Analysis of the Effect of Machining Parameters on Surface Roughness of EN 36 Nickel Steel

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ABSTRACT

Quality and productivity play significant role in today's manufacturing market. From customers' viewpoint quality is very important because the extent of quality of the procured item (or product) influences the degree of satisfaction of the consumers during its usage. Therefore, every manufacturing or production unit should concern about the quality of the product. Quality of a product can be described by various quality attributes. The attributes may be quantitative or qualitative. Our present study is based on the analysis of machining parameters on surface roughness on EN 36 shafts using Carbide and Cobalt tool on CNC lathe. In metal cutting and manufacturing industries, surface finish of a product is very crucial in determining the quality. Good surface finish not only assures quality, but also reduces manufacturing cost. Surface finish is important in terms of tolerances, it reduces assembly time and avoids the need for secondary operation, thus reduces operation time and leads to overall cost reduction. Besides, good-quality turned surface is significant in improving fatigue strength, corrosion resistance, and creep life. In this research, the main objective is to study the effect of cutting speed and depth of cut on surface roughness of EN 36 in turning operation.

Keywords: *quality, productivity, straight turning, surface roughness, flank wear, contact type stylus profilometer.*

I. INTRODUCTION

The CNC turning process is relatively new process in the manufacturing technology compared to conventional lathe turning. CNC machines provide flexibility in selecting accurate cutting speed, depth of cut and feed rate simultaneously. So it provides a new range of process variable. In this paper selected workpeice material EN 36 commonly called Nickel Steel. It i**s** case hardening steel specifically designed for carburizing to give a very hard case with strong core. It is generally used in gears, crane shafts and gear shafts in various automobiles.

II. EXPERIMENTATION

Literature depicts that a considerable amount of work has been carried out by previous investigators for modeling, simulation and parametric optimization of surface properties of the product in turning operation. Issues related to tool life, tool wear, cutting forces have been addressed to. Apart from optimizing a single response (process output), multiobjective optimization problems have also been solved. Accordingly the present study has been done through the following plan of experiment.

a) Checking and preparing the CNC Lathe ready for performing the machining operation.

b) Cutting EN36 shafts by power saw and performing initial turning operation in Conventional Lathe to get desired dimension of the work pieces.

c) Performing straight turning operation on specimens in various cutting environments involving various combinations of process control parameters like: - spindle speed, feed and depth of cut.
d) Measuring surface roughness and surface profile with the help of a portable contact type stylus profilometer.

III. INPUT PROCESS VARIABLES

Spindle Speed(RPM)	Feed Rate(mm/min)	Depth of Cut(mm)
125	5	0.1
400	20	0.3
800	40	0.6
1200	60	0.9

IV. EQUIPMENTS USED

1. CNC Lathe

Specifications

Distance between centers	300 mm
Swing over Bed	150 mm
Swing over Cross Slide	60 mm
Maximum Machining Diameter	30 mm
Maximum Machining Length	60 mm

2. Tools Used

i. Tungsten Carbide Tip: Tungsten carbide is an inorganic chemical compound (specifically, a carbide) containing equal parts of tungsten and carbon atoms. Sintered tungsten carbide cutting tools are very abrasion resistant and can also withstand higher temperatures than standard high speed steel tools. Its density is around 15.7 gm/cm^3. Hardness is 90 on Rockwell Scale. Its Young's Modulus is 670 GPa. Nose Radius is 0.8 mm. Machining can be performed with six tips.

ii. Cobalt Tip: It has excellent resistance to abrasion and very good red-hardness for working difficult materials. Its hardness is around 65 on Rockwell Scale. It has the nose radius of 0.8 mm. Machining can be done with three cutting tips.

3. Servo Cutting Oil

It forms a milky emulsion with water and contains rust inhibitor to impart anti-rust, anti-corrosion properties and a biocide to prevent bacterial growth in the emulsion. This oil has superior cooling and lubricating properties which impart excellent surface finish and minimizes tool wear. For stable working, emulsion oil should be added to water in concentration of 10% for turning operations.

