International Journal For Technological Research In Engineering
Volume 7, Issue 3, November-2019 *ISSN (Online): 2347 - 4718*

OPTIMIZATION OF TURNING PROCESS PARAMETERS USING TAGUCHI METHOD

Satish Kumar[1], Dr. Dinesh Kumar[2], Ravi Bishnoi[3]
[1]M. Tech Scholar,[2]HOD, [3]Asst. Professor
Department of Mechanical Engineering , Jan Nayak Chaudhary Devi Lal Memorial College of Engineering, Sirsa

Abstract: In the present work, Turning Parameters were optimized using Taguchi Method. Also, the effect of turning parameters such as rotational speed, feed rate, depth of cut and tool nose radius on surface roughness of high carbon steel was investigated. L_8Taguchi's method was used for designing the experiments and optimization of turning parameters. Eight experiments were conducted with four factors having two levels for each factor. Results revealed that tool nose radius has a significant effect on surface roughness and it is the most dominating factor affecting the surface roughness with contribution of 99.58 %. The optimal parameter combination of oil hardening non shrinking die steel (OHNS) round steel bar for minimum surface roughness is found to be $A_2B_2C_2$ D_1i.e., rotational speed of 400 rpm, feed rate of 21 mm/min, depth of cut of 0.8 mm and tool nose radius of 0.8 mm

Key Words: L_8- Taguchi Method; Surface Roughness; High carbon steel, Turning

I. INTRODUCTION

In machining process, unwanted material is removed from a work piece in the form of chips for producing finished parts of required dimensions and accuracy. Metal cutting is a highly non-linear and coupled thermo-mechanical process, where the mechanical work is converted into heat through the plastic deformation involved during chip formation and also due to frictional work between the tool, chip and work piece.

Taguchi Method

Taguchi method is a statistical method developed by Taguchi and Konishi, Initially it was developed for improving the quality of goods manufactured (manufacturing process development), later its application was expanded to many other fields in Engineering, such as Biotechnology etc. Professional statisticians have acknowledged Taguchi's efforts especially in the development of designs for studying variation. Success in achieving the desired results involves a careful selection of process parameters and bifurcating them into control and noise factors. Selection of control factors must be made such that it nullifies the effect of noise factors. Taguchi Method involves identification of proper control factors to obtain the optimum results of the process. Analysis of variance (ANOVA) is used to study the effect of process parameters on the machining process. The approach is based on Taguchi method, the signal to-noise (S/N) ratio and the analysis of variance (ANOVA) are employed to study the performance characteristics.

Turning

Turning is a very basic operation and generally produces cylindrical surfaces. The machine tool used for this type of operation is known as a lathe. Turning is also one of the most commonly employed operation in experimental work and metal cutting.

Cutting Factors in Turning are as:-

spindle speed: Speed always refers to the spindle and the work piece. In turning V in m/s is related to the rotational speed of the workpiece by the equation:

$V = \pi DN$

Where V is the cutting speed in m/s

D is the diameter of the work piece, m;

N is the rotational speed of the work piece, rev/s.

Feed: Feed is defined as the distance that a advance into the work during one revolution of the headstock spindle. It is usually given as a linear movement per revolution of the spindle or job. On most power-fed lathes, the feed rate is directly related to the spindle speed and is expressed in mm (of tool advance) per revolution (of the spindle), or mm/rev.

$F= f*N$ mm/min

Here, F is the feed in mm per minute, f is the feed in mm/rev and N is the spindle speed in RPM

Depth of Cut

Depth of cut is practically self-explanatory. It is the thickness of the layer being removed (in a single pass) from the work piece or the distance from the uncut surface of the work to the cut surface, expressed in mm.

Tool nose radius: tool nose radius effects the strength of tool as well as it effects the surface roughness of the work piece very much

II. OBJECTIVE OF THE STUDY

The objective of this study is to illustrate the procedure adopted in using Taguchi Method to a lathe facing operation. The orthogonal array, signal-to-noise ratio, and the analysis of variance are employed to study the performance characteristics on facing operation. In this analysis, four factors namely speed, feed and depth of cut and tool nose radius were considered. Accordingly, a suitable orthogonal array was selected and experiments were conducted. After conducting the experiments the surface roughness was measured and Signal to Noise ratio was calculated. With the help of graphs, optimum parameter values were obtained and the confirmation experiments were carried out. These results were compared with each other to find the optimum combination of the machining parameters for surface roughness.

