# Experimental Investigation on Surface Roughness and Material Removal Rate during Turning of EN8 Steel

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**Abstract – The present paper is an experimental study to investigate the effect of cutting parameters (cutting speed, depth of cut and feed) surface roughness and material removal rate (MRR) during turning of EN8 steel. Turning experiments were conducted with cutting speeds: 1000,1250,1500 rpm , feeds: 0.1, 0.2, 0.3 mm/rev and depth oh cuts: 0.3, 0.4, 0.5 mm. The experimental layout was designed based on the Taguchi's analysis. Orthogonal array technique and analysis of variance (ANOVA) was performed to identify the effect of the cutting parameters on the response variables. Finally, the relationship between cutting parameters and the performance measures (machining time, surface roughness and material removal rate) were developed by using multiple regression analysis.**

**Index Terms – Mild Steel (EN 8), Turning, MRR, surface roughness.**

## 1. INTRODUCTION

Machinability is defined as ease of machining of a material, characterized by low cutting forces, high material removal rate, good surface finish, accurate and consistent work piece geometrical characteristics, low tool wear rate and good curl or chip breakdown of chips etc.

Common operations performed on a lathe are: facing, parallel turning, taperturning, knurling, and thread cutting, drilling, reaming, and boring. The spindle is the part of the lathe that rotates. Various workholding attachments such as three jaw chucks, collets, and centres can be held in the spindle. The spindle is driven by an electric motor through a system of belt drives and/or gear trains. Spindle speed is controlled by varying the geometry of the drive train. The main function of lathe is to provide a means of rotating a work piece against a cutting tool, thereby removing metal. All lathes, regardless of size and design are basically the same and serve 3 functions:

(i) A support for the lathe accessories or the work piece

(ii) A way of holding and revolving the work piece

(iii) A means of holding and moving the cutting

Turning is one of the general machining processes. That is, the part is rotatedwhile a single point cutting tool is moved parallel to the axis of rotation. Turning can be done either on the external or internal surface of the part. It is to produce straighst, conical, curved, or grooved work pieces. Following are some of the operations that canbe done using Lathe Machine,

(i) Facing is part of the turning process. It is to produce a flat surface at the end ofthe part and perpendicular to its axis. It is useful for parts that are assembled with other components.

(ii) Parting is also called cutting off. It is used to create deep grooves which willremove a completed or part-complete component from its parent stock intodiscrete products.

(iii) Grooving is like parting, except that grooves are cut to a specific depth by aform tool instead of severing a completed/part-complete component from thestock. Grooving can be performed on internal and external surfaces, as well ason the face of the part.

Turning operation is widely used in workshop practice for applications carried out in conventional machine tools, as well as in NC and CNC machine tools, machining centres and related manufacturing systems. Turning involves the use of a lathe and is used primarily to produce conical and cylindrical parts. With common attachments, flat faces, curved surfaces, grinding and boring can be done with a lathe. Therefore, it is valuable to increase tool life, to improve surface accuracy, to reduce main cutting force, feed force and to reduce machining zone temperatures (chip-tool interface temperature) in turning operations through an optimization study.

Turning machines typically referred to as lathes, can be found in a variety ofsizes and designs. While most lathes are horizontal turning machines, vertical machinesare sometimes used, typically for large diameter work pieces. Turning machines can alsobe classified by the type of control that is offered. A manual lathe requires the operatorto control the motion of the cutting tool during the turning operation. Turning machinesare also able to be computer controlled, in which case they are referred to as a computernumerical control (CNC) lathe. CNC lathes rotate the work piece and move the cuttingtool based on commands that are preprogrammed and offer very high precision. In thisvariety of turning machines, the main components that enable the work piece to berotated and the cutting tool to be fed into the work piece remain the same.

1.1.WORK PIECE

The work material was EN8steel in form of round rod bar having 25 mm diameter and100mm axial cutting length. EN8steel is a unalloyed steel renowned for its wear resistance propensities and also where high strength properties are required. Another benefit of bright steel bars is a marked increase in physical strength over hot rolled bars of the same section. EN8: unalloyed medium carbon steel (BS 970 080m40) has high strength levels compared to normal bright mild steel, due to thermo mechanical rolling. EN8 is suitable for all round engineering purposes that may require a steel of greater strength.work piece material- EN8 MEDIUM CARBON STEEL shown in fig 1.2

Figure 1..work piece material- EN8

Medium-carbon steel:

- It provides material properties that are acceptable for many applications.
- Price is low.
- Good tensile strength,
- EN8 grade through-hardening medium carbon steel,
- It is readily machinable in any condition.

Table 1 CHEMICAL COMPOSITION OF EN8

| | |
|---|---|
| C | 0.36%-0.44% |
| Mn | 0.60%-1.00% |
| Si | 0.10%-0.40% |
| P | 0.050max |
| S | 0.050max |

As the steel progressively deformed, starts to form at the ferrite grainboundaries and at any inclusions that present. Turning of medium-carbon steels produce long chips. Built-up edge will form on an indexable insert if a chip breaker doesn't create a sufficient shear angle to curl the chip away from the insert's rake face. Low cutting speed is another cause of built up edge, (BUE) which acts as an extension of the cutting tool, changing part dimensions and imparting rough surface finishes. When thatis the case, the cutting speed should be increased 15 to 20% or more until the surface finish improves.

In this work experimental investigations have been conducted to study the

Machinability of EN8 steel while turning with cemented carbide tools. It is selected for machinability studies, because it is widely used in automotive industry for the production of axle, roller bearings, ball bearings, shear blades, spindle mandrels, forming and moulding dies, rollers, blanking and forming tools, knurling tools and spline shafts, etc. Turning is the main machining process for the production of these parts (HMT, 1996). Main interest of present research is to a solid-liquid lubricant for chip-tool interface while turning, so that the machinability of steelis improved and an attempt a new technique of applying the lubricant so that real minimum quantity lubricant can be achieved

1.2 CUTTING TOOL

Cutting tool is any tool that is used to remove metal from the work piece bymeans of shear deformation and they are generally made of tool steels. The selection of cutting-tool materials for a particular application is among the most important factors in machining operations. The cutting tool is subjected to high temperatures, high contact stresses, and rubbing along the tool–chip interface and along the machined surface.