4. Workpeice Material

Workpeice material taken for the turning is EN 36 (Nickel Steel). It is case hardening steel specifically designed for carburizing to give a very hard case with strong core. It is generally used in gears, crane shafts and gear shafts in various automobiles. Its hardness is 55 on Rockwell Scale. Its composition is as follows

Carbon	Nickel	Chromium	Silicon	Manganese
0.700 %	3.200 %	1.050 %	0.250 %	0.420 %

5. Contact Type Stylus Profilometer

This instrument is used to measure the surface roughness of the machined workpeice. Sampling length is taken to be 5 mm. Average force applied is 0.7 mN. Least count of the instrument is 0.1 microns. Measurement is taken at three different points and their average values are taken.

V. DATA ANALYSIS

Roughness Values for Tungsten Carbide Tool

1. Surface Roughness Values with Variable Cutting Speed

Fixed Parameters

Depth of Cut = 0.2 mm

Feed Rate = 10 mm/min

RPM	Ra_1(in microns)	Ra_2(in microns)	Ra_3(in microns)	Average Ra (in microns)
125	3.5	3.9	3.1	3.5
400	3.2	3.0	2.8	3.0
800	3.6	2.8	2.3	2.9
1200	2.3	1.8	2.2	2.1

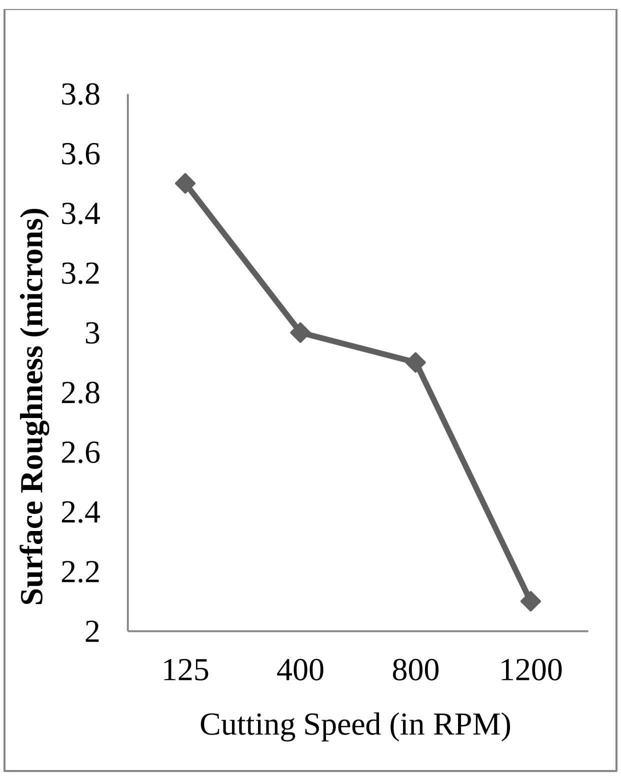

Figure 1: Surface Roughness vs Cutting Speed

2. Surface Roughness Values with Variable Feed Rate

Fixed Parameters

Depth of Cut = 0.2 mm

Cutting Speed = 400 RPM

Feed Rate (in mm/min)	Ra_1(in microns)	Ra_2(in microns)	Ra_3(in microns)	Average Ra (in microns)
5	2.4	2.8	3.5	2.9
20	3.2	3.4	3.3	3.3
40	2.9	3.1	4.2	3.4
60	3.4	3.6	4.7	3.9

