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Optimization of Turning Parameters Using Taguchi Method

Sharda R. Nayse[1], M. G. Rathi[2]

[1]Student, Department of Mechanical Engineering, Government Engineering College Aurangabad, (MS), India.

[2]Associate professor, Department of Mechanical Engineering, Government Engineering College Aurangabad, (MS), India.

Abstract: *Today in manufacturing and metal industries customer satisfaction is very important to make own place in competitive market and also to make mirror image with faith in the heart of customer, because customer gives preference to buy good quality product. In the metal and manufacturing industries for the product low surface roughness is very important. Lowest surface roughness assures not only good quality but also reduces manufacturing cost. In this paper the main objective is to study effect of cutting speed, feed rate and depth of cut on surface roughness of mild steel in turning operation and as a result of that the combination of optimum level of factors was obtained to get lowest surface roughness. Experiments have been conducted using Taguchi's experimental design technique. An orthogonal array, signal to noise ratio, and analysis of variance are employed to investigate cutting characteristics of mild steel using high speed steel. Experimental results show that among the cutting parameter cutting speed is the most significant machining parameter for surface roughness followed by feed rate and depth of cut.*

Keywords: *Surface roughness, Turning operation, S/N Ratio.*

I. Introduction

The machining processes generate a wide variety of surface textures. Surface texture consists of the repetitive and random deviations from the ideal smooth surface. These deviations are

- Roughness: small, finely spaced surface irregularities (micro irregularities)
- Waviness: surface irregularities of greater spacing (macro irregularities)
- Lay: predominant direction of surface texture

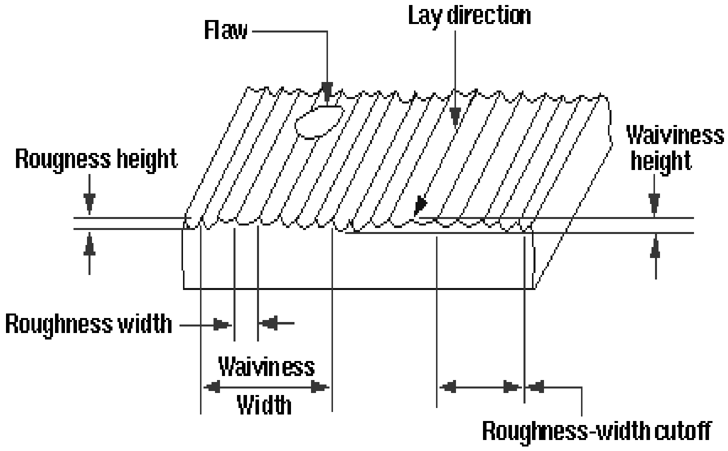

Fig 1: Surface characteristics

Three main factors make the surface roughness the most important of these parameters:

- Fatigue life: The service life of a component under cyclic stress (fatigue life) is much shorter if the surface is high.
- Bearing properties: A perfectly smooth surface is not a good because it cannot maintain a lubricating film.
- Wear: High surface roughness will result in more intensive surface wear in friction.

Factors Affecting Quality of Turning Process:

The three key mechanical inputs in metal removal operations are speed, feed and depth of cut. Manipulating the speed, feed and depth of cut can maximize the benefits of a particular cutting fluid and can increase productivity. However, like most decisions, the choice of feed, speed and depth of cut must be based on the customer's objectives. What is their goal in this application? Do they want to manufacture parts faster or maximize tool life? How important is the surface finish and dimensional accuracy of the part? Answers to these questions will drive their decisions on feed, speed and depth of cut.

Definitions:

- Speed: speed is the rate of rotation of the spindle where the tool is held. It is measured in revolutions per minute (RPMs).
- Feed: feed is the rate at which the tool is moved into the part or part into the tool. Feed is measured in feet, inches or millimeters per time period.
- Depth of Cut (DOC): the measurement (normally in inches or millimeters) of how wide and deep the tool cuts into the work piece.

II. Taguchi Method

Taguchi methods are statistical methods developed by Genichi Taguchi to improve the quality of manufactured goods, and more recently also applied to engineering, biotechnology, marketing and advertising. Professional statisticians have welcomed the goals and improvements brought about by Taguchi methods, particularly by Taguchi's development of designs for studying variation, but have criticized the inefficiency of some of Taguchi's proposals. The performance measure, signal to noise ratio (S/N) proposed by Taguchi is used to obtain the optimum parameter combinations. The larger S/N means the relation to the quality will become better.

