Chaudhari Y D / International Journal Of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com
Vol. 3, Issue 2, March -April 2013, pp.317-321

# Investigation Of Tool Wear In Hard Turning Using Taguchi Method

**Chaudhari Y D**
[1] Mechanical Engineering Department,
Sankalchand Patel College Of Engineering, Visnagar, Gujarat, 384 315.

## ABSTRACT

**Hard turning is a machining process defined of hardness higher than 45 HRC under appropriate cutting tools and cutting speed. The objective of this paper is to investigate the optimum process parameters for a particular work piece-tool material combination. . In this study, three levels of each parameters viz. Hardness (HRC), Speed(mm/min), Feed(mm/rev) and three different tool materials are evaluated for process quality characteristics such as tool wear. The three different tool materials used are High CBN, Low CBN, Mixed ceramic. AISI H 11 was taken as work piece material. The experiment is designed using Taguchi Method. The results obtained from the experiments are transformed into signal to noise (S/N) ratio and used to optimize the value of tool wear. The analysis of variance (ANOVA) is performed to indentify the statistical significance of parameters. The final results of experimental investigation are presented in this paper. The conclusions arrived at are critically discussed at the end.**

**Keywords:** Hard turning, Taguchi Technique, ANOVA, Surface Finish, Flank Wear.

## INTRODUCTION

Precision hard turning, an alternative to conventional grinding, is a cost-effective, high productivity and flexible machining process for ferrous metal components, which are often hardened above 45 HRC [1,2]. The material removal rate (MRR) in hard turning is much higher than grinding even though smaller depth of cut and feed rates are required [3]. It has also been reported that the resulting machining time reduction is as high as 60% in hard turning [4]. The turning of hardened components are used in many applications such as gears, shafts, bearings, cams, forgings, dies and molds, which significantly reduce the manufacturing costs, lead times and improve overall product quality [5–8].

The hard turning is generally performed without a coolant using ceramics and cubic boron nitride (CBN) cutting tools due to the required tool material hardness. The cutting tools required for hard turning are relatively expensive as compared to grinding operations and hence there is a need to investigate the tool life to assure the economic justification for hard turning. As reported by Byrne et al. [9] and Klocke et al. [10], the hard turning can provide a relatively high accuracy for hardened components but the problems occur with surface finish and tool wear.The design of experiment is a significant tool for Improvement of production process in engineering world. Firstly, in the 1920s, it was used by an English statistician Sir Ranold Fisher. Then, in Japan, new arrangements were made by Professor Genici Taguchi so that the method can be used in the production sector. Taguchi method is a method of the experimental design in which the variability in the product or process minimizes, choosing the optimum levels and combinations of controllable factors against factors which the variability forms uncontrolled factors. The method is straightforward, easy to follow, and needs no guesswork to take the initial experimental steps. It relies on the assignment of factors in specific orthogonal arrays to determine these test combinations. This approach facilitates the identification of the influence of individual factors establishing the relationship between factors and operational conditions, and finally establishing performance at the optimum levels obtained. The Taguchi method not only helps in saving considerable time and cost, but also leads to a more fully developed process. However, by applying Taguchi method, only effective parameters and their interactions are determined, but no ultimate values for optimum parameters are obtained. Therefore, it is necessary that multiple level experiments are conducted in order to determine optimum parameters [11].

Taguchi recommends the use of the S/N ratio for the determination of the quality characteristics implemented in engineering design problems. The S/N ratio characteristics can be divided into three stages: smaller the better, nominal the best, and larger the better, signed–target type.Since the purpose of this study is to minimize surface roughness within the optimal levels of process parameters, the smaller the better quality characteristic is selected. In addition to the S/N ratio, a statistical analysis of variance (ANOVA) can be employed to indicate the impact of process parameters on surface roughness. In this way, the optimal levels of process parameters can be estimated.

**Table: 2.2. L9 Orthogonal array**

| Exp. No. | Tool material | Hardness (HRC) | Speed (m/min) | Feed (mm/rev) |
|---|---|---|---|---|
| 1 | High CBN | 45 | 180 | 0.12 |
| 2 | High CBN | 50 | 230 | 0.15 |
| 3 | High CBN | 54 | 250 | 0.30 |
| 4 | Low CBN | 45 | 230 | 0.30 |
| 5 | Low CBN | 50 | 250 | 0.12 |
| 6 | Low CBN | 54 | 180 | 0.15 |
| 7 | Mixed ceramic | 45 | 250 | 0.15 |
| 8 | Mixed ceramic | 50 | 180 | 0.30 |
| 9 | Mixed ceramic | 54 | 230 | 0.12 |

Many machining factors affect the quality characteristics of TURNING process. Taguchi method can provide efficient evaluation than the traditional factorial design in experiment with fewer trials and low cost. Several researches have investigated the TURNING performance using Taguchi method [12-17].

