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Optimization of Turning Parameters of En-8 Steel Cylindrical Rods Using Taguchi Methodology

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In this research the experiments were performed by using material specimens of EN8 to know the effect of different machining parameters on tool wear. The main objective of this study was to investigate the effect of cutting parameters and the work piece on the tool wear during a machining of EN8 material. The quality of work piece material is main contributing factor as spindle speed, depth of cut and feed rate which may be influence by tool wear through cutting operation. The experimental design was formed based on Taguchi's Technique. An orthogonal array $L(3)_9$ and Analysis of Variance are employed to investigate the turning conditions and machining was done using coated tool insert with specific density of 7.8 Kg/m^3.
Keywords: EN-8, Turning Parameters, Taguchi, DOE, S/N Ratio, ANOVA.

I. INTRODUCTION

The recent developments in science and technology have put tremendous demands on manufacturing industries. The present work includes EN-8 steel finding many applications such as shaft, axle, gears and Fasteners due to their high hardness, strength to weight ratio. Optimum machining parameters of turning operations are greatly influenced with concern along with manufacturing environment. The EN8 steel with different parameters such as cutting speed, feed and depth of cut are greatly influenced by response parameters. It is normally supplied in the cold drawn or as rolled condition. Tensile properties can vary but are usually between 500-800 N/mm^2. EN8 is widely used for applications which require better properties than mild steel but does not justify the costs of an alloy steel. EN8 can be flame or induction hardened to produce a good surface hardness with moderate wears resistance. EN8 is available from stock in bar and can be cut to your requirements. . Turning is a form of machining, a material removal process, which is used to create rotational parts by cutting away unwanted material. The turning process requires a turning machine or lathe, work piece, fixture, and cutting tool. The work piece is a piece of pre-shaped material that is secured to the fixture, which itself is attached to the turning machine, and allowed to rotate at high speeds[4-5] .The Lathe is a machine tool used to remove unwanted material from a given work piece to get desired shape. It is generally used for machining cylindrical work-pieces. The origins of lathe can be traced back to Ancient Egypt and ancient Greece. In ancient Egypt, two-person lathes were extensively used. In a two-person lathe, one person would turn the wood (work piece) and the other individual would cut the wood with a single point cutting tool. Cutting operation in this lathe involved a lot of manual labour and consumed a large amount of time. In Ancient Rome, the Egyptian Design was modified [7].

A. Turning

A turning bow was used to turn the work piece. In the medieval period, pedals were used to turn and cut the work piece. The pedals were operated by human legs. The origin of modern lathe can be traced back to the time when the Industrial Revolution took place. The Industrial revolution brought a lot of changes to the world of machines [8]. During that golden period, a number of mechanisms were introduced to lathe. These mechanisms enabled humans to operate lathe semi-automatically. Power generated from steam engines were used to drive lathes. A single point cutting tool is mounted on the tool post. The work piece is rotated continuously by rotating the head stock spindle. The single point cutting tool is fed against the circumferential area of the work piece. Unwanted material is removed and a cylindrical job with smooth surface finish is obtained. During the machining process, the cutting tools are loaded with the heavy forces resulting from the deformation process in chip formation and friction between the tool and work piece [10]. The heat generated at the deformation and friction zones overheats the tool, the chip and partially the work piece.

II. LITERATURE SURVEY

Matsumara*et al.* (2004) performed turning operation and studies the machinability of steel and gives key note to determination of optimal cutting conditions for surface finish obtained in turning using design of experiments for carbide coated tool [11].
Sutter *et al.* (2005) gives analyzing the chip formation and chip geometrics during high speed machining for orthogonal cutting

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conditions and obvious that achievements of proper surface finish of the manufactured parts are desirable and essential in some applications [12].

Ghosh Amitabh *et al.* (2006) have discussed the surface finish in machining and have indicated that the resultant roughness produced by a machining operation is the combined effect of two independent quantities namely ideal roughness and natural roughness. According to them, ideal roughness is a result of the geometry of the tool and the feed [13].

Sijo M. T. *et al* (2011) analyzed that for solving machining optimization problems, various conventional techniques had been used so far ,but they are not robust and have problems when applied to the turning process, which involves a number of variables and constraints. To overcome the above problems, Taguchi method is used in this work. Since Taguchi method is experimental method it is realistic in nature. According to this study the prime factor affecting surface finish is feed rate[14].

Vikram Kumar and Ramamoorthy *et al* (2007) have dealt with Performance of coated tools during hard turning under minimum fluid application [15].

Further Sarma and Dixit *et al* (2007) have compared the dry and air-cooled turning of grey cast iron with mixed oxide ceramic tool [16].

Gokkaya Hasan and Nalbant Muammer *et al* (2007) have studied The effects of cutting tool geometry and processing parameters on the surface roughness of AISI 1030 steel[17].