1.2.1 Cutting insert

TNMG 160404 AH120,

where,

| | | |
|---|---|---|
| T | - | Shape of tool |
| N | - | Clearance |
| M | - | Tolerance |
| G | - | Size |
| S | - | Type of Cutting Edge |
| M | - | Medium of finishing |
| 120 | - | Tool Grade Number |

Figure 2 TNMG 160404 AH120

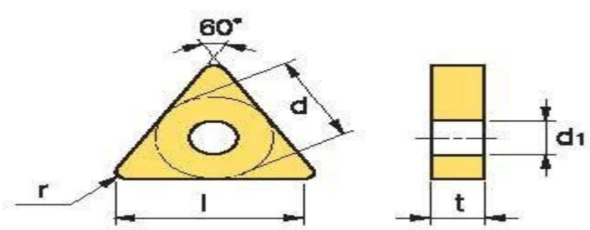



Figure 3 tool nomenclature

Table .2 Cutting insert details

| NAME | LENGTH |
|---|---|
| L cutting edge length | 16.5 mm |
| R corner radius | 0.4 mm |
| IC inscribed circle diameter | 9.525 mm |
| S insert thickness | 4.76mm |

## 2. LITERATURE REVIEW

**Alpesh R. Patel et al [2014] [1]**This paper is all about the possible factor that influence in hard turning process. Attempt has to made to show relationship between all input variables like speed, feed, depth of cut, tool materials, work piece hardness and output variables like surface roughness, tool wear and three force components during hard turning. Various authors have applied statistical analysis and experimentation to validate their work. The contribution of speed, feed and depth of cut is mentioned in this paper based on surface roughness, tool wear and machining force components. Taguchi, ANOVA, response surface method and FE analysis are useful tools to develop relationships between various variables.

**AmitPhogat et al [2013][2] ,** This paper presents the findings of an experimental investigation into the effects of cutting speed, feed rate, depth of cut, nose radius and cutting environment in Lathe turning of mild steel tool. Design of experiment techniques, i.e. response surface methodology (RSM) has been used to accomplish the objective of the experimental study. Face centered central composite design have been used for conducting the experiments. 3D surface plots of RSM revealed that cryogenic environment is the most significant factor in minimizing power consumption followed by cutting speed and depth of cut. The effects of feed rate and nose radius were found to be insignificant compared to other factors. Though both the techniques predicted near similar results, RSM technique seems to have an edge over the Taguchi's technique.

**Abrar A. Arshi et al [2013][3]**Titanium nitride (TiN) has been used in the coating of tool steels since the mid-sixties. The reasons to coat cutting tools in a production situation are to increase tool life, to improve the surface quality of the product, and to increase the production rate. The advantages of TiN coating include high hardness, good ductility, excellent lubricity, high chemical stability and tough resistance to wear, corrosion and temperature. In this paper, the principles, advantages and limitations of various TiN coating processes are summarized. With the growing popularity of TiN-coated tools and new development of coating process, this paper deals with the study of the performance of coated tools in machining hardening steel under dry conditions. This paper involves of machining hardened steel using Titanium nitride (TiN), coated carbide tools is studied using full factorial experiments. Many parameters influence the quality of the products in turning process. The objective of this study is on the effect of coating on tool to determine its various parameters such as temperature, cutting velocity, feed and depth of cut in machining hardened steel. Machining of hardened steels has become an important manufacturing process, particularly in the automotive and bearing industries.

**Aravind Kumar [2014] [4],** Engineering materials are presently in use at a very vast range in today's industries. As Mild steel1018 has a wide variety of applications in construction of pipelines, products, construction as structural steel, car manufacturing industries and other major industries. The machining of these types of materials requires very important consideration. There are a number of parameters like cutting speed, feed and depth of cut etc. which must be given consideration during the machining of this alloy. So it becomes necessary to find out the ways by which itcan be machined easily and economically. For the present work the parameter to be optimised selected is material removal rate that is optimised by using selected combination of machining parameters by using taguchi orthogonal array.

**AshishYadav et al [2012] [5],** A common method to manufacture parts to a specific dimension involves the removal of excess material by machining operation with the help of cutting tool. Turning process is the one of the methods to remove material from cylindrical and non-cylindrical parts. In this work the relation between change in hardness caused on the material surface due the turning operation with respect to different machining parameters like spindle speed, feed and depth of cut have been investigated. Taguchi method has been used to plan the experiments and EN24 metal selected as a work piece and coated carbide tool as a tool material in this work and hardness after turning has been measured on Rockwell scale. The obtained experimental data has been analyzed using signal to noise and. The main effects have been calculated and percentage contribution of various process parameters affecting hardness also determined**.**

## 3. EXPERIMENTAL SETUP

### 3.1 Workpiece Material

The workpiece material was EN8 steel in the form of round bars having 25 mm diameter and length of 100 mm. EN8 steel is a easy-to-machine material because and their typical applications are in manufacturing of machine tool parts like spindles, shafts, bearing and automobile products.

### 3.1.2 Cutting Inserts

In tests, cemented carbide inserts of TNMG 160404 AH120 (60 triangular shaped insert) without chip breaker geometry has been used for experimentation. The cutting inserts were clamped on the insert holder.

### 3.1.3 Experimental Procedure

The turning tests on the workpiece were conducted under normal conditions on a CNC lathe (PRIDE ULTRA LYNX) which have a maximum spindle speed of 4000 rpm and maximum power of 7.5 kW. A hole was drilled on the face of workpiece to allow it to be supported at the tailstock . Prior to actual machining, the rust layers were removed by a new cutting insert in order to minimize any effect of in homogeneity on the experimental results.Material removal rate (MRR) has been calculated from the difference of volume of workpiece before and after each experiment by using the following formula.

MRR = (wt of the material before machining-wt of the material after machining/M.c time) mm3/min

where, w1 and w2 are weight of work piece before and after machining.

### 3.1.4 Surface Roughness

Surface roughness is quantified by the deviations in the direction of the normal vector of a real surface from its ideal form. If the deviations are large the surface is rough; the deviations are small the roughness is smooth. Roughness plays aimportant role in determining how areal object will interact with its environment.