T. Tamizharasan · T. Selvaraj · A. Noorul Haq[18].used Taguchi method to determine tool flank wear,material removal rate and tool life by using different hardness of work piece and different grade of CBN tool.

This paper investigates the optimization of process parameters for work piece material AISI H11 at different hardness and different tool material to obtain the performance with tool wear at the selected machining parameters using Taguchi method for CNC turning.

## 1. EXPERIMENTAL PROCEDURE

The AISI H11 work piece material is selected and the composition of work piece material is as follows: C-0.33-0.44, Mn-0.20-0.50, Si-0.8-1.20, Cr- 4.75-5.50, P<0.03, Ni<0.3, Mo-1.10-1.60, V-0.3-0.6, Cu<0.25, S <0.03%. we have taken three different bars of work piece material having equal length of 250 mm and 50 mm diameter. After equal length of three parts were sent to achieve different hardness by heat treatment process (Viz. 45, 50, 54 HRC). Generally, the heat treatment process includes steps of operations like annealing, hardening, quenching and tempering. The material is heat treated $1030^{o}$c upto 30min and then oil quench $60^{o}$ to $80^{o}$c and then tempering $630^{o}$c for one hour achieving 45HRc.similarly another two bar tempera $600^{o}$ and $560^{o}$c temperature for achieving 50 and 54HRc respectively. The experiment is designed using Taguchi method using three factors and each factor is considered at three levels as shown in table 2.1.

**Table: 2.1. Variable factors and their level**

| Factor | Column | Level 1 | Level 2 | Level 3 |
|---|---|---|---|---|
| Tool material | A | High CBN | Low CBN | Mixed ceramic |
| Hardness (HRC) | B | 45 | 50 | 54 |
| Speed (mm/min) | C | 180 | 230 | 250 |
| Feed (mm/rev) | D | 0.12 | 0.15 | 0.30 |

L9 orthogonal array is employed which is shown in table 2.2.three inserts we have selected for machining on different work piece material. KBN10B-TNGA160408S01225SE Low CBN content insert, KBN65B-TNGA 160408T01215SE High content CBN insert and mixed ceramic inserts. the experimental tool wear measure by using profile projector and surface roughness measure on surface roughness tester.

## 2. TOOL WEAR RATIO:

Prediction of tool wear is complex because of the complexity of machining system [15]. Tool wear in cutting process is produced by the contact and relative sliding between the cutting tool and the work piece and between the cutting tool and the chip under the extreme conditions of cutting area; temperature at the cutting edge can exceed 530°C and pressure is greater than 13.79 N/mm2. Any element changing contact conditions in cutting area affects tool wear. In my study the tool flank wear measured on profile projector (SCOPE II -355H) at differene cutting time shown in Table 3.1.

**Table 3.1 Flank wear readings**

| Exp. No. | Flank wear (mm) | | | |
|---|---|---|---|---|
| | 1 min | 2 min | 3 Min | 3.45 min |
| 1 | 0.072 | 0.103 | 0.210 | 0.245 |
| 2 | 0.083 | 0.154 | 0.214 | 0.289 |
| 3 | 0.165 | 0.224 | 0.244 | 0.296 |
| 4 | 0.068 | 0.099 | 0.127 | 0.225 |
| 5 | 0.067 | 0.100 | 0.149 | 0.248 |
| 6 | 0.150 | 0.250 | 0.278 | 0.312 |
| 7 | 0.167 | 0.217 | 0.273 | 0.354 |
| 8 | 0.108 | 0.214 | 0.270 | 0.344 |
| 9 | 0.186 | 0.227 | 0.268 | 0.321 |

The results are analyzed by the S/N ratio. These are 9 different combinations as shown in the table 3.1.

Each experiment is performed four different times. In practice, the S/N ratio of particular ratio is to be high as per the Taguchi method. . Since, for tool wear, quality depends on smaller the better and thus value of S/N ratio can be calculated by Minitab 15. The S/N ratio for each of experiments in given in table 3.2 as given below.