Goek *et al* (2007) also report the possibility of finish turning of steel with CNB inserts under high speeds[18].

Ersan Aslam*et al* (2007) has shown that the optimized machining parameters while machining A1S1 140 steel with ceramic tool and shown that cutting speed, feed rake and depth of cut inter actions have significant influence on surface roughness[19].

Paulo Davin *et al* (2008) express a note on the determination of optimal cutting conditions for surface finish obtained in turning using design of experiments for carbide coated tool turning. Design Of Experiment (DOE) is a structured, organized method used to determine the relationship between the different input factors (Xs) and the outputs (Ys) of a process. Design of experiment involves designing a set of experiments, in which all relevant factors are varied systematically [20].

Quazi T Z *et al* (2013) have made an attempt to review the literature on optimizing machining parameters in turning processes by Taguchi method. The settings of turning parameters were determined by using Taguchi's experimental design method. Orthogonal arrays of Taguchi, the signal-to-noise (S/N) ratio, the analysis of variance (ANOVA) are employed to find the optimal levels and to analyze the effect of the turning parameters [21].

W. H. Yang *et al* (1998) have discussed an application of the Taguchi method for optimizing the cutting parameters in turning operations. The Taguchi method provides a systematic and efficient methodology for the design optimization of the cutting parameters with far less effect than would be required for most optimization techniques. It has been shown that tool life and surface roughness can be improved significantly for turning operations [22].

M. Adinarayana *et al* (2000) have presented in paper the multi response optimization of turning parameters for Turning on AISI 4340 Alloy Steel. Experiments are designed and conducted based on Taguchi's L27 Orthogonal array design. This paper discusses an investigation into the use of Taguchi parameter Design and Regression analysis to predict and optimize the Surface Roughness, Metal Removal Rate and Power Consumption in turning operations using CVD Cutting Tool. The Analysis of Variance is employed to analyze the influence of Process Parameters during Turning. This paper also remarks the advantages of multi-objective optimization approach over the single-objective one. The useful results have been obtained by this research for other similar type of studies and can be helpful for further research works on the tool life and vibration of tools [23].

Vikas B. Magdum *et al* (2013) this study used for optimization and evaluation of machining parameters for turning on EN8 steel on Lathe machine. This study investigates the use of tool materials and process parameters for machining forces for selected parameter range and estimation of optimum performance characteristics. Develop a methodology for optimization of cutting forces and machining parameters.

III. EXPERIMENTAL WORK

Table 1. Chemical Composition of EN-8 Steel

C	Si	Mn	S	P
0.4	0.8	0.25	0.015	0.015

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Table 2. Mechanical Properties of En8 steel

Max. Stress	700-850n/mm^2
Yield Stress	465n/mm^{2}Min
Proof Stress	450n/mm^{2}Min
Elongation	16% Min
Impact Strength	28joules Min
Hardness Value	201-255Brinell

Table 3. Experimental Conditions

Work Piece Material	EN8 Steel
Length of the Work Piece	203 mm
Diameter of the Work Piece	19.0 mm

The condition of the material EN8 is before the operation. And the samples are prepared and marked with numbering 1,2,3,4,5,6,7,8 and 9 respectively and shown in figure 1.

Figure 1.

TWR was calculated by measuring the difference between initial and final weight of tool using a weighing machine with least count as 0.001 gm. For each trial Tool Wear Rate (TWR) was calculated using equation

$$TWR = \frac{(Wit - Wft) \text{ X } 1000}{\rho t \text{ X } t} \qquad (mm^3/min)$$

Where,

w_{it} =Initial weight of the tool material (in gm),

w_{ft}=Final weight of tool material after experimentation (in gm),

ρt=Density of tool material (in gm/cm^3) and

t =Machining time (in min).

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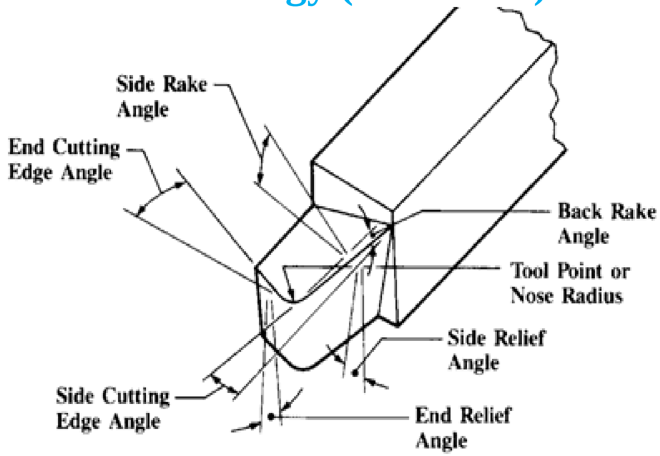

