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# Effect of Process Parameter on diametric deviation during CNC lathe turning of EN-31 Steel

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## ABSTRACT

Thegrowing demand for new class of structural material leads to the optimum machining performance at low cost. In today industries, the major criteria are to select the suitable range of process parameters to provide favourable machining results. In this paper an attempt is made to measure the effect of process parameters of CNC lathe machine on diametric deviation during turning process. The Taguchi orthogonal array has been applied to predict the mathematical relation and ANOVA table to check the significant process parameter on diametric deviation. The result shows that the diametric deviation is significantly affected by the process parameters.

***Keyword: Depth of cut, feed rate, cutting speed, Taguchi's orthogonal array***

## I. INTRODUCTION

Now days industries focus to achieve specific quality product in less time, in other word we can say industries trying to achieve high production rate with the help of different standard machines like CNC lathe**[1,2]**. Now days industries use many type of steel and their alloy material to obtained favourable condition. Among such material EN 31 has high degree of hardness, abrasion resistance and compressive strength.It proofs better in the manufacturing field of bearing, shafts and other automobile parts. Since it is very hard by nature so machining process cannot be done easily and create some problem such as chip tool interface temperature, surface roughness and high cutting force**[3, 4]**.To obtained better machining result cubic boron nitride (CBN)tool insert can be applied. CBN tool has excellent properties like, high strength and toughness at high temperature, better wear resistance.Various types of conventional and non-conventional manufacturing processes can be applied to achieve the desired machining outcomes CNC lathe turning is one of them**[5, 6].** CNC lathe machine is a kind of automated lathe machine in which the turning operation can be done by the physical contact of work piece and tool. The material is removed in the form of continuous and discontinuous chip. However, the tool is subjected to high cutting forces and high temperature. The variable process parameter of CNC lathe turning such as cutting speed, feed rate and depth of cut**[7]**.

During turning operation, the possibilities of irregularities on the work piece surface increases which leads to the diametric deviation. Many of the researchers have reported their work to find the significant process parameters on machining outcomes**[5,6, 8].Gunay and Yucel [9]** has optimized the process condition to measure the surface roughness at different level of hardness. **Aslan et al. [10]**has optimized the process condition during hardened AISI 4140 steel turning to obtained favourable flank wear and surface roughness.**Azizi et al [11]** analyses the effect of cutting parameters (cutting speed, feed rate and depth of cut) and work piece hardness on surface roughness and cutting force components.**Abhang et al [12]**has optimized the turning process parameters by using grey relational analysis to measure the surface roughness and chip thickness. **Shetty et al. [13]**has used Taguchi and Response Surface Methodologies to obtained favourable surface roughness in turning of discontinuously reinforced aluminium composites (DRACs) having aluminium alloy 6061.**Derakhshan and Akbari [14]**has studied on AISI 4140 grade work piece and examined the effect of hardness on work piece and cutting speed on surface roughness by using of CBN cutting tools.**Vishal et al.[15]**has optimise the turning process parameter by using Taguchi Grey Relational analysis and stated their effect on surface roughness during hardened EN 31 steel turningon CNC lathe machine with CBN tool.**Ucun et al [16]**has investigated on AISI 52100 steel grade bearing and examined tool wear, surface roughness and their effects on the cutting parameters in hard turning. **Sahin Y [17]**has studied and comparedCBN and ceramic inserts tool life in turning hard steels by using Taguchi method. **Neseli et al. [18]**has studied and focused on tool geometry parameters on the surface roughness during turning of AISI1040 steel by using RSM method

## II. EXPERIMENTAL PROCEDURE

In the present work, EN–31 tool steel (IS designation: T105 Cr 1 Mn 60) is used as a work piece. The chemical composition and mechanical properties of EN 31 tool steel is given in table 1 and 2, respectively.