## 4. MACHINING TIME ANALYSIS

The analysis is made with the help of software package minitab16. The main effects are shown in the plots shown below. They show the variation in the response with the four parameters' i.e cutting speed, feed, depth of cut, nose radius separately. The x axis indicates the value of each process parameters at three levels and the y axis is the response. The horizontal line indicates the mean value of response. The main effects plot of SN ratio are used to determine the optimal design conditions to obtain the machining time. The plot shown below represents the main effects plot of SN ratio for the Machining time.

## 5. MATERIAL REMOVAL RATE ANALYSIS

The analysis is made with the help of software package minitab16. The main effects are shown in the plots shown below. They show the variation in the response with the four parameter's i.e cutting speed, feed, depth of cut, nose radius separately. The x axis indicates the value of each process parameters at three levels and the y axis is the response. The horizontal line indicates the mean value of response. The main effects plot of SN ratio are used to determine the optimal design conditions to obtain the metal removal rate. The plot shown below represents the main effects plot of SN ratio for the MRR

## 6. SURFACE ROUGHNESS ANALYSIS

The analysis is made with the help of software package minitab16. The main effects are shown in the plots shown below. They show the variation in the response with the four parameters i.e cutting speed, feed, depth of cut, nose radius separately. The x axis indicates the value of each process parameters at three levels and the y axis is the response. The horizontal line indicates the mean value of response. The main effects plot of SN ratio is used to determine the optimal design conditions to obtain the Surface roughness. The plot shown below represents the main effects plot of SN ratio for the surface roughness.

Table 3 Tabulated readings are noted for nr 0.4 under variable conditions

| Exp | SPEED (rpm) | FEED (mm/rev) | DEPTH OF CUT (mm) | NOSE RADIUS (mm) | WEIGHT BEFORE MACHINING (kg) | WEIGHT AFTER MACHINING (kg) | MRR (kg/sec) | MACHINING TIME (sec) | ROUGHNESS (µm) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1000 | 0.1 | 0.3 | 0.4 | 0.388 | 0.320 | 0.000121 | 561 | 2.815 |
| 2 | 1000 | 0.2 | 0.4 | 0.4 | 0.388 | 0.320 | 0.000304 | 224 | 3 |
| 3 | 1000 | 0.3 | 0.5 | 0.4 | 0.388 | 0.300 | 0.000615 | 143 | 5.175 |
| 4 | 1250 | 0.2 | 0.4 | 0.4 | 0.388 | 0.320 | 0.00037 | 184 | 3.8 |
| 5 | 1250 | 0.2 | 0.5 | 0.4 | 0.388 | 0.300 | 0.000615 | 143 | 3.85 |
| 6 | 1250 | 0.3 | 0.3 | 0.4 | 0.388 | 0.300 | 0.000524 | 168 | 4.85 |
| 7 | 1500 | 0.1 | 0.5 | 0.4 | 0.388 | 0.320 | 0.000301 | 226 | 3.345 |
| 8 | 1500 | 0.2 | 0.3 | 0.4 | 0.388 | 0.300 | 0.000433 | 203 | 3.51 |
| 9 | 1500 | 0.3 | 0.4 | 0.4 | 0.388 | 0.320 | 0.000607 | 112 | 3.69 |

Table 4 Tabulated readings are noted for nr 1.2 under variable conditions

| Exp | SPEED (rpm) | FEED (mm/rev) | DEPTH OF CUT (mm) | NOSE RADIUS (mm) | WEIGHT BEFORE MACHINING (kg) | WEIGHT AFTER MACHINING (kg) | MRR (kg/sec) | MACHINING TIME (sec) | ROUGHNESS (µm) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1000 | 0.1 | 0.3 | 1.2 | 0.388 | 0.320 | 0.006122 | 558 | 2.595 |
| 2 | 1000 | 0.2 | 0.4 | 1.2 | 0.388 | 0.300 | 0.000393 | 224 | 1.95 |
| 3 | 1000 | 0.3 | 0.5 | 1.2 | 0.388 | 0.300 | 0.000615 | 143 | 2.245 |
| 4 | 1250 | 0.2 | 0.4 | 1.2 | 0.388 | 0.300 | 0.000478 | 184 | 3.215 |
| 5 | 1250 | 0.2 | 0.5 | 1.2 | 0.388 | 0.320 | 0.000476 | 143 | 3.115 |
| 6 | 1250 | 0.3 | 0.3 | 1.2 | 0.388 | 0.300 | 0.000524 | 168 | 3.515 |
| 7 | 1500 | 0.1 | 0.5 | 1.2 | 0.388 | 0.300 | 0.000389 | 226 | 3.01 |
| 8 | 1500 | 0.2 | 0.3 | 1.2 | 0.388 | 0.300 | 0.000433 | 203 | 3.28 |
| 9 | 1500 | 0.3 | 0.4 | 1.2 | 0.388 | 0.300 | 0.000786 | 112 | 3.42 |

Table 5. Analysis of varience of SN ratios

| Source | DF | Seq SS | Adj SS | Adj MS | F | P |
|---|---|---|---|---|---|---|
| SPEED | 2 | 59.396 | 40.064 | 20.032 | 132.27 | 0 |
| FEED | 2 | 142.46 | 125.88 | 62.937 | 415.55 | 0 |
| DEPTH OF CUT | 2 | 50.885 | 50.885 | 25.443 | 167.99 | 0 |
| NOSE RADIUS | 1 | 0 | 0 | 0.0002 | 0 | 0.97 |
| SPEED*NOSE RADIUS | 2 | 0 | 0 | 0.0001 | 0 | 0.999 |
| FEED*NOSE RADIUS | 2 | 0 | 0 | 0.0002 | 0 | 0.999 |
| D O C*NOSE RADIUS | 2 | 0 | 0 | 0.0001 | 0 | 0.999 |
| Residual Error | 4 | 0.606 | 0.606 | 0.1515 | | |
| Total | 17 | 253.25 | | | | |