Figure 2. Single point cutting tool

Process Parameters Cutting feed - The distance that the cutting tool or work piece advances during one revolution of the spindle, measured in inches per revolution (IPR). In some operations the tool feeds into the work piece and in others the work piece feeds into the tool. For a multi-point tool, the cutting feed is also equal to the feed per tooth, measured in inches per tooth (IPT), and multiplied by the number of teeth on the cutting tool. Cutting speed - The speed of the work piece surface relative to the edge of the cutting tool during a cut, measured in surface feet per minute (SFM). Spindle speed - The rotational speed of the spindle and the work piece in revolutions per minute [24].

Table 4. Design of Experiments

Number of Experiments	Speed	Feed	Depth of Cut
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

IV. RESULTS AND DISCUSSION

The parameters speed of the spindle is measured by using tachometer. The weights of the samples are measured by digital weighing machine as Shown in Figure 7. Depth of cut as taken as range 2 to 3 mm by varying the speed at level I , level II and Level III as the measured speed 178 rpm,300 rpm and 475 rpm respectively. Finally, the TWR is calculated by using equation as mentioned above.

Table 5. Turning Parameters

Speed (RPM)	Feed (mm/min)	Depth of Cut (mm)	TWR (mm^3/min)
175	0.071	0.5	0.08
175	0.11	1	0.07
175	0.25	1.5	0.13
300	0.071	1	0.12
300	0.11	1.5	0.22
300	0.25	0.5	0.1
475	0.071	1.5	0.3
475	0.11	1	0.14
475	0.25	0.5	0.2

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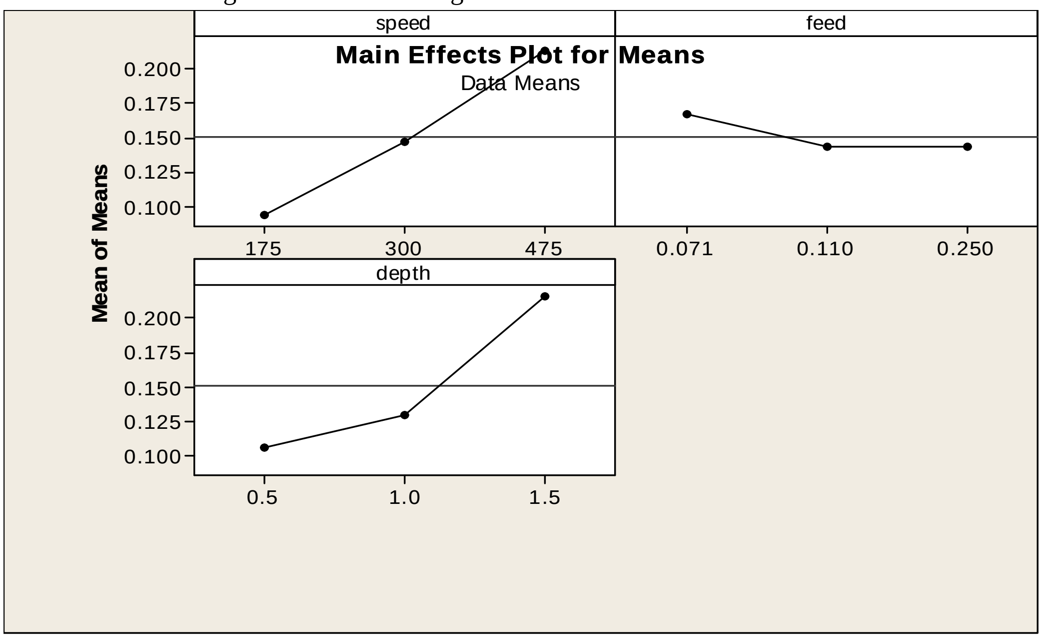
The results for various combinations of parameters were obtained on conducting the experiments the response signal-Noise as shown in Table 8. Firstly, the most factors which affects the signal to noise is Speed in rpm 0.09333, 0.14667, 0.21333.and delta value is 0.12000 and secondly, the factor is depth of cut in mm 0.10667,0.13000,0.21667 and delta value is 0.11000.and last one affect the signal to noise is feed mm/min 0.16667,0.14333,0.14333and delta value is 0.02333. In table 8 shows the rank of factor is speed in first rank, depth of cut is second rank and feed is third rank.

