TO EVALUATE THE PERFORMANCE PARAMETERS WHILE MACHINING EN-8D STEEL WITH MQL TECHNIQUE

Subeg Singh[1], Sanjeev Kumar[2], Sunil Kumar[3]
Department of Mechanical Engineering, BCET Gurdaspur.
Email:[1]Singh.subeg73@gmail.com

Abstract

Machining is widely used process in manufacturing industries. In the present scenario the demand of manufacturing industries to reduce the machining cast and to improve the quality of finished product. However, the various factors that affect the quality of finished product are geometrical parameters, Cutting parameters, Tool Materials, Tool shape, Workpiece material and environmental conditions. The temperature of cutting zone also affects the quality of finished product. Therefore, the quality of finish product can be enhanced by controlling the temperature of cutting area, traditionally it is controlled by using flooded coolant. However, due to environmental regulations the use of coolant is prohibited. Therefore new technique minimum quantity of lubrications(MQL) are widely used now days, Therefore in this research work the performance of an environmental friendly vegetable oil based cutting fluids is investigated during the maching of EN8D steel.

Key Word: Design of experiment, Surface roughness, Cutting fluid, ANOVA.

1. Introduction

Machining process is the gradual removal of metal from a cylindrical workpiece in the form of a chip. At present the aim of all manufacturing industries to obtain to lower machining costs by increasing the productivity and improving the quality of the surface. The number of parameters affecting the cutting performance such as speed, feed, depth of cut, insert shapes, environmental conditions, etc. Surface finishing is the most significant product quality characteristics. The resultant surface roughness in the cutting operation is determined by surface roughness (geometry machining parameters) and natural surface roughness due to irregularities and uncontrollable factors in the cutting process) [1]. During the machining operation, surface roughness is also influenced by work material factors, geometrical factors, environmental factors and machine tool factors [2]. The better surface quality was achieved by machining EN-8D steels at low feed rate and high speed [3]. It is investigated that the feed also has effect of surface roughness [4]. For the surface roughness, the feed rate was the primary influencing factor, followed by the tool nose radius and cutting speed. Depths of cut have no significant effect on the surface roughness [5]. The surface quality was improved when the cutting speed increased [6]. The feed rate, cutting speed has a primary influence on the surface roughness. Higher the cutting the speed smaller the value of surface roughness [7]. Analysed that there is a significant reduction in tool wear and surface roughness during the minimum quantity of vegetable oil-based cutting fluid during the machining of AISI 9310 steel. The ribbon type continuous chips are produced at lower feed rates and tubular type continuous chips at higher feed rates under dry and wet condition during the machining. However, during machining with MQL, the form of these ductile chips did not change appreciably but their back surface appeared much brighter and smoother. It indicates that reduction in temperature as results in a reduction in tool wear and surface roughness [8]. It is investigated that the surface roughness and cutting forces are significantly reduced by the application of MQL supply during the machining of AISI 1045 steel when compared to the wet condition. Hence several researchers have been done the research on machining, and it is found that the surface quality is the desired output during the machining [9].

2. Experimental details

2.1 Work Materials

In this study, a work material made of EN-8D steel was used. This materials is used for wide range of applications i.e. manufacture axles, rams and ring gears, conveyor parts, logging parts, spindles, shafts, sprockets, studs, pinions pump shafts, etc. Work pieces are having length 350 mm and 60 mm were used in experimentation. The workpiece material was hardened to 179 HRC before machining. The chemical composition of workpiece material has been shown in Table 1. given below.

Table 1: Composition of Material EN-8D.

C%	Si%	Mn%	P%	S%	Fe%
0.398	0.20	0.60	0.050	0.050	98.702

2.2 Cutting Inserts

As per the problem formulated, the surface roughness was investigated for the different shapes of carbide inserts. The tungsten carbide cutting inserts were selected for the experimentation. The inserts were triangular and trapezoidal in shape. The cutting inserts were purchased from the Sandvik Company Ltd.

2.3 Machine Tool

A machine that holds the workpiece between two rigid and high supports, called the centre. The chuck is attached to the lathe spindle by back plate to the spindle nose. The cutting tool is rigidly held and supported in the tool post with various tool holders and is fed against the revolving work. There are many types of machine tools are available in the market but the required machine tool, which was used in the present study was made of HMT Limited. The lathe machine of the LB-17 model was used.

Figure 1: Photographic view of the Experimental Setup

3. Experimental Design:

In this design of experiment, (DOE) Taguchi approach is used. Taguchi method is a powerful tool for the design of high-quality systems. It provides design can optimize the performance characteristics through the setting of design parameters and reduce the sensitivity of the system performance to the various sources of variation. S/N ratio and orthogonal array are two primary tools used in the robust design. The S/N ratio characteristics can be divided into three categories (a) Nominal is best (b) Smaller is better (c) Higher is better features. For the surface roughness, the solution is “smaller is better” and S/N ratio is determined according to the following equation:

$$S/N = -10 \log_{10} [\text{mean of sum of squares of measured data}]$$

Where, S/N = Signal to Noise Ratio, n = No. of Measurements, y = Measured Value.