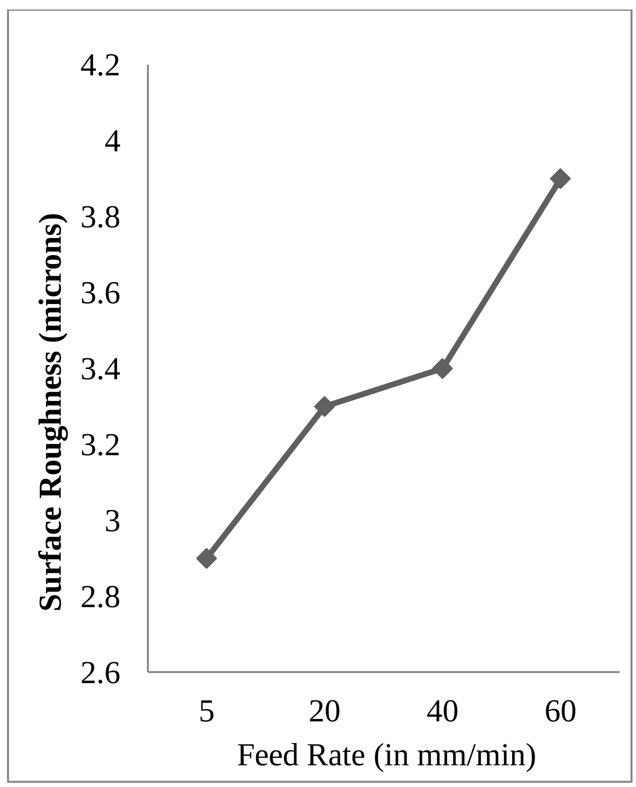

Figure 2: Surface Roughness vs Feed Rate

3. Surface Roughness Values with Variable Depth of Cut

Fixed Parameters

Cutting Speed = 400 RPM

Feed Rate = 10 mm/min

Depth Of Cut (in mm)	Ra_1(in microns)	Ra_2(in microns)	Ra_3(in microns)	Average Ra (in microns)
0.1	5.0	4.6	3.9	4.5
0.3	4.8	5.1	4.2	4.7
0.6	6.3	6.0	7.2	6.5
0.9	4.9	6.4	5.5	5.6

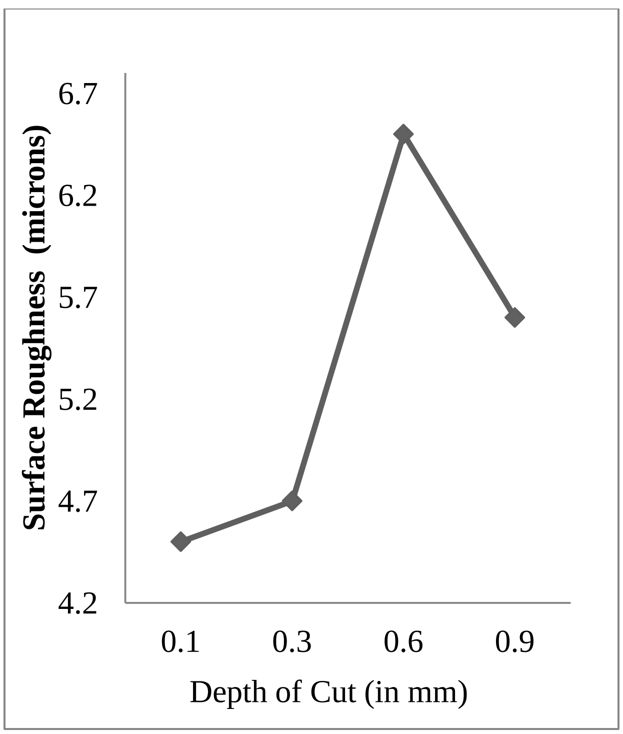

Figure 3: Surface Roughness vs Depth of Cut

Roughness Values for Cobalt Tool Insert

4. Surface Roughness Values with Variable Cutting Speed

Fixed Parameters

Depth of Cut = 0.2 mm

Feed Rate = 15 mm/min

RPM	Ra_1(in microns)	Ra_2(in microns)	Ra_3(in microns)	Average Ra (in microns)
125	3.4	4.0	4.3	3.9
400	3.6	3.0	3.0	3.2
800	2.5	3.8	1.8	2.7
1200	2.6	2.4	1.9	2.3

