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Optimization Of Turning Parameters Using Taguchi Method

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ABSTRACT- Present work investigates the effect of turning parameters such as rotational speed, feed rate and depth of cut on surface roughness of high carbon steel. Taguchi's method was used for designing the experiments and optimization of turning parameters. Experiments were conducted as per L9orthogonal arraywith three factors having three levels for each factor. The analysis of variance technique is employed to study the significance and contribution of each factor on surface roughness. Results revealed that feed rate 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 A1B1C2 i.e., rotational speed of 315 rpm, feed rate of 15 mm/min and depth of cut of 0.8 mm.

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

1. INTRODUCTION

Machining is a versatile shaping process of major importance for component manufacturing. The importance of machining in modern automated manufacturing systems has in fact increased due to the significant increase in the production time and the need to offset the high capital investment in these modern systems. 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 one of the most commonly employed operations in experimental work and metal cutting. The tool is held rigidly in a tool post and moved at a constant rate along the axis of the bar, cutting away a layer metal to form a surface or more complex profile as the part is being rotated. Turning is also used to as a secondary process to produce better surface finish after being processed by primary processes such as casting, forging, extrusion or drawing process. Turning generates axially symmetric shapes with a single-point tool. A single-point tool removes material by means of one cutting edge. In most cases the tool is held in a fixed position with the work piece rotating about a turning axis. There are also tools held on the spindle centreline (drills, reamers, taps) for hole-making applications that have speed and feed limitations. Turning is a manufacturing process which carried out through relative rotation of part and cutting tool. The main power comes from the work piece which mounted in the chuck derived by the motor. Turning is the most basic and common machining method which plays an important role in production in many shops. Turning is suitable for processing rotary surface, most of the work piece with the rotary surface can be processed with the turning method, such as internal and external cylindrical surface, inside and outside the cone surface, face, groove, thread and rotating forming surface, etc.
In various metal cutting machine tools, the lathe is the most common kind, accounting for 50% of the total number of machine tools. Lathe tool can be used for turning on the work piece, and also drill bits, reamers, taps and knurl for drilling, reaming, tapping and knurling operation.

2. LITERATURE REVIEW

Krishankant et.al (2012) optimized turning process parameters (Spindle speed, Feed rate, Depth of cut) using Taguchi method on machined EN24 steel for improving material removal rate. The bars used are of diameter 44mm and length 60mm. They conducted experiments by varying one parameter and keeping other two fixed so maximum value of each parameter was obtained. The metal removal rate was considered as the quality characteristic with the concept of "the larger-the-better". Every day scientists are developing new materials and for each new material, we need economical and efficient machining. It is also predicted that Taguchi method is a good method for optimization of various machining parameters as it reduces the number of experiments.
Abhang et.al (2012)studied the optimization of machining parameters in steel turning operation by Taguchi method. They performed experimental work by turning EN-31 steel alloy using tungsten carbide inserts. There were three main purposes of their study. The first was to explain and demonstrate a systematic procedure of Taguchi parameter design and applying it to the data on turning. The second was to find out the optimal combination of process parameters

based on S/N ratio and to know the significance of each parameter by performing ANOVA analysis. The third important aim was to find out the effect of lubricant temperature in steel tuning process on the response (i.e. surface roughness). They varied feed rate, depth of cut, and lubricant temperature to observe the effects on responses. The main conclusion drawn from their study was that better surface finish was obtained by applying cooled lubricant. Even with higher depth of cuts surface finish was improved if lubricant temperature is lowered.

Gulhane et.al (2012)investigated the parameters affecting the roughness of surfaces produced in the turning process of 316L Stainless Steel. Design of experiments was conducted for analysis of the influence of turning parameters such as cutting speed, feed rate and depth of cut on surface roughness. They revealed that feed rate was found to be the most significant parameter influencing the surface roughness in the turning process

Zafar (2004)performed turning operation on AISI304 stainless steel with WC ISO p10 cemented carbide cutting tool and found that average chip thickness decreases as the cutting speed increases regardless of the feed. At the same time, power consumption decreases owing to low chip thickness during chip removal. Less vibration was observed and surface roughness got better due to the decrease of power consumption

3. EXPERIMENTAL PROCEDURE

3.1 Material and machine

High carbon steel was used as a base material in present investigation. High carbon steel is direct hardening materials and can be hardened to 58-60 HRC. High carbon steel posses good hardness which leads to its use for manufacturing press tools and sheering blades. HC steel is highly used in manufacturing industries. This steel has good hot hardness and strength. Common applications for these tool steels include forging dies, die-casting die blocks, and drawing dies.The chemical composition of HC steel is presented in Table 1.

The experimental studies were performed on a lathe machine which is shown in Fig. 1.