III. LITERATURE REVIEW

Rajesh Mahto et al. [1].discussed the process parameter of heat treatment of low carbon steel by using Taguchi approach and Fuggy Logic approach. In bearing industry, when shell of bearing is heat treated then shell has not optimum hardness due to unsuitable process parameter such as carburizing temperature, carbon potential, holding time and quenching time. So, his aim is to obtain optimizing condition of different parameter in order to get sufficient hardness of low carbon steel as per requirement. Taguchi and Fuggy logic approach both are optimizing software.

P. G. Inamdar et al. [2]. optimise the surface roughness in conventional turning operation using Taguchi Method for the material medium carbon steel EN8. In this work cutting speed, feed rate and depth of cut are taken as performance parameters to achieve better surface roughness. Taguchi Method is used to obtained the main parametric effect on the surface roughness using there levels and factors. L9 orthogonal array is used to design the experiments. Also analysis of variance (ANOVA) was carried out with the significance factor of 95%. After the experimentation, it was found that cutting speed has more influenced on the surface roughness in conventional turning process than feed rate and depth of cut.

Abburi et al. [3]. developed a knowledge-based system for the prediction of surface roughness in turning process. Fuzzy set theory and neural networks were utilized for this purpose. The authors developed rule for predicting the surface roughness for given process variables as well as for the prediction of process variables for a given surface roughness.

Ali. et al. [4]. recognized the importance of achieving dimensional accuracy, good surface finish and maximum material removal rate in the machining process; and optimized the cutting parameters viz. Feed, cutting speed and depth of cut for maximizing the surface finish and material removal rate for an aluminium alloy 6061. L-8 orthogonal array, signal- to-noise ratio, analysis of variation has been employed to study the process characteristics, and L8 Taguchi method experiment design has been used to optimize the cutting parameters for the material using uncoated inserts. An experiment has been conducted to confirm and verify the effectiveness of Taguchi optimization method. Surface roughness and material removal rate are found to be maximum at 11.6%and 14%; and minimum at 4.4% and 3.7% respectively. Cutting parameters viz. cutting speed, feed rate and depth of cut are found to be affecting the machining process at 45%, 36% and 19% respectively for minimum surface finish of 0.256 microns with an error percentage of 4.4%

Abhang et al. [5]. carried out the experimental work to optimize the cutting parameters viz. feed rate, depth of cut and lubricant temperature in the turning operation of EN-31 steel alloy by using tungsten carbide inserts. The work aimed at explaining and demonstrating the systematic procedure of Taguchi parameter design; finding the optimal combination of cutting parameters using the signal-to-noise ratio; knowing the significance level of each cutting parameter using ANOVA analysis; and therefore, finding out the effect of lubricating temperature on the response i.e. surface finish. It has been proved experimentally that better surface finish can be observed with cooled lubricant and higher depth of cuts

Al-Ahmari [6]. developed empirical models for tool life, surface roughness and cutting force for turning operation. The process parameters used in the study were speed, feed, depth of cut and nose radius to develop the machinability model. The methods used for developing aforesaid models were Response Surface Methodology (RSM) and neural networks (NN).

Ilhan et al. [7]. focused on optimizing turning parameters based on Taguchi method to minimize surface roughness (Ra and Rz). Experiments have been conducted using L8 orthogonal array in a CNC turning machine. Dry turning tests were carried out on hardened AISI 4140 (51 HRC) with coated carbide cutting tools. As a result, they observed that the feed rate has the most significant effect on Ra and Rz.

Ahmed [8]. developed the methodology required for obtaining optimal process parameters for prediction of surface roughness in Al turning. For development of empirical model nonlinear regression analysis with logarithmic data transformation was applied. The developed model showed small errors and satisfactory results. The study concluded that low feed rate was good to produce reduced surface roughness and also the high speed could produce high surface quality within the experimental domain.