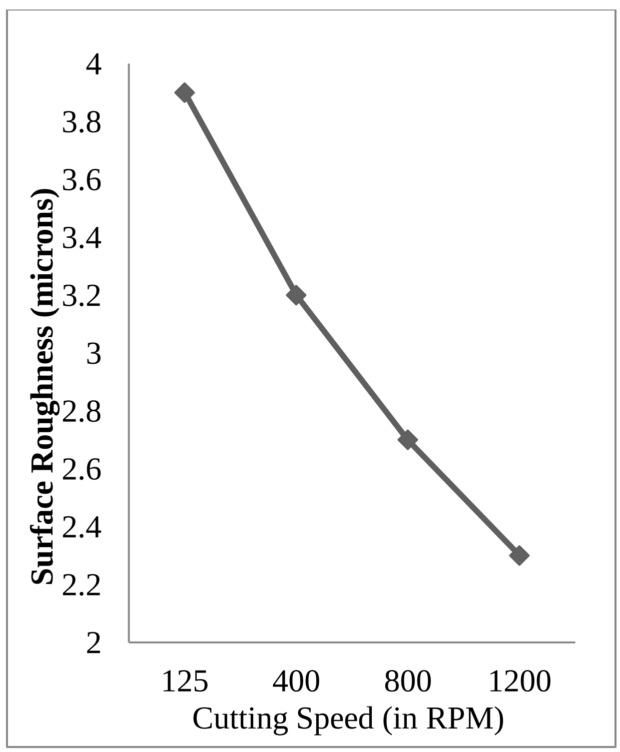

Figure 4: Surface Roughness vs Cutting Speed

5. Surface Roughness Values with Variable Feed Rate

Fixed Parameters

Depth of Cut = 0.4 mm

Cutting Speed = 500 RPM

Feed Rate (in mm/min)	Ra_1(in microns)	Ra_2(in microns)	Ra_3(in microns)	Average Ra (in microns)
5	3.6	3.1	3.2	3.3
20	3.7	3.4	3.4	3.5
40	4.1	3.9	3.4	3.8
60	4.7	4.2	4.3	4.4

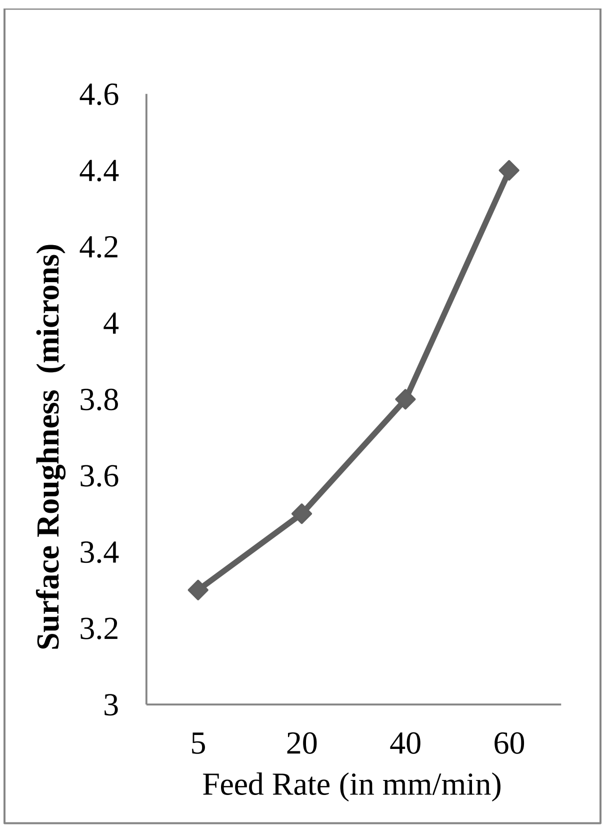

Figure 5: Surface Roughness vs Feed Rate

6. Surface Roughness Values with Variable Depth of Cut

Fixed Parameters

Cutting Speed = 500 RPM

Feed Rate = 15 mm/min

Depth Of Cut (in mm)	Ra_1(in microns)	Ra_2(in microns)	Ra_3(in microns)	Average Ra (in microns)
0.1	4.8	4.1	4.9	4.6
0.3	5.0	4.6	4.8	4.8
0.6	5.1	5.3	5.8	5.4
0.9	5.5	5.7	5.9	5.8