Table 6 Estimated Model Coefficients for SN ratios

| TERM | Coef | SE Coef | T | P |
|---|---|---|---|---|
| CONSTANT | -46.379 | 0.09729 | -476.7 | 0 |
| SPEED 1000 | -1.9767 | 0.13372 | -14.783 | 0 |
| SPEED 1250 | 0.3364 | 0.14504 | 2.319 | 0.081 |
| FEED 0.1 | -4.3663 | 0.17465 | -25.001 | 0 |
| FEED 0.2 | 0.8529 | 0.14504 | 5.88 | 0.004 |
| D.O.C 0.2 | -2.1582 | 0.13372 | -16.14 | 0 |
| D.O.C 0.4 | 0.2109 | 0.14504 | 1.454 | 0.22 |
| NR 0.4 | -0.0039 | 0.09729 | -0.04 | 0.97 |
| SPEED*NR 1000* | -0.0039 | 0.13372 | -0.029 | 0.978 |
| SPEED*NR 1250* | 0 | 0.14504 | 0 | 1 |
| FEED*NR 0.1*0.4 | -0.0078 | 0.17465 | -0.044 | 0.967 |
| FEED*NR 0.2*0.4 | 0.0039 | 0.14504 | 0.027 | 0.98 |
| D.O.C*NR 0.3*0.4 | -0.0039 | 0.13372 | -0.029 | 0.978 |
| D.O.C*NR 0.4*0.4 | 0 | 0.14504 | 0 | 1 |

Table 7 Response table for means

| Level | Speed | Feed | Depth of cut | Nose radius |
|---|---|---|---|---|
| 1 | 0.000362 | 0.000233 | 0.00036 | 0.000432 |
| 2 | 0.000498 | 0.000438 | 0.00049 | 0.000468 |
| 3 | 0.000492 | 0.000612 | 0.000502 | 0 |
| Delta | 0.000136 | 0.000379 | 0.000142 | 0.000036 |
| Rank | 3 | 1 | 2 | 4 |

Table 8 Response table for signal to noise ratios

| Level | Speed | Feed | Depth of cut | Nose radius |
|---|---|---|---|---|
| 1 | -70.59 | -73.81 | -70.39 | -68.16 |
| 2 | -66.16 | -67.34 | -66.66 | -67.4 |
| 3 | -66.6 | -64.35 | -66.29 | 0 |
| Delta | 4.43 | 9.46 | 4.11 | 0.75 |
| Rank | 2 | 1 | 3 | 4 |

