EFFECT OF VARYING PROCESS PARAMETERS ON TURNING OF HIGH CARBON STEEL BY USING TAGUCHI'S L-8 METHOD

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Abstract: In the present work, Effect of Varying process parameters on turning of High Carbon steel by using Taguchi's L-8 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 for minimum surface roughness is found to be $A_1B_1C_1$ D_2 i.e., rotational speed of 310 rpm, feed rate of 13 mm/min, depth of cut of 0.4 mm and tool nose radius of 1.2 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.

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.

II. CUTTING FACTORS IN TURNING

Spindle speed: Speed always refers to the spindle and the work piece

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.

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.

III. LITERATURE REVIEW

Abburi et al. [1]. 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. [2]. 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 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. [3]. 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 [4]. 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. [5]. focused on optimizing turning parameters based on Taguchi method to minimize surface roughness (Ra and Rz). Experiments have been conducted using L9 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 [6]. 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. [7]. discussed the development of surface roughness prediction models for turning EN 24T steel (290 BHN) utilizing response surface methodology. A 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.

IV. EXPERIMENTAL PROCEDURE

4.1 Material and machine

High carbon steel was used as a base material in present investigation and lathe machine were used .

Table 1. Chemical Material Composition of High Carbon Steel

Element	Composition (Wt %)
C	0.88
Si	0.53
Mn	1.39
P	0.084
Cr	0.433
Ni	0.084
Cu	0.100
Co	0.066
W	0.80
Fe	95.33

4.2 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.

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

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

4.3 Design of Experiments (DOE)

The DOE helpfor conducting experiments in a more systematic way. The process parameters with their levels are specified in Table below.

Table 2. Experimental Factors and their Levels

Factor	Symbol	Level-1	Level-2
Spindle speed	A	310	400
Feed rate	B	13	21
Depth of cut	C	0.4	0.8
Nose radius	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, L8 orth orthogonal array used as shown in table 3.

Table 3 (L8 OA)

Experiment no.	A (Spindle Speed)	B (Feed Rate)	C (Depth of Cut)	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

4.5 S/N RATIO Table 4

Exp. No.	A	B	C	D	S/N Ratio
1	310	13	0.4	0.8	0.772
2	310	21	0.8	0.8	-11.65
3	310	13	0.8	1.2	-19.38
4	310	21	0.4	1.2	-0.53
5	400	13	0.4	1.2	-11.99
6	400	21	0.8	0.8	-19.63
7	400	13	0.8	0.8	-0.08
8	400	21	0.4	1.2	-13.06

V. RESULTS AND DISCUSSIONS

Eight experiments were successfully conductedbased 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 4.

Fig 1. Machined work piece

5.1 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 5 lists the ANOM results.

The combination of machining parameters $A_1B_1C_1D_2$is found to be optimum for surface roughness during turning of high carbon steel.

Table 5: Analysis of Mean (ANOM)

S. No.	Symbol	Level 1	Level 2	Rank
1	A	**9.88**	10.90	2
2	B	**10.11**	10.67	4
3	C	**10.09**	10.69	3
4	D	10.96	**9.82**	**1**

Best combination so generated is $A_1B_1C_1D_2$

From the experiment, it is found that tool nose radius is the significant parameter for effecting surface roughness. Also Fig.2 shows percentage contribution of tool nose radius (D) is maximum i.e., 99.5845%.

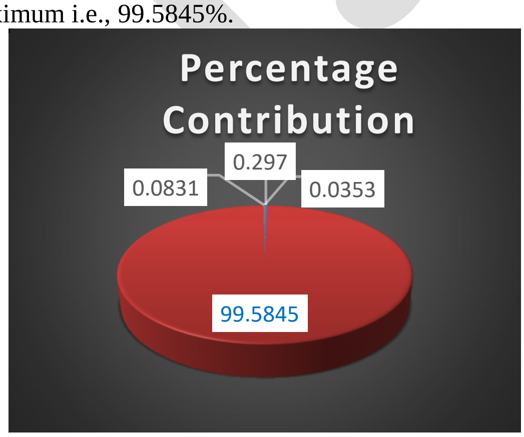

Fig 2. Percentage contribution

VI. CONCLUSIONS

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_1 B_1 C_1 D_2 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 $A_1B_1C_1$ D_2, i.e., at spindle speed (A) at 310 rpm, feed rate (B) at 13 mm/min, and depth of cut (C) at 0.4 mm, and tool nose radius (D) at 1.2 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.

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