**Table 3.2 S/N Ratio for Flank wear**

| Exp.no | Avg flank | S/N ratio |
|---|---|---|
| 1 | 0.1575 | 16.0544 |
| 2 | 0.1850 | 14.6566 |
| 3 | 0.2322 | 12.6809 |
| 4 | 0.1297 | 17.7379 |
| 5 | 0.1410 | 17.0156 |
| 6 | 0.2475 | 12.1285 |
| 7 | 0.2527 | 11.9462 |
| 8 | 0.2340 | 12.6157 |
| 9 | 0.2505 | 12.0238 |

**3.1 Response table and response diagram for Flank wear:**

The response table, which contains the sum of all S/N ratio of each level and for each factor. The response table (table: 3.2) shows the sum of S/N ratio for each level and each factor.

**Table 3.3 Response table for Flank wear**

| Level | A | B | C | D |
|---|---|---|---|---|
| 1 | 14.46 | 15.26 | 13.60 | 15.03 |
| 2 | 15.63 | 14.76 | 14.81 | 12.91 |
| 3 | 12.20 | 12.28 | 13.88 | 14.34 |
| Delta | 3.43 | 2.97 | 1.21 | 2.12 |
| Rank | 1 | 2 | 4 | 3 |

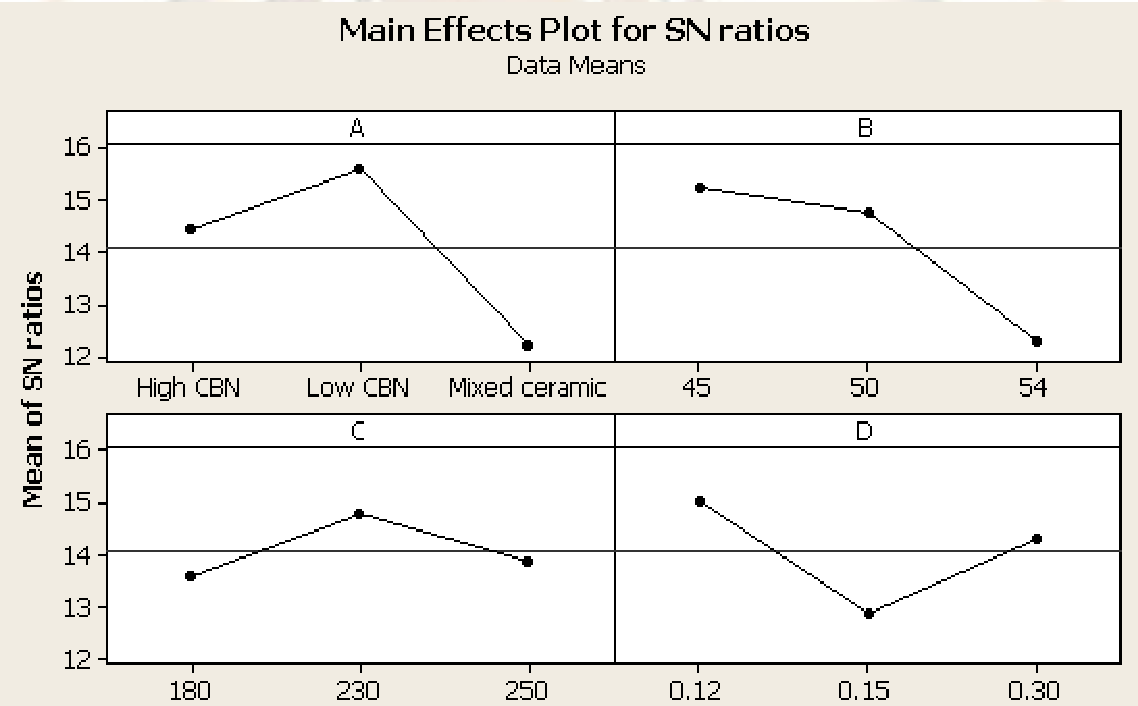


**Fig. 1 Main effect plot for S/N Ratio.**

The graph prepared from response table 3.3, which shows that highest sum of S/N ratio is given by A2-B1-C2-D1 indicated by yellow mark.
Therefore the following are the optimum parameters are shown in table-3.4.

**Table-3.4 Optimum conditions**

| Tool material | Hardness | Speed | Feed |
|---|---|---|---|
| Low CBN | 45 | 230 | 0.12 |

Analysis of variance for Flank wear shown in Table 3.5.

**Table 3.5 Analysis of Variance for Flank wear.**

| Factor | S.S | D.F | M.S | F | %P |
|---|---|---|---|---|---|
| A | 1.2123 | 2 | 0.6061 | 1 | 2.47% |
| B | 21.179 | 2 | 10.589 | 17.470 | 43.30% |
| C | 7.722 | 2 | 3.861 | 6.370 | 15.78% |
| D | 18.792 | 2 | 9.3960 | 15.502 | 38.42% |
| Error | | 0 | | - | |
| Total | 48.9053 | 8 | | - | 100 |
| Pooled error | 1.2123 | 4 | 0.6061 | - | |

## 4. CONCLUSION:

Taguchi method is generally used to identify the best optimum parameter and find the factor, which is most effecting on the process. So here we have tried to identify the main optimum parameter.