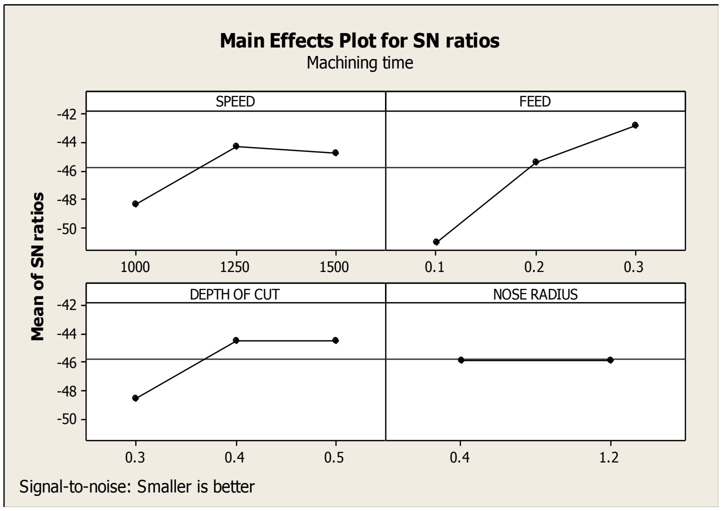



Figure 4 Main effect plot for SN ratios to Machining time

Cutting speed= 1250 rpm

Feed = 0.3 mm/rev

Depth of cut = 0.5 mm

Nose radius = 0.4mm

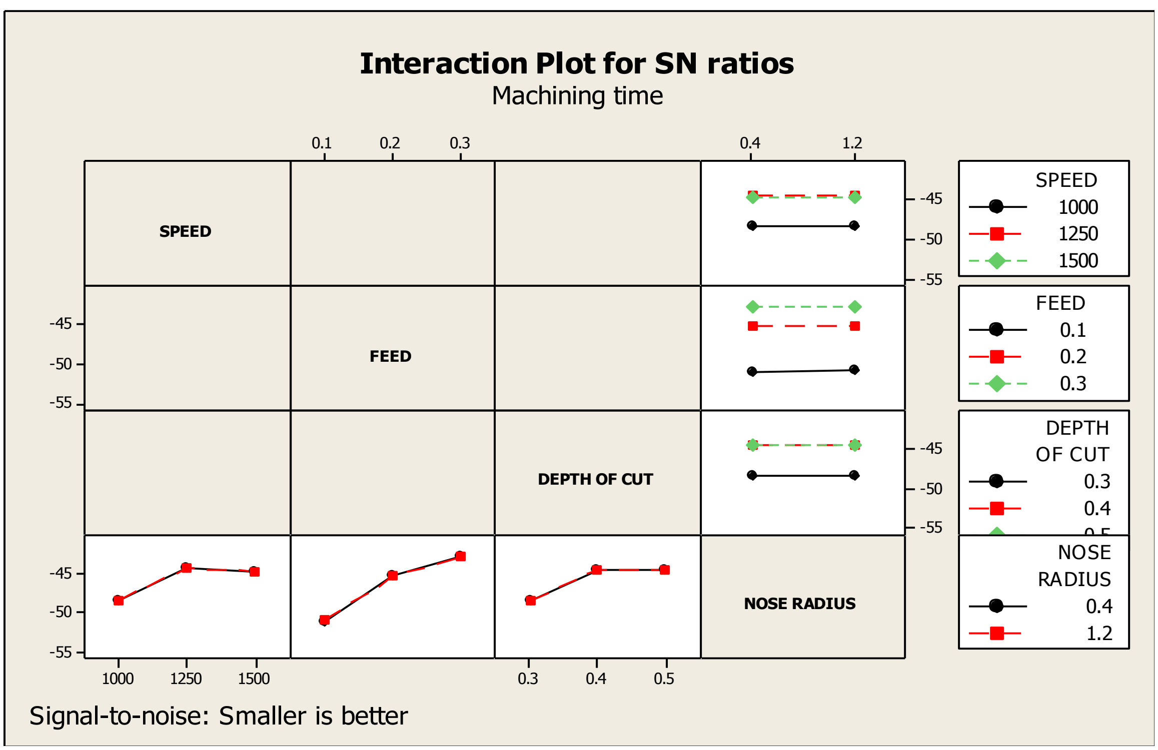



Figure 5. Interaction plot for SN ratio to Machining time

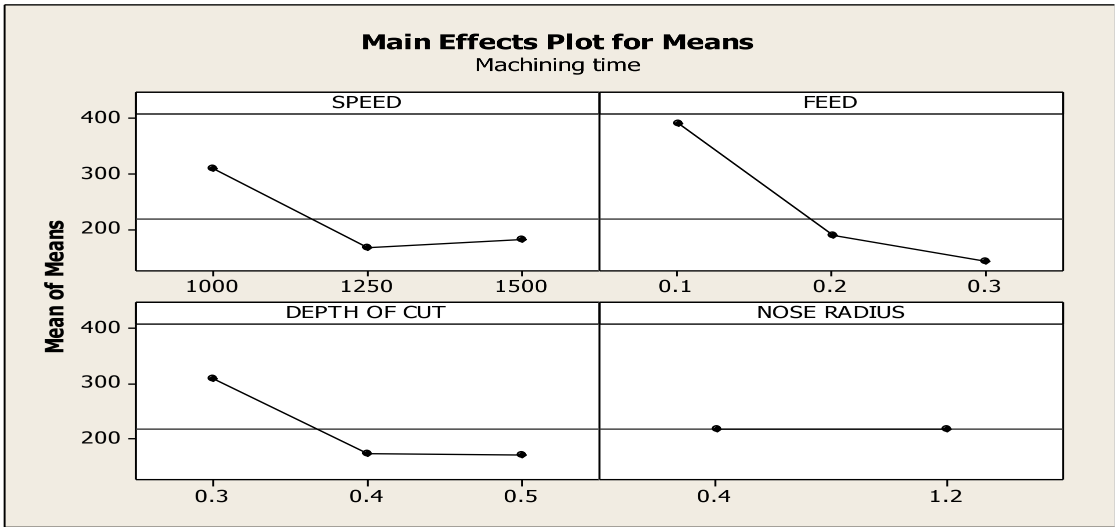



Figure 6 Main effect plot for means to Machining time

Table 9 Analysis of varience of SN ratios

| Source | DF | Seq SS | Adj SS | Adj MS | F | P |
|---|---|---|---|---|---|---|
| SPEED | 2 | 71.41 | 47.93 | 23.96 | 21.4 | 0.007 |
| FEED | 2 | 194.3 | 183.8 | 91.92 | 82.06 | 0.001 |
| DEPTH OF CUT | 2 | 51.42 | 51.42 | 25.72 | 22.96 | 0.006 |
| NOSE RADIUS | 1 | 2.543 | 3.541 | 3.541 | 3.16 | 0.15 |
| SPEED*NOSE RADIUS | 2 | 1.672 | 0.651 | 0.326 | 0.29 | 762 |
| FEED*NOSE RADIUS | 2 | 0 | 1.289 | 0.644 | 0.58 | 0.603 |
| DOC*NOSE RADIUS | 2 | 6.269 | 6.269 | 3.135 | 2.8 | 0.174 |
| Residual Error | 4 | 4.48 | 4.48 | 1.12 | | |
| Total | 17 | 332.1 | | | | |

Table 10 Estimated Model Coefficients for SN ratios

| TERM | Coef | SE Coef | T | P |
|---|---|---|---|---|
| CONSTANT | -68.5159 | 0.2646 | -258.96 | 0 |
| SPEED 1000 | -2.07 | 0.3646 | -5.963 | 0.005 |
| SPEED 1250 | 0.1497 | 0.3944 | 0.38 | 0.723 |
| FEED 0.1 | -5.3927 | 0.4749 | -11.354 | 0 |
| FEED 0.2 | 1.2261 | 0.3944 | 3.109 | 0.036 |
| D.O.C 0.3 | -1.8783 | 0.3636 | -5.165 | 0.007 |
| D.O.C 0.4 | -0.349 | 0.3944 | -0.885 | 0.426 |
| NR 0.4 | -0.4704 | 0.2646 | -1.778 | 0.15 |
| SPEED*NR 1000*( | 0.0894 | 0.3636 | 0.246 | 0.818 |
| SPEED*NR 1250*( | 0.1866 | 0.3944 | 0.473 | 0.661 |
| FEED*NR 0.1*0.4 | -0.4743 | 0.4749 | -0.999 | 0.374 |
| FEED*NR 0.3*0.4 | 0.3771 | 0.3944 | 0.956 | 0.393 |
| D.O.C*NR 0.3*0.4 | 0.4627 | 0.3636 | 1.272 | 0.272 |
| D.O.C*NR 0.4*0.4 | -0.9331 | 0.3944 | -2.366 | 0.077 |

Table 11 Response table for means

| Level | Speed | Feed | Depth of cut | Nose radius |
|---|---|---|---|---|
| 1 | 0.00036 | 0.000233 | 0.00036 | 0.000432 |
| 2 | 0.0005 | 0.000438 | 0.00049 | 0.000468 |
| 3 | 0.00049 | 0.000612 | 0.000502 | 0 |
| Delta | 0.00014 | 0.000379 | 0.000142 | 0.000036 |
| Rank | 3 | 1 | 2 | 4 |

Table 12 Response table for signal to noise ratios

| Level | Speed | Feed | Depth of cut | Nose radius |
|---|---|---|---|---|
| 1 | -70.59 | -73.81 | -70.39 | -68.16 |
| 2 | -66.16 | -67.34 | -66.66 | -67.4 |
| 3 | -66.6 | -64.35 | -66.29 | 0 |
| Delta | 4.43 | 9.46 | 4.11 | 0.75 |
| Rank | 2 | 1 | 3 | 4 |