Selection of parameters and their levels must be taken into consideration before finalizing the design of experiments. In the present’s research two different cutting parameters spindle speed, feed and environment having three different levels of each parameter are used as shown in Table 2. Also, two different types of inserts are used during experimentation. Therefore, total four parameters are considered in the experiment. The Degrees Of Freedom (DOF) for cutting parameters (speed, feed and environment) are two each and 1 DOF for cutting inserts. Total DOF in the present investigation are:

2+2+2+1+2x2+2x1 = 13.

Hence, the most suitable orthogonal array can be used for this experiment L_{18}, which has 13 degree of freedom assigned to its various columns as shown in Table 3. Where cutting speed are 75, 100 and 125 m/min and feed rate are 0.1, 0.2, and 0.3 mm/rev have been taken in the experiment. Also, two tool shapes and environments, triangular and trapezoidal insert and Dry, Wet and MQL have been made.

Table 2: Input machining parameters at different levels

Input machining parameter	Levels and corresponding values of machining parameters		
	Level 1	Level 2	Level 3
Tool Shape	Triangular	Trapezoidal	………..
Speed (mm/min)	75	100	125
Feed (mm/rev.)	0.1	0.2	0.3
Environment	Dry	Wet	MQL

4. Results and Discussion:

Hence, based on the different setting of various parameters provided by the design of experiment as in Table 3. The test is performed, and the surface roughness is measured. At least one run with the same setting of parameters was taken into consideration and the SN ratio as shown in the table (4). All these calculation were performed using software Minitab-14.

The main effect plot of different process parameters (cutting speed, feed, Environment and tool shapes) on surface roughness is calculated and plotted as shown in Fig 2

The average value of SN ratio has been calculated to find out the effects of different parameters and as well as their levels. Both ANOVA technique and S/N ratio are used to analyze the results and to reach on the best solution. The table 5. indicates the response for S/N ratio in which rank show the relative importance of each factor to the response.

Table-3: Mixed Design L_{18} Orthogonal Array

Tool Shape	Speed	Feed	Environment
Triangular	75	0.1	Dry
Triangular	75	0.2	Wet
Triangular	75	0.3	MQL
Triangular	100	0.1	Dry
Triangular	100	0.2	Wet
Triangular	100	0.3	MQL
Triangular	125	0.1	Wet
Triangular	125	0.2	MQL
Triangular	125	0.3	Dry
Trapezoidal	75	0.1	MQL
Trapezoidal	75	0.2	Dry
Trapezoidal	75	0.3	Wet
Trapezoidal	100	0.1	Wet
Trapezoidal	100	0.2	MQL
Trapezoidal	100	0.3	Dry
Trapezoidal	125	0.1	MQL
Trapezoidal	125	0.2	Dry
Trapezoidal	125	0.3	Wet

The ranks and the delta values for various parameters show that Speed has the greatest effect on surface roughness and is followed by the depth of cut feed and inserts form. As surface roughness is smaller the better type quality characteristic. It can be seen from Table 5. that first level of Tool shape (A1), first level of Speed (B1), third level of Feed rate (C3) and first level of Lubricant (D1) provide minimum value of surface roughness.

Table 4: Output data for surface roughness and S/N Ratio

Tool Shape	Speed	Feed	Environment	Ra	SNRA1
Triangular	75	0.1	Dry	3.26	-10.2644
Triangular	75	0.2	Wet	2.17	-6.7292
Triangular	75	0.3	MQL	2.01	-6.0639
Triangular	100	0.1	Dry	3.10	-9.8272
Triangular	100	0.2	Wet	2.02	-6.1070
Triangular	100	0.3	MQL	1.98	-5.9333
Triangular	125	0.1	Wet	1.32	-2.4115
Triangular	125	0.2	MQL	1.12	-0.9844
Triangular	125	0.3	Dry	2.87	-9.1576
Trapezoidal	75	0.1	MQL	1.62	-4.1903
Trapezoidal	75	0.2	Dry	2.73	-8.7233
Trapezoidal	75	0.3	Wet	2.54	-8.0967
Trapezoidal	100	0.1	Wet	1.21	-1.6557
Trapezoidal	100	0.2	MQL	1.03	-0.2567
Trapezoidal	100	0.3	Dry	3.67	-11.2933
Trapezoidal	125	0.1	MQL	0.97	0.2646
Trapezoidal	125	0.2	Dry	2.34	-7.3843
Trapezoidal	125	0.3	Wet	1.12	-0.9844

Table 5: Response Table of S/N Ratios for surface roughness

Level	Tool Shape	Speed	Feed	Environment
1	**-6.387**	**-7.345**	-4.681	**-9.442**
2	-4.702	-5.846	-5.031	-4.331
3		-3.443	**-6.922**	-2.861
Delta	1.684	3.902	2.241	6.581
Rank	4	2	3	1

Analysis of variance (ANOVA) was performed at 97 % confident level to identify the significant of each cutting parameters from the table (6). It is clear that the Environmental has a significant effect on the surface roughness. The contribution of another parameter cutting speed, feed and inserts from having less effect. Also, it is clear from ANOVA table (6) the contribution by the error associated are 2.9. The terms R-Sq = 97.1 % indicates that the model is best, and it covered all the variation provided by different process parameters.