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

Fig. 1. Lathe machine

3.2 Experimental Design

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. Taguchi proposed to acquire the characteristic data by using orthogonal arrays, and to analyse the performance measure from the data to decide the optimal process parameters. This method uses a special design of orthogonal arrays to study the entire parameter space with small number of experiments only, according to the Taguchi quality design concept, there are three categories of performance characteristics in the analysis of the S/N ratio: the lower-the better, the higher-the-better, and the nominal-the better. A larger S/N ratio corresponds to better performance characteristic. Therefore, the optimal level of the process parameters is the level with the highest S/N ratio. Also, a statistical analysis of variance (ANOVA) is performed to identify the process parameters that are statistically significant. 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.

$$\eta = -10 \log \left[\frac{1}{N \sum_{n}^{i=1} y_i}\right]$$

Nine experimental runs based on the orthogonal array L9 were carried out.

3.3 Design of Experiments (DOE) and Process Parameters

The DOE helpfor conducting experiments in a more systematic way. The process parameters with their levels are specified in Table 2 below. Table 2 shows three parameters, i.e. spindle speed (A), feed rate (B), and depth of cut (C),with three levels for each factor.

Table 2. Experimental Factors and their Levels

Factor	Symbol	Level-1	Level-2	Level-3
Spindle speed	A	315	500	775
Feed rate	B	15	47	80
Depth of cut	C	0.4	0.8	1.2

3.4 Orthogonal Array (OA)

OA allows for the maximum number of main effects to be estimated in an orthogonal manner, with minimum number of runs in experiment, L9 orthogonal array used in the study as presented in Table 3.

Table 3: L9 Orthogonal Array of the Experimental Runs

Experiment no.	A (Spindle Speed)	B (Feed Rate)	C (Depth of Cut)
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	3
5	2	2	1
6	2	3	2
7	3	1	2
8	3	2	3
9	3	3	1

4. RESULTS AND DISCUSSIONS

Nine experiments were successfully conducted based on Taguchi method and machined samples are shown in Fig. 2. The experimental results for the surface roughness along with corresponding S/N ratios are listed in Table 4. Typically, small values of surface roughness are desirable for good quality and accuracy in the machining operation. Thus, the data sequences have a “smaller- the-better characteristic" for surface roughness.

Fig 2. Machined samples

Table 4. Surface Roughness Values and corr

Exp. No.	A	B	C	Ra(µm)	S/N Ratio
1	315	15	0.4	0.915	0.772
2	315	47	0.8	3.826	-11.65
3	315	80	1.2	9.315	-19.38
4	500	15	1.2	1.063	-0.53
5	500	47	0.4	3.978	-11.99
6	500	80	0.8	9.584	-19.63
7	775	15	0.8	1.009	-0.08
8	775	47	1.2	4.500	-13.06
9	775	80	0.4	10.467	-20.39

4.1 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 and the Fig. 3 shows mean S/N graph. The combination of machining parameters A1B1C2 is found to be optimum for surface roughness during turning of high carbon steel. Spindle speed at 315 rpm, feet rate of 15 mm/min and depth of cut of 0.8 mm is found to be optimum parameter combination for minimizing surface roughness of high carbon steel. However, optimized parameter combination is not available in the selected design. Therefore, another experiment was conducted at optimized parameter and surface roughness was measured which is found to be 0.891µm. Hence, Taguchi method optimizes the parameters not only those available in the selected design but it optimizefrom all possible combinations.

Table 5: Analysis of Mean (ANOM)

S. No.	Symbol	Level 1	Level 2	Level 3
1	A	-10.0890	-10.7183	-11.1795
2	B	0.0544	-12.2375	-19.8037
3	C	-10.5394	-10.4546	-10.9929

Sources of variation	Sum of square	DOF	Mean square	F value	Contribution (%)
Spindle speed (A)	1.80	2	0.899	8.41	0.297
Feed rate (B)	602.7	2	301.339	2819.26	99.58
Depth of cut(C)	0.503	2	0.251	2.35	0.083
Error	0.214	2	0.107		0.035
Total	605.2	8			100

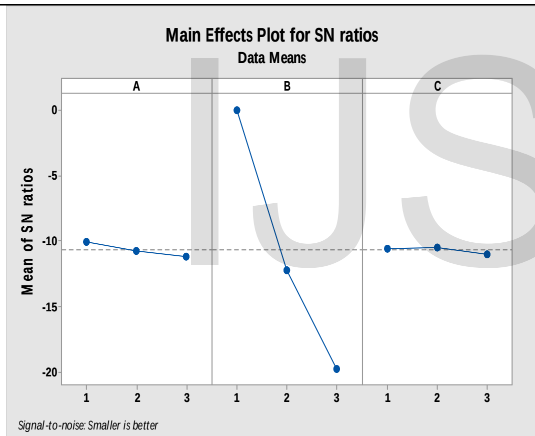

Fig. 3. Mean S/N Graph

4.2 ANOVA

Normal probability plot (Fig. 4) was obtained to ensure that the data is normally distributed. It can be seen from Fig. 4 that the data points either lie on the straight line or are close to it which validates the normality distribution of the measured data. The purpose of ANOVA experiments is to reduce and control the variation of process, so the decisions can be made concerning which parameter affect the performance of the process. ANOVA is a statistical method used to interpret the experimental data to take necessary decisions. Through ANOVA the parameters can be categorized into significant and insignificant parameters.