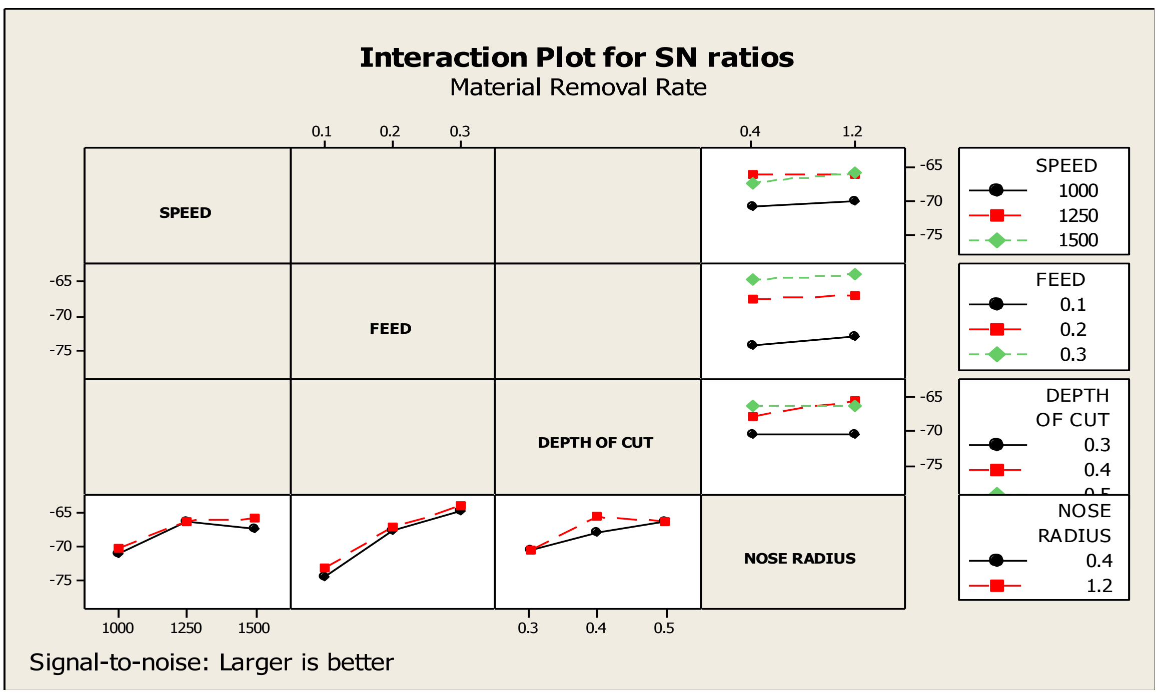



Figure.7 Interaction plot for means to Material removal rate

Cutting speed = 1250 rpm

Feed = 0.3 mm/rev

Depth of cut = 0.5 mm

Nose radius = 0.4mm

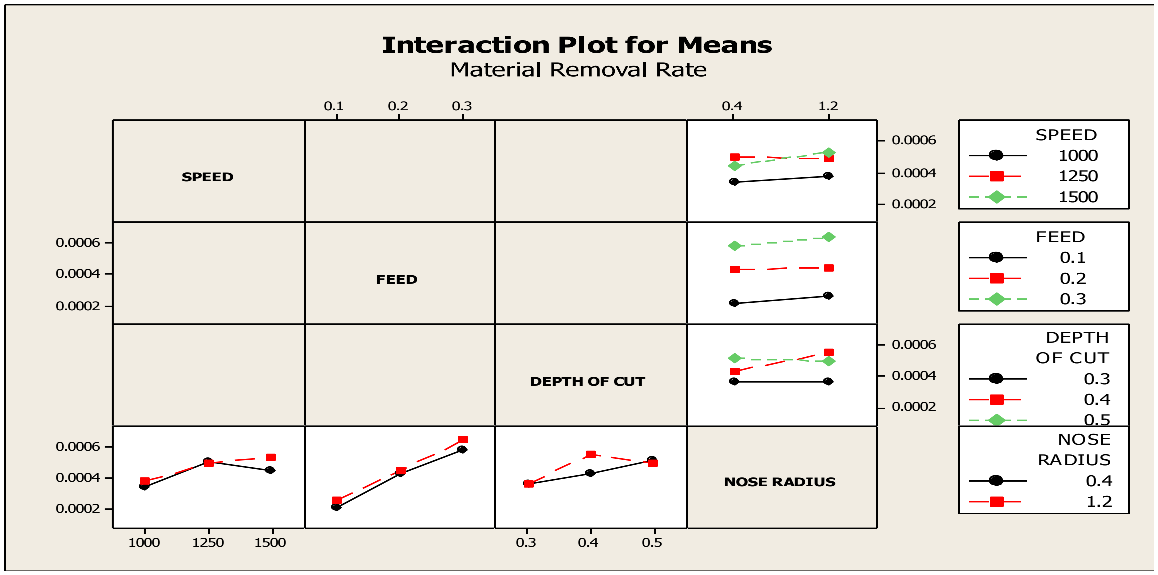



Figure 8 Interaction plot for means to Material removal rate

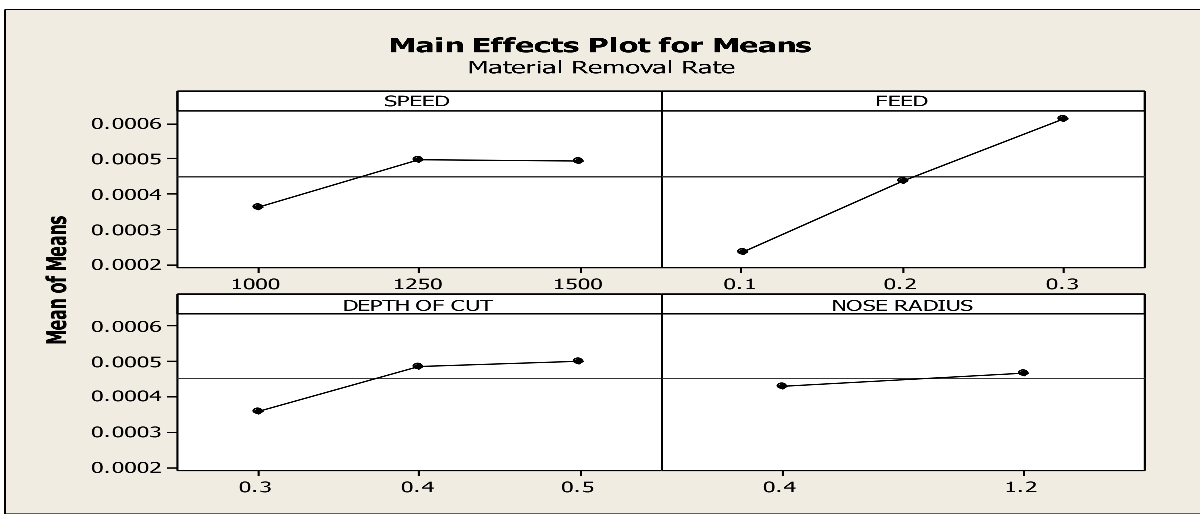



Figure 9 Main effect plot for means to Material removal rate

Table 13 Analysis of varience of SN ratios

| Source | DF | Seq SS | Adj SS | Adj MS | F | P |
|---|---|---|---|---|---|---|
| SPEED | 2 | 17.034 | 14.122 | 7.0612 | 7.91 | 0.041 |
| FEED | 2 | 9.762 | 9.875 | 4.9373 | 5.53 | 0.071 |
| DEPTH OF CUT | 2 | 1.883 | 1.833 | 0.9164 | 1.03 | 0.437 |
| NOSE RADIUS | 1 | 22.125 | 15.654 | 15.6544 | 17.53 | 0.014 |
| SPEED*NOSE RADIUS | 2 | 7.659 | 8.378 | 4.1891 | 4.96 | 0.089 |
| FEED*NOSE RADIUS | 2 | 5.337 | 6.175 | 3.0873 | 3.46 | 0.134 |
| DEPTH OF CUT*NOSE RADIUS | 2 | 3.916 | 3.916 | 1.9581 | 2.19 | 0.227 |
| Residual Error | 4 | 3.571 | 3.571 | 0.8928 | | |
| Total | 17 | 71.237 | | | | |

Table 14 Estimated Model Coefficients for SN ratios

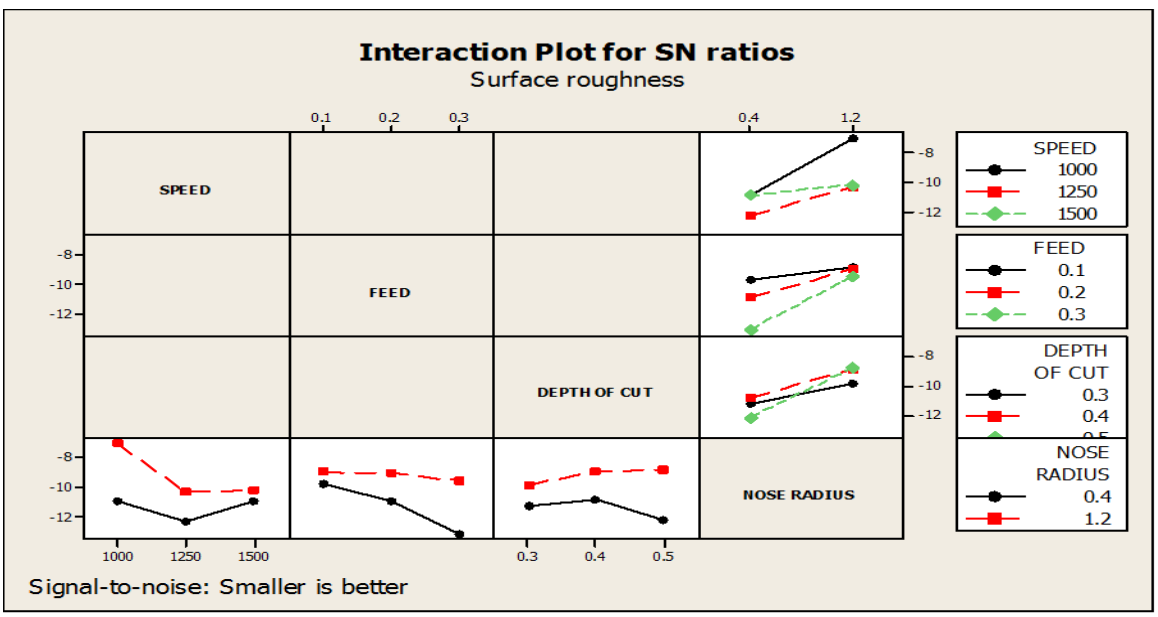
| TERM | Coef | SE Coef | T | P |
|---|---|---|---|---|
| CONSTANT | -10.2537 | 0.2362 | -43.408 | 0 |