**Table 1- Specific Chemical composition of EN-31**

| Elements | Chemical Composition (wt. %) |
|---|---|
| Carbon | 0.96 |
| Silicon | 0.226 |
| Manganese | 0.410 |
| Phosphorous | 0.020 |
| Sulphur | 0.024 |
| Chromium | 1.22 |
| Molybdenum | 0.019 |
| Iron | 96.96 |
| Nickel | 0.068 |
| Vanadium | 0.013 |
| Aluminum | 0.020 |
| Cobalt | <0.01 |

The experimental work of EN-31 alloy steel was carried out with CBN insert tool on the CNC lathe machine (Model No. GSK980TDb). Figure 1 show the schematic diagram of CNC lathe machine. Taguchi's orthogal array of design L9 has been applied along with ANOVA table to predict the mathematical relation between process parameter and out response. In the present work diametric deviation is selected as a machine out come and it is evaluated in terms of effect of process parameters on it. The main objective of the work is to represent the effect of process parameter on the output responses. Three process parameters namely cutting speed, feed rate and depth of cut is selected as a variable process parameters and their range for the machining operations is given in table 3

**Table 2 Mechanical property of EN-31**

| **Element** | **Objective** |
|---|---|
| Tensile strength | **750N/mm²** |
| Yield strength | **450N/mm²** |
| Reduction of area | **45%** |
| Elongation | **30%** |
| Modula's of elasticity | **215000N/mm²** |
| Hardness | **63HRC** |
| Density | **7.8Kg/m³** |

**Fig. 1- CNC Turning machine (Model No. GSK980TDb)**

**Table 3- Experimental Factor with factor level**

| Experiment control factor | Levels of Experimental factor | | |
|---|---|---|---|
| | Level-1 | Level-2 | Level-3 |
| A-Cutting speed(m/min) | 120 | 150 | 180 |
| B-Feed rate (mm/rev.) | 0.10 | 0.14 | 0.18 |
| C- Depth of cut(mm) | 0.15 | 0.30 | 0.45 |

## III. RESULT AND DISCUSSION

The turning operation via CNC lathe is successfully applied on the EN 31 tool steel workpiece. The machining process by using CBN insert is shown in figure 2. The orthogonal array L9 has been applied, the experimental design and their corresponding machining out comes is given in table 4.

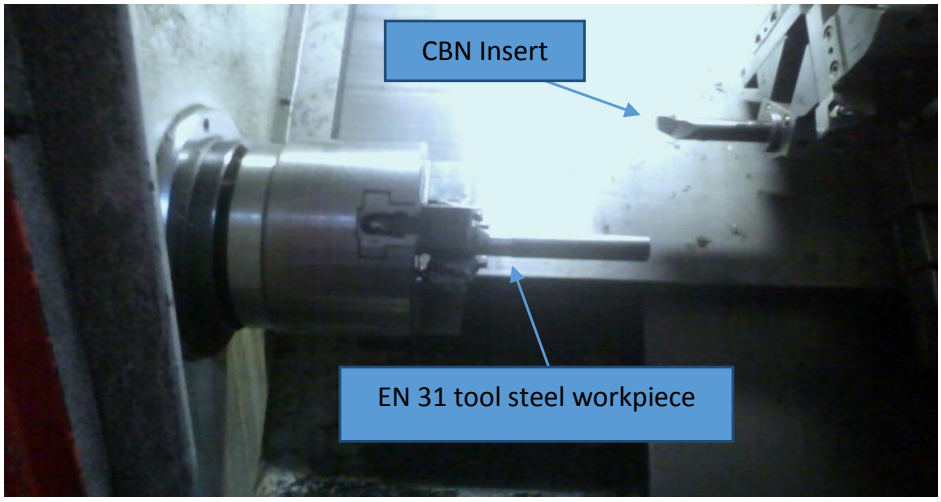


**Fig 2- CNC Turning machining process**

**Table 4 Orthogonal array $L_9$ ($3^3$) of the experimental run and results**

| Experiment No | Cutting speed | Feed rate | Depth of cut | Diametric deviation Φ(μm) |
|---|---|---|---|---|
| 1 | 120 | 0.10 | 0.15 | 0.10 |
| 2 | 120 | 0.14 | 0.30 | 0.08 |
| 3 | 120 | 0.18 | 0.45 | 0.04 |
| 4 | 150 | 0.10 | 0.45 | 0.09 |
| 5 | 150 | 0.14 | 0.15 | 0.07 |
| 6 | 150 | 0.18 | 0.30 | 0.05 |
| 7 | 180 | 0.10 | 0.30 | 0.02 |
| 8 | 180 | 0.14 | 0.45 | 0.02 |
| 9 | 180 | 0.18 | 0.15 | 0.06 |