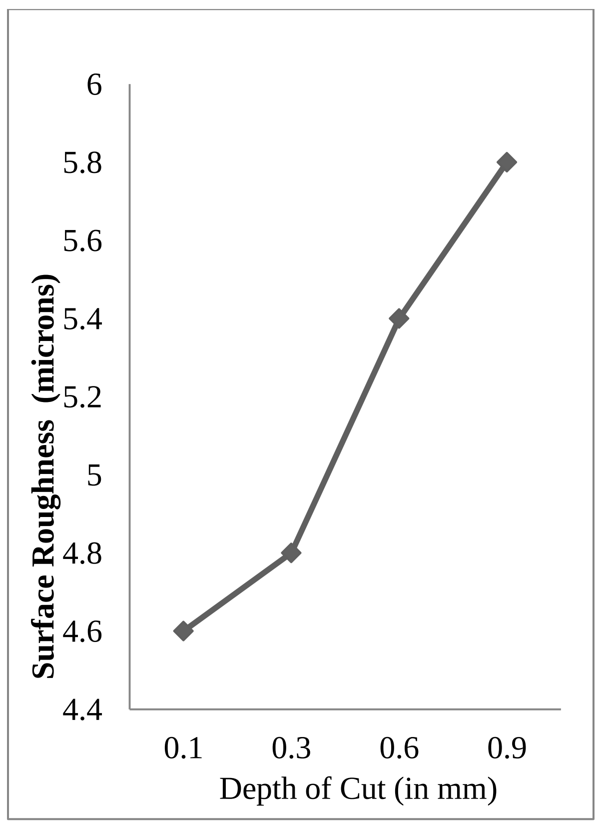

Figure 6: Surface Roughness vs Depth of Cut

VI. RESULTS AND CONCLUSIONS

Result and Discussion

The study was undertaken to investigate the effect of process parameters on surface roughness during dry turning operation for Nickel steel EN 36. Turning operation was carried out on CNC Trainer Lathe machine using various machining parameters. Machining data of surface roughness was tabulated accordingly. Two types of tool material was used namely Tungsten Carbide insert and Cobalt Insert. A contact type Stylus profilometer was used to calculate the surface roughness produced. Surface roughness is determined from the vertical stylus displacement produced during transverse travelling on surface irregularities. The measurement was displayed on the digital screen. Following are the relationship between process parameters and surface roughness-

(i) Depth of cut:

- Increasing the depth of cut increases the cutting resistance and the amplitude of vibrations. As a result, cutting temperature also rises.
- Therefore, it is expected that surface quality will deteriorate.

(ii) Feed:

- Experiments show that as feed rate increases surface roughness also increases due to the increase in cutting force and vibration.

(iii) Cutting speed:

- Increase in cutting speed improves the surface finish due to the continuous reduction in built up edges.
- The formation of built up edges is reduced due to the rise in temperature.
- Further increase in cutting speed the surface roughness continues to decrease.

Conclusions

The study deals with analysis of multiple surface roughness parameters in search of an optimal parametric combination (favorable process environment) capable of producing desired surface quality of the turned product in a relatively lesser time. EN 36 Nickel Steel has been machined under different cutting conditions to investigate the relation between machining parameters and surface roughness and following conclusion is given-

- Process parameters do not have the same effect for every response.
- Most effecting parameter is feed rate followed by depth of cut. Cutting Speed is least significant factor affecting surface roughness.
- The optimum value of surface roughness (Ra) comes out to be 2.1 microns at depth of cut 0.2mm, feed rate 10mm/min and RPM 1200 for Tungsten Carbide insert.
- The optimum value of surface roughness (Ra) comes out to be 2.3 microns at depth of cut 0.2mm, feed rate 15mm/min and RPM 1200 for Cobalt insert.
- Turning with servo cutting oil we get the optimum surface roughness equals to 2.0 microns.
- In low cutting speeds, the discontinuous form chips produced in machining may be changed to continuous form.
- The selection of cutting fluids for machining processes generally provides various benefits such as longer tool life, higher surface finish quality and better dimensional accuracy.

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