| SPEED 1000 | 1.2674 | 0.3246 | 3.904 | 0.017 |
| SPEED 1250 | -0.9705 | 0.3251 | -2.756 | 0.051 |
| FEED 0.1 | 0.6877 | 0.424 | 1.622 | 0.18 |
| FEED 0.2 | 0.3848 | 0.3521 | 1.093 | 0.336 |
| D.O.C 0.2 | -0.2678 | 0.3246 | -0.825 | 0.456 |
| D.O.C 0.4 | 0.5041 | 0.3521 | 1.432 | 0.226 |
| NR 0.4 | -0.9891 | 0.2362 | -4.187 | 0.014 |
| SPEED*NR 1000*0.4 | -0.9613 | 0.3246 | -2.961 | 0.042 |
| SPEED*NR 1250*0.4 | 0.333 | 0.3251 | 0.946 | 0.398 |
| FEED*NR 0.1*0.4 | 0.9358 | 0.424 | 2.207 | 0.092 |
| FEED*NR 0.2*0.4 | -0.1399 | 0.3251 | 0.397 | 0.711 |
| D.O.C*NR 0.3*0.4 | 0.3072 | 0.3246 | 0.946 | 0.398 |
| D.O.C*NR 0.4*0.4 | 0.3721 | 0.3251 | 1.057 | 0.35 |

Table 15 Response table for means

| Level | Speed | Feed | Depth of cut | Nose radius |
|---|---|---|---|---|
| 1 | 2.963 | 2.941 | 3.428 | 3.782 |
| 2 | 3.724 | 3.215 | 3.179 | 2.927 |
| 3 | 3.376 | 3.816 | 3.457 | 0 |
| Delta | 0.761 | 0.875 | 0.278 | 0.854 |
| Rank | 3 | 1 | 4 | 2 |

Table 16Response table for signal to noise ratios

| Level | Speed | Feed | Depth of cut | Nose radius |
|---|---|---|---|---|
| 1 | -8.986 | -9.333 | -10.522 | -11.396 |
| 2 | -11.325 | -9.986 | -9.851 | -9.179 |
| 3 | -10.551 | -11.326 | -10.49 | 0 |
| Delta | 2.339 | 1.993 | 0.671 | 2.217 |
| Rank | 1 | 3 | 4 | 2 |