Choudhary et al. [9]. discussed the development of surface roughness prediction models for turning EN 24T steel (290 BHN) utilizing response surface methodology. A L8- OA factorial design technique was used to study the effects of the main cutting parameters such as spindle speed, feed and depth of cut, nose radius on surface roughness.

MATERIAL USED

High carbon steel is steel-containing carbon in the range of 0.70 to 1.05% and is especially classed as high carbon steel. Considering the microstructure of slowly cooled steel; for mild steel, for instance, with 0.2% carbon. Such steel consists of about 75% of proeutectoid ferrite that forms above the eutectoid temperature and about 25% of pearlite (pearlite and ferritebeing microstructure components of steel).

Table 1 physical properties

Property	Standard	Metric
Density at room temperature	0.2833 lb/in.^{3}	7.85 x 10^3 kg/m^3
Specific gravity at room temperature	7.85	7.85
Shear modulus at room temperature	10.88–11.61 ksi x 10^3	75.0–80.0 (GPa)
Melting point	2597ºF	1425ºC
Poisson’s Ratio at room temperature	0.29	0.29

Table 2 chemical properties

Properties	Metric	Imperial
Tensile strength, ultimate	635 MPa	92100 psi
Tensile strength, yield	490 MPa	71100 psi
Modulus of elasticity	0.27-0.30	0.27-0.30
Bulk modulus (typical for steel)	140 GPa	20300 ksi

IV. EXPERIMENTAL PROCEDURE

- From a high carbon steel bar, eight bars were cut by power hacksaw
- Turning operation is started after setting the work material
- Turning is done on eight individual bars as per L_8-OA
- After machining on lathe machine, we measured surface roughness of each bar by surface roughness tester
- Two readings(repetition) on each bar was taken by help of surface roughness tester.
- Taguchi experimental design is done and we find the optimal combination of factors and their levels.

Experimental Design

L_8-Taguchi method, a powerful tool for parameter design of performance characteristics, was used to determine optimal machining parameters for minimum surface roughness in turning process. The optimal level of the process parameters is the level with the higher S/N ratio. The lower the better criterion for the surface roughness was selected for obtaining optimum machining performance characteristics.

For lower the better criteria, S/N ratio values corresponding to the experimental values of surface roughness was calculated using the below equation.

$$\frac{S}{N} = -10Log(Y')^2$$

Eight experimental runs based on the orthogonal array L8 were carried out.

Design of Experiments (DOE)

The DOE helpfor conducting experiments in a more systematic way. The process parameters with their levels are specified in Table no. 3 below.

Table No. 3

Factor	Symbol	Level-1	Level-2
Spindle speed (rpm)	A	310	400
Feed rate (mm/sec)	B	13	21
Depth of cut (mm)	C	0.4	0.8
Tool nose radius (mm)	D	0.8	1.2

Orthogonal Array (OA)

OA allows for the maximum number of main effe cts to be estimated in an orthogonal manner, with minimum number of runs in experiment, L_8 orth orthogonal array used as shown in Table 4.

Table 4. Orthogonal array L_8

Experiment no.	A (Spindle Speed)	B (Feed Rate)	C (Depth of Cut)	D (Tool nose radius)
1	1	1	1	1
2	1	2	2	1
3	1	1	2	2
4	1	2	1	2
5	2	1	1	2
6	2	2	2	1
7	2	1	2	1
8	2	2	1	2

V. RESULTS AND DISCUSSIONS

Eight experiments were successfully conducted based on Taguchi L_8 method and machined samples are shown in Fig. 1. The experimental results for the surface roughness along with corresponding S/N ratios are listed in Table No.5.

Fig 1. Machined work piece

Table 5 Experimental Results and S/N ratio

Exp. No.	A	B	C	D	Ra(µm) orY'	S/N Ratio
1	310	13	0.4	0.8	0.3387	09.40
2	310	21	0.8	0.8	0.2500	12.04
3	310	13	0.8	1.2	0.3837	08.32
4	310	21	0.4	1.2	0.3243	09.79
5	400	13	0.4	1.2	0.3050	10.31
6	400	21	0.8	0.8	0.3167	09.99
7	400	13	0.8	0.8	0.2387	12.44
8	400	21	0.4	1.2	0.2863	10.87