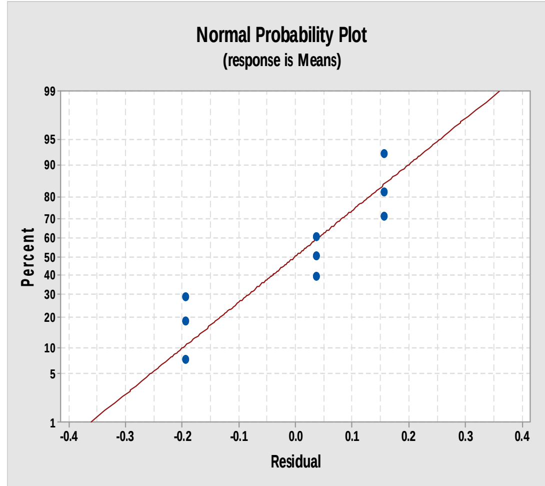

Fig. 4. Normal probability plot

The importance of machining parameters was investigated to determine the optimum combinations of the machining parameters by using ANOVA. F-test provides a decision at some confidence level as to whether these estimates are significantly different.

Table 6. ANOVA results for surface roughness

From F-value table and ANOVA table, it is found that feed rate is the significant parameter for effecting surface roughness. Also Fig.5 shows percentage contribution of feed rate (B) is maximum i.e., 99.5845% followed by spindlespeed (A) of 0.2970% and depth of cut(C) of 0.0831%.

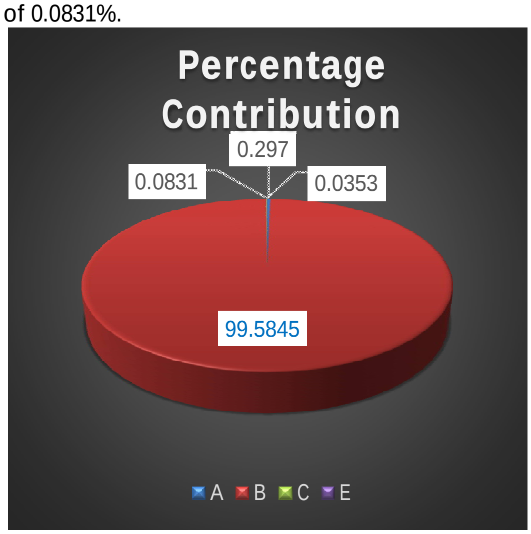

Fig 5. Percentage contribution

5. CONCLUSIONS

In this paper, effect of turning parameters on surface roughness of high carbon steel using carbide tool was investigated. Experimentation was done as per Taguchi's L9 orthogonal array. Optimal combination of machining parameters and their levels for minimum surface roughness was obtained and significance of the machining parameters was determined using ANOVA. Based on the results of the present study following conclusions are drawn:

1). Taguchi's robust design was successfully used for optimizing turning parameters on high carbon steel.

2). Optimal combination of the machining parameters for surface roughness is found o be A1B1C2, i.e., at spindle speed (A) at 315 rpm, feed rate (B) at 15mm/min, and depth of cut (C) at 0.8 mm. Surface roughness value obtained at optimum parameter combination was 0.891μm.

3). Feed rate contributes maximum (99.5845%) followed by spindle speed (0.2970%) and depth of cut (0.0831%) to minimize the surface roughness

REFERENCES

[1]. S.R. Das, R.P. Nayak and D. Dhupal, "Optimization of cutting parameters on tool wear and work piece surface temperature in turning of AISI D2 steel," International journal of lean thinking. 3(2): 3095-3104 (2012).

[2]. Krishankant, JatinTaneja, MohitBector and Rajesh Kumar, "Application of taguchi method for optimizing turning process by the effects of machining parameters," International journal of engineering and advanced technology. 2(1): 263-274 (2012).

[3]. U.D. Gulhane, A.B. Dixit, P.V. Bane and G.S. Salvi, "Optimization of process parameters for 316L stainless steel using taguchi method and anova," International journal of mechanical engineering and technology. 3(2): 1-14(2012).

[4]. L.B. Abhang, and M. Hameedullah, "Optimization of machining parameters in steel turning operation by taguchi method," International conference on modeling optimization and computing, Procedia Engineering 38: 40-48 (2012)

[5]. M. Kaladhar, K. VenkataSubbaiah, Ch. Srinivasa and K. NarayanaRao, "Optimization of process parameters in turning of AISI202 austenitic stainless steel," ARPN journal of engineering and applied sciences 5, no.9 (2010).

[6]. W.H. Yang, and Y.S. Tarng, "Design optimization of cutting parameters for turning operations based on the taguchi method," Journal of materials process technology 84: 122-129 (1984)