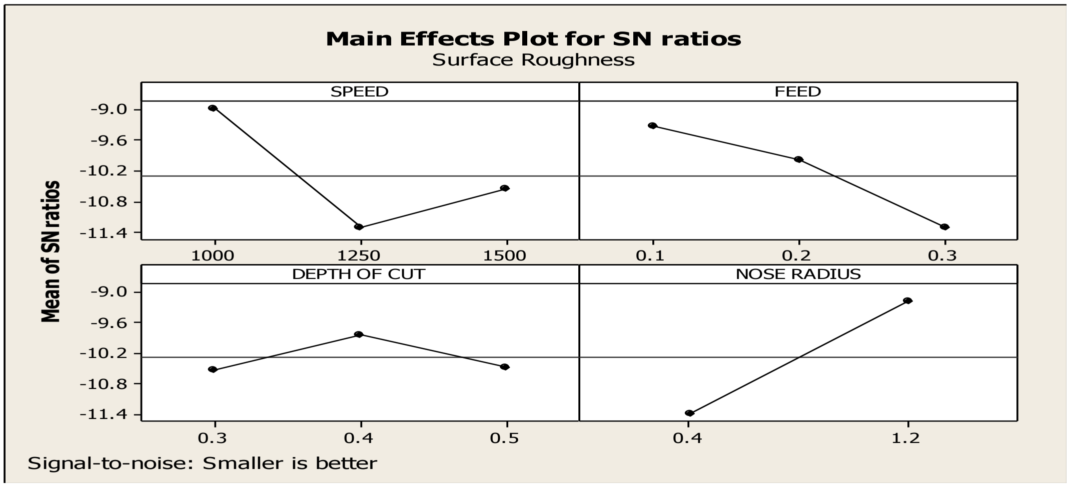



Figure .10 Main effect plot for SN ratio to Surface roughness

Cutting speed = 1000 rpm

Feed = 0.1 mm/rev

Depth of cut = 0.4 mm

Nose radius = 0.4 mm

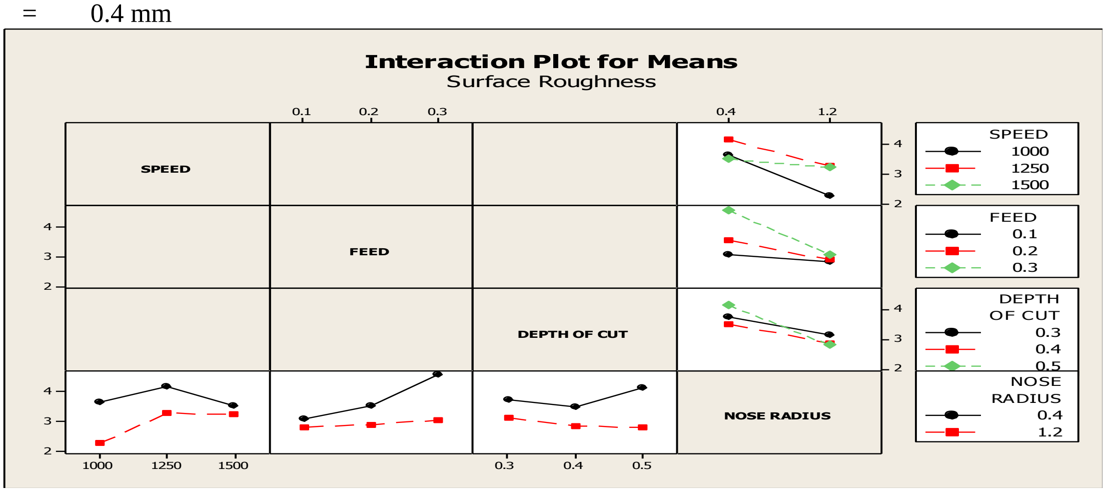



Fig .11 Interaction plot for means to Surface roughness

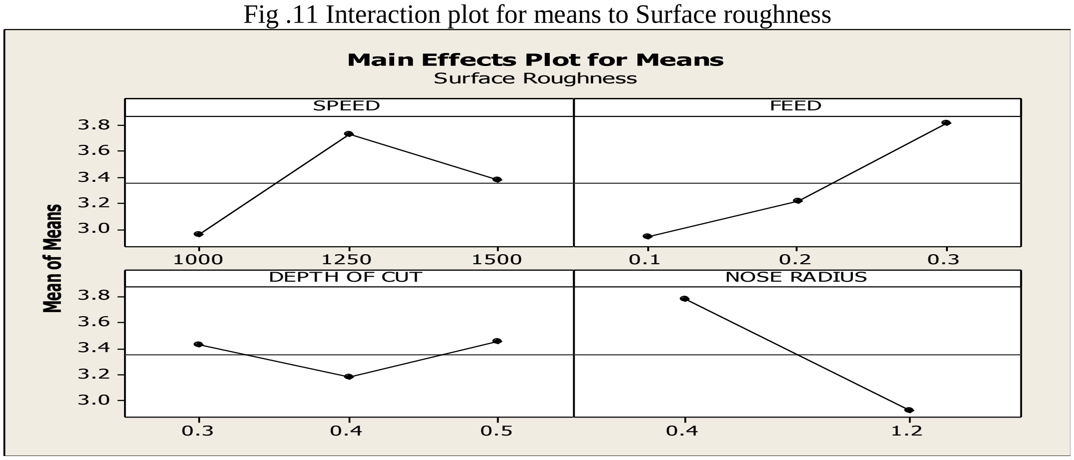



Figure12 Main effect plot for means to surface roughness

7. RESULT

The effect of three machining parameters i.e. Cutting speed, feed rate and depth of cut and their interactions are evaluated with the help of MINITAB 16 statistical software.The purpose of this study is to identify the important turning parameters in prediction of Material Removal Rate and Surface Roughness.

## 8. CONCLUSION

We focused on analyzing the turning it on material EN8 buy turning it on CNC machine under variable input conditions. In Machining time, the speed of 1250 rpm, the depth of cut 0.5mm, feed of 0.5mm/rev had obtained the better machining time. In Material removal rate, the speed of 1250 rpm, the depth of cut 0.5 mm, feed of 0.3mm/rev had obtained the better Material removal rate.In Surface roughness, the speed of 1000 rpm, the depth of cut 0.4 mm, feed of 0.1mm/rev had obtained the better Surface roughness.It is also shown that the performance characteristics of the turning operations, such as the material removal rate and the surface roughness are greatly enhanced by using this method.

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