Table 6. Response Table for Signal to Noise Ratios Smaller is better

S. No	Speed (RPM)	Feed(mm/min)	Depth of Cut (mm)
1	0.09333	0.16667	0.10667
2	0.14667	0.14333	0.13000
3	0.21333	0.14333	0.21667
Delta	0.12000	0.02333	0.11000
Rank	1	3	2

Figure 3. Shows the Signal to Noise Ratio Values



V. CONCLUSION

A. The present study includes the use of Taguchi method to analyze the effect of machining parameters of material EN8 steel. After conducting experimental work, analysis of the results revealed the optimized parameter for machining by using EN8 material.

B. The results obtained from the analysis showed that spindle speed varying from 175 to 475 rpm is the highest significant parameter followed by depth of cut from 0.5 to 1.5mm resulted in rapid increase in tool wear 0.22. Therefore, it shows that speed is most important parameter to reduce the tool tip wear than other remaining two parameters and the optimized parameter setting was found by using Taguchi L9 orthogonal array.

C. Further, it was observed that the effect of speed was more critical than the depth of cut and rest of parameter as feed rate and predicted results to found that optimized setting found are correct after conducting confirmation results.

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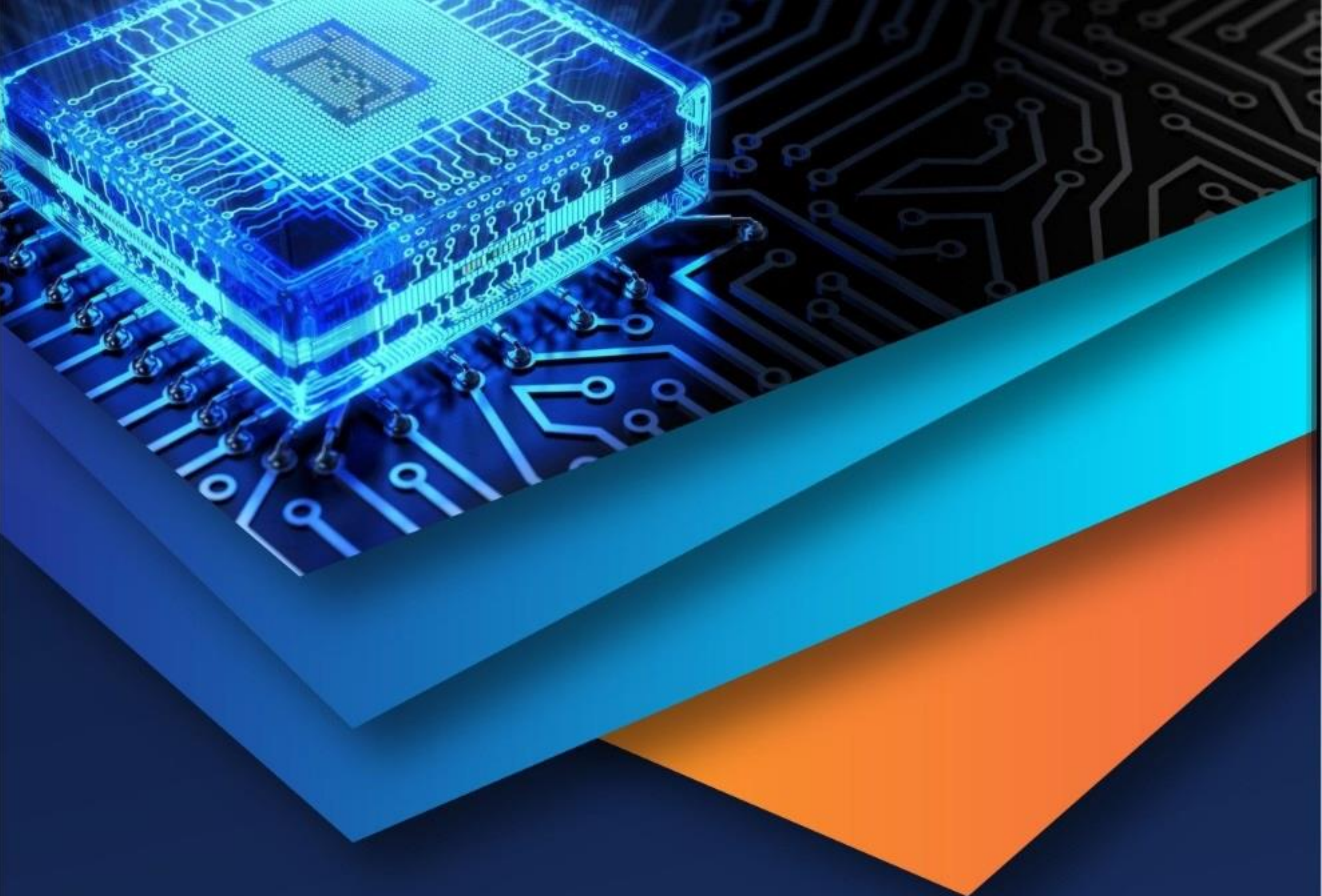

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