/Rev)	Depth of cut (mm)	Metal Removal Rate (Mm3/Min)	Surface Roughness, RA (µM)
1	1000	0.2	0.5	1547.50	45.90
2	1000	0.35	0.8	7815.13	432.50
3	1000	0.5	1.0	14655.49	33.15
4	1500	0.2	0.8	3951.21	51.10
5	1500	0.35	1.0	16590.29	31.12
6	1500	0.5	0.5	15277.16	37.85
7	2000	0.2	1.0	7510.91	45.11
8	2000	0.35	0.5	19894.17	48.12
9	2000	0.5	0.8	42979.70	44.89

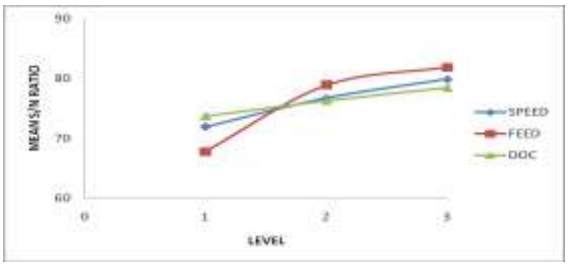

Fig 2 Effect of Speed, Feed and Depth of cut on Metal Removal Rate

The Fig. 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.

4.6 Taguchi Analysis: MRR versus Speed, Feed, DOC.

Table 6 Response Table for Signal to Noise Rations

Level	Speed	Feed	Doc
1	71.93	67.79	73.75
2	76.75	78.88	76.30
3	79.90	81.91	78.53
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.

Table 7 ANOVA For Material Removal Rate

Source	DF	Seq SS	Adj SS	Adj MS	% Of Contribution	Rank
Speed (a)	2	74726704	74726704	36353351	25.56	2
Feed (b)	2	221597469	221597469	100848733	71.06	1
Depth of cut(c)	2	8162736	8162736	3980362	3.38	3
Error	2	25319457	25319457	11640238	6.72	
Total	8	329806366			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 71.06% on material removal rate.

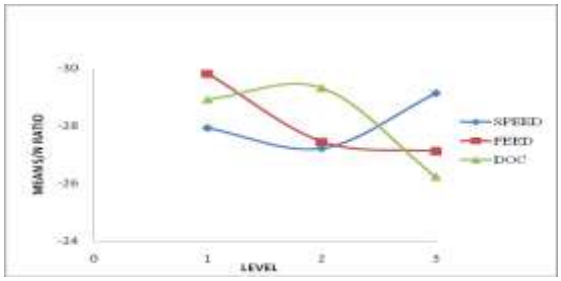

Fig 3 Effect of Speed, Feed and Depth of cut on Surface roughness

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.

4.7 Taguchi Analysis: SR versus Speed, Feed and DOC

Table 8 Response Table for Signal to Noise Ratios

Level	Speed	Feed	Doc
1	-27.92	-29.81	-28.92
2	-27.22	-27.45	-29.32
3	-29.13	-27.11	-26.23
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 9 ANOVA For Surface Roughness

Source	Df	Seq SS	Adj SS	Adj MS	% of contribution	Rank
Speed (a)	2	54.74	54.74	27.87	12.07	3
Feed (b)	2	184.6	184.6	91.81	44.04	1
Depth of cut(c)	2	177.4	177.4	89.21	40.82	2
Error	2	9.851	9.851	4.426	3.07	
Total	8	426.620			100	

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

5. 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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