The main effect plot is constructed by using Taguchi orthogonal array technique with the help of Minitab software 14. The signal to noise ratio was found by considering smaller the better for surface roughness. The plot between data means and mean of the S/N ratio as shown in fig (2).

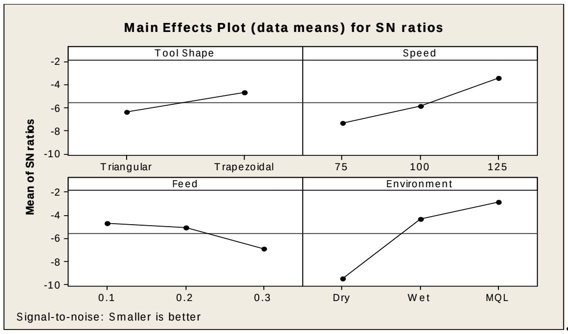
Table 6: ANOVA for S/N ratio

Source	**DF**	**Seq SS**	**Adj SS**	**Adj MS**	**F**	**P**	**%contribution**
Tool Shape	1	12.765	12.765	12.765	7.36	0.053	5.3%
Speed	2	46.486	46.486	23.243	13.40	0.017	19.45%
Feed	2	17.437	10.541	5.271	3.04	0.157	7.3%
Environment	2	143.185	143.185	71.593	41.29	0.002	59.92%
Tool Shape * Environment	2	4.327	4.991	4.495	1.44	0.338	1.81 %
Speed * Environment	4	7.798	7.798	1.950	1.12	0.456	3.26 %
Residual Error	4	6.936	6.936	1.734			2.9%
Total	17	238.934					

S = 1.317 R-Sq = 97.1% R-Sq (adj) = 87.7%

From the figure (2) the optimum parameters found are cutting speed 125 m/min, feed 0.3 mm/rev, trapezoidal insert shape and MQL environment. The minimum surface roughness for the optimum parameter is recorded on these levels.

Figure 2: Main effect plot for surface roughness



.

5. Conformation Test:

In order to validate the results, confirmation experiments were conducted for response characteristic (surface roughness) at optimal levels of the process variables. The average values of the features was obtained and compared with the predicted values It is to be pointed out that these optimal values are within the specified range of process variables

Surface roughness at optimum level	Experimental value mean	Predicted value	% error
$A_1B_1C_3$ D_1	1.538	1.4689	4.49%

CONCLUSIONS

1. The ANOVA for the mean SN ratio shows that Environment as significantly affects the surface roughness, and its contribution is 59.92 %.
2. It is observed that at speed 125 m/min, feed rate 0.1 mm/rev, MQL environment and trapezoidal insert shape the surface Roughness is minimum.
3. The confirmation test shows that the error in experimental and predicted values is 4.49 % that is less than 15 %. It result shows that our experimental results are fit to the best.
4. The surface roughness is observed to be minimum with MQL.

Reference

1. Maharadika, M. (2005). “Neural network prediction of cutting the tool wears while turning operations." The University of Malaya, Malaysia.
2. Groover, M. P., (2007),“Fundamental of modern manufacturing material process and systems”. John Wiley & Sons, Singapore,
3. Satheesh Kumar, N. Shetty Ajay, Ananth K, Harsha Shetty.(2012), “ Effect of spindle speed and feed rate on the surface roughness of Carbon Steels in CNC turning” International Conference on Modeling, Optimization and Computing.
4. Singh Hardeep, Khanna Rajesh, Garg M.P., (Dec. 2011). “ effect of Cutting Parameters on MRR and Surface Roughness in Turning EN-8” Journal of current Trends in Engineering Research Vol.1, No.1
5. Ashvin J. Makadia , J.I. Nanavati, (2013),“Optimisation of machining parameters for turning operations based on response surface methodology” Journal of Measurement vol. 46, pp.1521–1529.
6. Salvi S.B, Deshmukh R.R., Deshmukh S.D., (2013), “Analysis Of Surface Roughness In Hard Turning By Using Taguchi Method” International Journal of Engineering Science and Technology (IJEST), Vol. 5.
7. Bhattacharya,A.,Das, S., Majumder, P., Batish, A., (2009), “Estimating the effect of cutting parameters on surface finish and power consumption during high speed machining of AISI 1045 Steel using Taguchi Design and Anova”. Journal of Production Engineering 3, pp31-40.
8. M.M.A. Khan, M.A.H. Mithu, N.R. Dhar, “Effects of minimum quantity lubrication on turning AISI 9310 alloy steel using vegetable oil-based cutting fluid”, Journal of Materials Processing Technology 209 (2009) 5573–5583.
9. Young Kug Hwang and Choon Man Lee, “Surface roughness and cutting force prediction in MQL and wet turning process of AISI 1045 using design of experiments” Journal of Mechanical Science and Technology 24 (8) (2010) 1669-1677.
10. Ross, PJ., (1989). “Taguchi Techniques for Quality Engineering”,Tata McGraw Hill, Industrial Engineering Series.