International Journal For Technological Research In Engineering
Volume 1, Issue 10, June-2014 *ISSN (Online): 2347 - 4718*

PERFORMANCE EVALUATION AND PARAMETRIC OPTIMIZATION OF HOT MACHINING PROCESS ON EN-8 MATERIAL

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ABSTRACT: The aim of these study deals with evaluation and optimization of hot machining process parameters in lathe machine using taguchi orthogonal array is used for statistical method. The work piece tested is EN-8 steel material. The input parameters during process are speed, feed and depth of cut. The output parameters are surface quality.
KEYWORD: Cutting speed, feed, Temperature, surface roughness.

I. INTRODUCTION

The production of super alloys, high hard and smart materials has become extremely essential to satisfy the design requirements for critical equipments, aerospace and defense industries. The machining of such materials has always been a great challenge before the production engineering. These alloys and materials can be machined by cutting tools of vary high hardness and strength, but is sometimes neither economical nor practical. Apart from this the non-conventional machining methods are generally restricted due to productivity viewpoint. The beneficial manufacturing of the components of excessive hard materials can be substantial in terms of reduced cost of machining and lead time as compared to the traditional way which involves metal machining in annealed state followed by Heat Treatment, and then finishing operations like grinding and polishing operations, which in turn consumes lots of effort, time and workspace. Machining of high hard materials through conventional processes is restricted due to excessive tool wear of cutting tools and undesired surface finish quality. So for a qualitative and productive process, the positive interest for hot machining process is being moderately developed in production technology. The basic of hot machining operation is to first soften the work piece is by preheating and thereby shear strength gets reduced, which results in easier machining of materials with many other added advantages. Hot machining is the process which is used for easy machining and to eliminate the problems of low cutting speed, feeds and heavy loads on the machine bearings. These problems arise when machining process is being done on the new and tough materials. The basic principal behind this process is the surface of the work piece which is to be machined is pre heated to a temperature below the re-crystallization. By this heating, the shear force gets reduced and machining process becomes easy. During the machining process, instead of increasing the quality of the cutter materials, softening of the work piece is one of an alternate. In hot machining, a part or whole of the work piece is heated. Heating is performed before or during machining. Hot machining prevents cold working hardening by heating the piece below the recrystallization temperature and this reduces the resistance to cutting and consequently favors the machining. Hot machinable materials are classified in four groups according to their composition and properties.

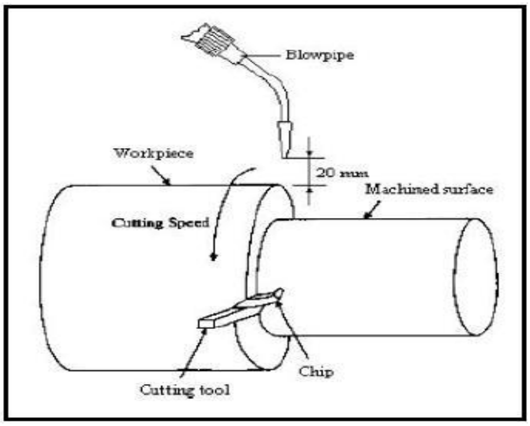

Figure 1: Schematic Diagram of Basic Principle of Hot Machining Process

II. EXPERIMENTAL DETAILS

Work piece is heated in the furnace up to the required temperature. Temperature can be set in the temperature indicator of the furnace and when the temperature is reached, the furnace automatically stabilizes the required temperature. EN8 is usually supplied untreated but can be supplied to order in the normalized or finally heat treated, which is adequate for a wide range of applications. EN8 is a very popular grade of through-hardening medium carbon steel, which is readily machinable in any condition. (Refer to our machinability guide). EN8 is suitable for the manufacture of parts such as general purpose axles and shafts, gears, bolts and studs. It can be further surface-hardened typically to 50-55 HRC by induction processes, producing components with enhanced wear resistance. EN8 in its heat treated forms possesses good homogenous metallurgical structures, giving consistent machining properties. The EN- 8 round bar of 37 mm diameter and 67mm length size has been used as a work piece material for the present experiments.