Analysis of Mean (ANOM)In ANOM, mean value of the S/N ratio at each level of the process parameters is computed by taking arithmetic mean average of S/N ratio at the

selected level. Table 6 lists the ANOM results.
The combination of machining parameters $A_2B_2C_2D_1$is found to be optimum for surface roughness during turning of high carbon steel

Table 6

S. No.	Symbol	Level 1	Level 2	Range (max-min)	Rank
1	A	9.88	**10.90**	1.02	2
2	B	10.11	**10.67**	0.56	4
3	C	10.09	**10.69**	0.6	3
4	D	**10.96**	9.82	1.14	**1**

Best combination so generated is A_2 B_2 C_2 D

VI. CONCLUSION

This work presents an experimental study in which turning operation is performed on high carbon steel using carbide tool. The effect of four machining parameters namely speed, feed rate, depth of cut and tool nose radius on the surface roughness was investigated. Experimentation was done as per Taguchi's L8 orthogonal array. Response variable (surface roughness) was measured, signal to noise ratio values were computed, subsequently, and by investigation it was found that A_2 B_2 C_2 D_1 as best combination.
The analysis of mean is performed to obtain optimum level of machining parameters for surface roughness.
Following conclusion is drawn from the present study:

- Taguchi's robust design was successfully used for optimizing turning parameters on high carbon steel.
- Optimal combination of the machining parameters for surface roughness is found to be $A_2B_2C_2$ D_1, i.e., at spindle speed (A) at 400 rpm, feed rate (B) at 21 mm/min, and depth of cut (C) at 0.8 mm, and tool nose radius (D) at 0.8 mm.
- Tool nose radius contributes maximum (99.5845%) followed by spindle speed (0.2970%), depth of cut (0.0831 %) and feed rate (0.0350%) to minimize the surface roughness.

REFERENCES

[1] Rajesh Mahto, Sunny Kumar, Shashi Kumar, Prof. Prakash kumar, Optimization of Heat Treatment Process Parameter using Taguchi and Fuggy Logic Approach in Bearing Manufacturing Industry by nternational Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056 Volume: 04 Issue: 02 | Feb -2017
[2] P. G. Inamdar , N. S. Bagal, V. P. Patil , K. K. Bhosale , V. V. Mane, Optimization of Surface Roughness in Turning Operation of EN8 using Taguchi Method by International Advanced Research Journal in Science, Engineering and Technology National Conference on Design, Manufacturing, Energy & Thermal Engineering (NCDMETE-2017) Vol. 4, Special Issue 1, January 2017
[3] Abburi N. R. and Dixit U. S. "A knowledge-based system for the prediction of surface roughness in turning process" Robotics and Computer Integrated Manufacturing, Volume 22, pp. 363–372.(2006)
[4] Abdallah Ali. BhuveneshRajamony, Abdulnasser Embark., 'Optimization of cutting parameters for surface roughness in CNC turning machining with aluminum alloy 6061 material', IOSR Journal of Engineering04(10); 01-10. (2014).
[5] Abhang L.B. andHameedullah M. 'Optimization of machining parameters in steel turning operation by taguchi method', International conference on Modeling, Optimization and computing, Procedia engineering, 38, pp 40-48. (2012)
[6] Al-Ahmari A. M. A."Predictive machinability models for a selected hard material in turning operations", Journal of Materials Processing Technology, Volume 190, pp. 305–311.(2007)
[7] AsilturkIlhan, AkkusHarun, Determining the effect of cutting parameters on surface roughness in hard turning using the Taguchi method, Measurement 44 1697–1704. (2011)
[8] Ahmed S. G. "Development of a Prediction Model for Surface Roughness in Finish Turning of Aluminum", Sudan Engineering Society Journal, Volume 52, Number 45, pp. 1-5.(2006)
[9] Choudhury I.A., EI-Baradie M.A., Surface roughness prediction in the turning of high-strength steel by factorial design of experiments, Journal of Materials Processing Technology 67, 55-61, (1997)
[10] Davim J. Paulo, Gaitonde V.N., Karnik S.R., Investigations into the effect of cutting conditions on surface roughness in turning of free machining steel by ANN models, journal of materials processing technology 205, 16–23.(2008)