- Similarly, for tool wear optimum condition can be achieved with work piece of 45HRC while using High CBN tool bit at speed of 230 mm/min and feed of 0.12 mm/rev.
- The most affecting parameter on tool wear is hardness which has impact of about 43.30%.

## 5. FUTURE SCOPE

- Hard turning process is a very important machining process. Still there is lots of work can be done like measurements of force and pressure components by using tool force dynamometer, measurements of tool wear by using machine vision technology, measurement of wear by using **SEM(scanning electron microscope) .**
- By doing above investigation we can get the detail idea about the proper speed, depth of cut and feed and we can apply it for machining of various hardened materials with different level of machining.
- Someone can make Higher order Mathematical model for Flank wear and crater wear and surface Roughness.

## 6. Acknowledgement

The authors wish special thanks to Motif engg. Pvt limited ahmedabad for given permission to conduct experimental work during research.

## REFERENCES:

1. Konig W, Berktold A, Koch KF. Turning versus grinding–a comparison of surface integrity aspects and attainable accuracies. Ann CIRP 1993;42(1):39–43.
2. Tonshoff HK, Arendt C, Ben Amor R. Cutting of hardened steel. Ann CIRP 2000;49(2):547–66.
3. Tonshoff HK, Wobker HG, Brandt D. Tool wear and surface integrity in hard turning. Prod Eng 1996;3(1):19–24.
4. Tonshoff HK, Wobker HG, Brandt D. Hard turning–Influence on the workpiece properties. Trans NAMRI/SME 1995;23:215–20.
5. Zou JM, Anderson M, Stahl JE. Identification of cutting errors in precision hard turning process. J Mater Process Tech 2004;153–154:746–50.
6. Rech J, Moisan A. Surface Integrity in finish hard turning of case hardened steels. Int J Mach Tool Manuf 2003;43:543–50.
7. Destefani J. Technology key to mold making success.Manuf Eng 2004;133(4):59 64.
8. Elbestawi MA, Chen L, Becze CE, EI-Wardany TI. High-speed milling of dies and molds in their hardened state. Ann CIRP 1997;46(1):57–62.
9. Byrne G, Dornfeld D, Denkena B. Advancing cutting technology. Ann CIRP 2003;52(2):483–507.
10. Klocke F, Brinskmeier E, Weinert K. Capability profile of hard cutting and grinding processes.Ann CIRP 2005;54(2):557–80.
11. Asli Secilmis, A. Murat Olmez, Murat Dilmec, H. Selcuk Halkaci, Ozgur Inan, "Determination of optimal EDM machining parameters for machined pure titanium-porcelain adhesion" Int J Adv Manuf Technol (2009) 45:55–61.
12. S.Thamizhmanii, S. Saparudin, S. Hasan."Analyses of surface roughness by turning process using Taguchi method" Journal of Achievements in Materials and Manufacturing Engineering
13. Hasan O ktem Tuncay Erzurumlu Mustafa Col "A study of the Taguchi optimization method for surface roughness in finish milling of mold surfaces" Int J Adv Manuf Technol (2006) 28: 694–700.
14. SThamizhmanii, K. Kamarudin, E. A. Rahim, A. Saparudin, S.Hasan"Optimizing Surface Roughness and Flank Wear on Hard Turning Process Using Taguchi Parameter Design" Proceedings of the World Congress on Engineering 2007 Vol II.

15. Bala Murugan Gopalsamy, Biswanath Mondal and sukmal "Taguchi Method and ANOVA an approach for process parameters optimization of hard machining while machining hardened steel" Journal of scientific and industrial research (2009).
16. Guey-Jiuh Tzou, Ding-Yeng Chen, Chun-Yao Hsu"Application of Taguchi method in the optimization of cutting parameters for turning operations"
17. Hari Singh "Optimizing Tool Life of Carbide Inserts for Turned Parts using Taguchi's Design of Experiments Approach" Proceedings of the International MultiConference of Engineers and Computer Scientists 2008 Vol II IMECS 2008.
18. T. Tamizharasan · T. Selvaraj · A. Noorul Haq "Analysis of tool wear and surface finish in hard turning" Int J Adv Manuf Technol (2006) 28: 671–679.