A. Work piece Material

Elements	Carbon (C)	Nickel (Ni)	Chromium (Cr)	Silicon (Si)	Manganese (Mn)	Sulphar (S)	Phosphorus (P)	Moly (Mb)
%	0.420	0.079	0.170	0.220	0.780	0.050	0.035	0.022
HARDNESS : 55 HRC								

Table 1 Chemical compositions of Work piece Material

Properties	Values
Hardness	207 BHN
Yield strength Ulitimate Tensile Stress	31.830KN 674.000 N/mm^2
Yield Stess	407.000 **N/**mm^2
Elongation	21.560

Table 2 Mechanical Properties of Work piece Material

Cutting method

Density	15.7g/cm3
Poisson's ratio	0.28
Hardness	90 HRc
Yield strength	2683 Mpa

B. Design of experiment based on Taguchi method
In this inve1stigation carried out by varying three control factors Temperature, Cutting Speed and Feed rate on Hot machining. For experimental work of Hot turning 35 mm diameters EN 8 Steel bar used for constant depth of cut 0.8 mm. Control factors along with their levels are listed in Table 3. Hence Taguchi based design of experiment method was implemented. In Taguchi method L25 Orthogonal array provides a set of well-balanced experiments, and Taguchi's signal-to-noise. (S/N) ratios.

Factors	Parameters	Level 1	Level2	Level3	Level4	Level5
A	Speed (m/min)	60	90	135	202	303
B	Feed (mm/rev.)	0.111	0.222	0.333	0.444	0.555
C	Temperature (^{0}C)	100	200	300	400	500

Table 3 Control factors and their factors

III. RESULT AND ANALYSIS

Table: 4Taguchi's L25 Standard Orthogonal Array

Sr. No.	Speed (m/min)	Feed (mm/rev)	Temp. (^{o}c)	Surface roughness
1	60	0.111	100	5.4234
2	90	0.222	100	5.3389
3	135	0.333	100	5.2194
4	202	0.444	100	5.0487
5	303	0.555	100	4.7988
6	60	0.222	200	4.717
7	90	0.333	200	4.6325
8	135	0.444	200	4.5131
9	202	0.555	200	4.3424
10	303	0.111	200	4.1654
11	60	0.333	300	4.0107
12	90	0.444	300	3.9262

13	135	0.555	300	3.8067
14	202	0.111	300	3.709
15	303	0.222	300	3.459
16	60	0.444	400	3.3043
17	90	0.555	400	3.2198
18	135	0.111	400	3.1734
19	202	0.222	400	3.0026
20	303	0.333	400	2.7527
21	60	0.555	500	2.598
22	90	0.111	500	2.5865
23	135	0.222	500	2.467
24	202	0.333	500	2.2963
25	303	0.444	500	2.0463

A. Effect on surface roughness

The main effect plot of surface roughness at different parameters like cutting speed, feed rate and temperature in hot machining process of EN-8 Material. From the figure, it can be seen that minimum surface roughness obtained is at cutting speed of 303 m/min, feed rate of 0.444 mm/rev and temperature 500 0C

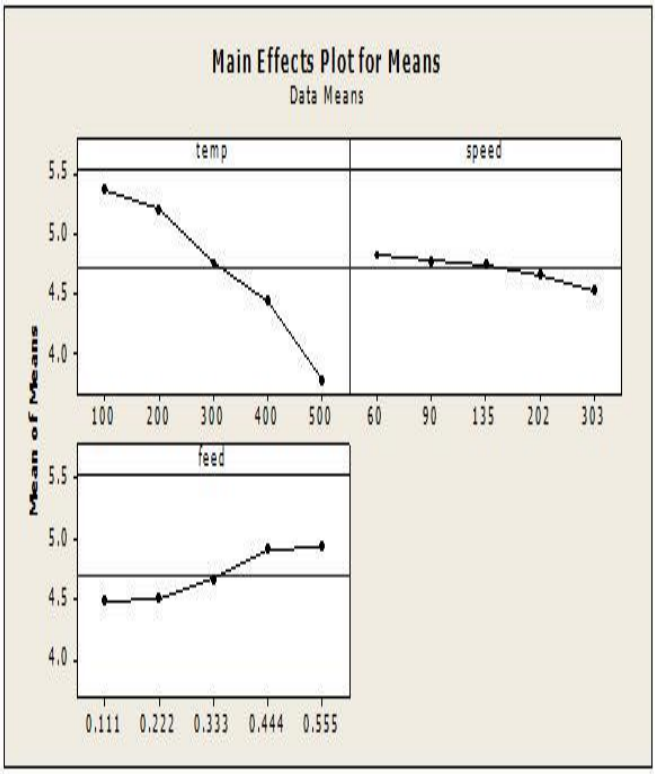

Figure 2 Main Effect Plot for Mean data

Main Effects Plot for Mean data and S/N ratio data are shown in fig 5.1 and 5.2 that displays effect of speed, feed and temperature on surface roughness on same scale base of surface roughness.