The ANOVA results are given in table 5. From the ANOVA table it is found that feed rate is most influencing factor followed by depth of cut cutting speed. With the help of ANOVA table, the percentage of contribution to the turning process, in sequence, is the feed rate (69.014%), depth of cut (25.352%) and the cutting speed (4.929%).The ANOVA table for the experimental run is shown in figure 5.

**Table 5-ANOVA table for diametric deviation (ϕ)**

| Factor | Degree of freedom | Sum of Square (S.S.) | Mean Square(M.S.) | F- ratio | Contribution (%) |
|---|---|---|---|---|---|
| A | 2 | 0.007 | 0.0035 | 7 | 4.929 |
| B | 2 | 0.098 | 0.049 | 98 | 69.014 |
| C | 2 | 0.036 | 0.018 | 36 | 25.352 |
| Error | 2 | 0.001 | 0.0005 | | 0.705 |
| Total | 8 | 0.142 | | | 100 |

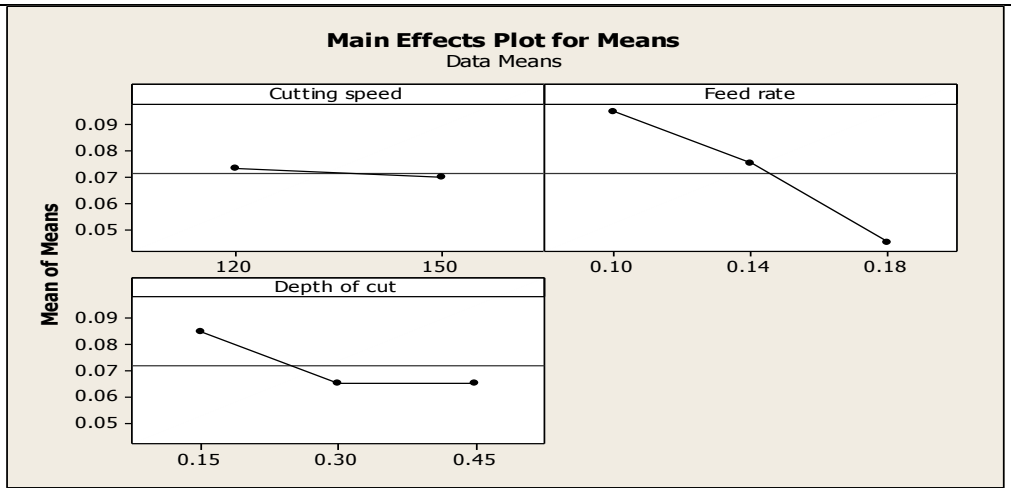


**Fig. 3 –Effect of process parameter on diametric deviation.**

Figure 3 shows that effect of process parameters on diametric deviation. It is clear from the graph while increasing the cutting speed, feed rate and depth of cut diametric deviation is reduced. This is due to the fact that at high cutting speed, depth of cut and feed rate the formation of cutting lines on the machined surface are reduced. It leads to the better surface finishing and less diametric deviation.

## IV. CONCLUSION

The machining operation via CNC machine has been successfully completed. Taguchi L9 orthogonal array has been applied for the experimental run to find the effect of process parameters on machining out comes (diametric deviation). The followings are the conclusion based on the experimental result.

1. Feed rate is most influencing factors for the diametric deviation. Increasing the feed rate decreases the diametric deviation.
2. CBN insert can be successfully applied for the EN 31 tool steel material with negligible tool wear.
3. The Taguchi design explain in the result can be applied to get the optimum value of diametric deviation.
4.

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