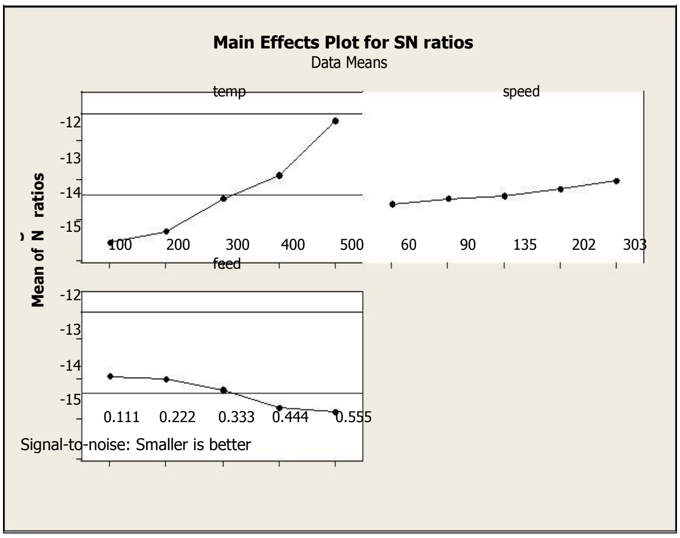

Figure 3 Main Effect Plot for S/N ratio data

B. Regression Model Analysis of Surface Roughness

The regression equation is

Ra = 5.67 - 0.00391 temp - 0.00120 speed + 1.18 feed

Table: 5 Estimated Model Coefficients for SN ratio (Surface Roughness)

Predictor	Coef	SE Coef	T	P
Constant	5.6682	0.1252	45.29	0.000
Temperature	-0.0039072	0.0002426	-16.11	0.000
Speed	-0.0011979	0.0003950	-3.03	0.006
Feed	1.1831	0.2186	5.41	0.000
S = 0.171547	R-Sq = 93.4% R-Sq(adj) = 92.5%			

The coefficients of model for S/N ratios for surface roughness are shown in Table 5.5. The parameter R2 describes the amount of variation observed in surface roughness is explained by the input factors. R2 = 93.4 % indicate that the model is able to predict the response with high accuracy. Adjusted R2 is a modified R2 that has been adjusted for the number of terms in the model. If unnecessary terms are included in the model, R2 can be artificially high, but adjusted R2 (=92.5 %.) may get smaller.

The standard deviation of errors in the modeling, S= 0.171547. Comparing the p-value to a commonly used α-level = 0.04, it is found that if the p-value is less than or equal to α, it can be concluded that all the effects are significant.

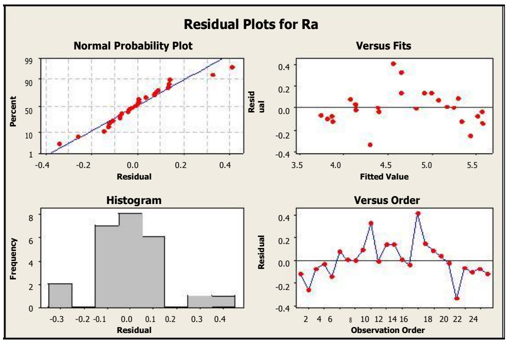

Figure 4 Residual Plots for Surface Roughness

The residual plot of cutting force is shown in Figure 5.3. The residual plots in the graph and the interpretation of each residual plot are explained below:
Normal probability plot indicates the data are normally distributed and the variables are influencing the response. Outliers don't exist in the data, because standardized residues are between -0.4 and 0.4. Residuals versus fitted values indicate the variance is constant and a nonlinear relationship exists as well as no outliers exist in the data. Histogram proves the data are not skewed and not outliers exist. Residuals versus order of the data indicate that there are systematic effects in the data due to time or data collection order

IV. CONCLUSIONS

After completing the experiments and analysis, the following conclusions were derived. Hot machining process gives good surface finish at high cutting speed, high temperature and low feed rate. And it is also beneficial in terms of surface roughness Optimum results are achieved when Cutting speed is 300 rev/min, Depth of Cut is 0.8 mm, Feed is 0.111 mm/rev and Temperature is 500o C During hot machining, the change of the work piece surface color was also observed at temperature of 5000 C

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