In Taguchi method desirable performance is classified in three categories such as the smaller-the-better quality, the larger-the-better-quality, and the nominal-the-best. Signal to noise analysis is designed to measure quality characteristic. It is given by

$$S/N = -10\log_{10}(MSD)$$

Where MSD= Mean Square Deviation

For the smaller the better characteristic,

$$MSD = (Y_1^2 + Y_2^2 + Y_3^2 + \cdots\cdots)/n$$

Larger the better characteristic,

$$MSD = (1/Y_1^2 + 1/Y_2^2 + 1/Y_3^2 + \cdots\cdots)/n$$

Nominal the best characteristic,

$$MSD = [(Y_1 - m)^2 + (Y_2 - m)^2 + (Y_3 - m)^2 + \cdots\cdots)]/n$$

Where Y_1, Y2, Y3 are the responses and n is the number of tests in a trial and m is the target value of the result. Smaller surface roughness values represent better or improved surface quality of the product. Therefore, a smaller-the-better quality characteristic was implemented and introduced in this study.

Quality implies delivering products and services that meet customer's standards and fulfill their needs and expressions. Quality has been traditionally assured by Statistical Process Control a collection of powerful statistical methods facilitating the production of quality goods by intelligently controlling the factors that affect a manufacturing process.

Experiments are carried out by researchers or engineers in all fields of study to compare the effects of several conditions or to discover something new. If an experiment is to be performed most efficiently, then a scientific approach to planning it must be considered. The statistical design of experiments is the process planning experiments so that appropriate data will be conducted, the minimum number of experiments will be performed to acquire the necessary technical information, and suitable statistical methods will be used to analyze the collected data.

The statistical approach to experimental design is necessary if we wish to draw meaningful conclusions from the data. Thus, there are two aspects to any experimental design: the design of the experiment and the statistical analysis of the collected data. They are closely related, since the method of statistical analysis depends on the design employed.

An outline for an experimental design is shown in figure 2:

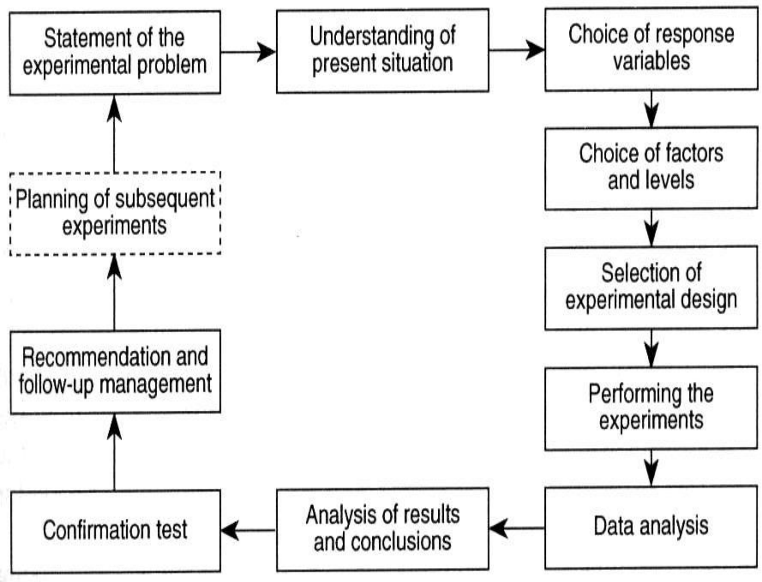

Fig 2: Outline of experimental design procedure

III. Experimental Design

In this study, the main objective is to study the effect of cutting speed, feed rate and depth of cut on the surface roughness of turned specimen of mild steel using Taguchi's L_9 orthogonal array design. The values of the input process parameters for the turning operation are as under:

Table I: Input Parameters

Notations	**Factors**	**Level 1**	**Level 2**	**Level 3**
A	Cutting Speed (rpm)	190	300	500
B	Feed (mm/rev)	0.044	0.088	0.132
C	Depth of Cut (mm)	0.2	0.4	0.6

Table Ii: Layout of L_9 Orthogonal Array

Trial	**Cutting Speed (rpm) (A)**	**Feed (mm/rev) (B)**	**Depth of Cut (mm) (C)**
1	Level 1	Level 1	Level 1
2	Level 1	Level 2	Level 2
3	Level 1	Level 3	Level 3
4	Level 2	Level 1	Level 2
5	Level 2	Level 2	Level 3
6	Level 2	Level 3	Level 1
7	Level 3	Level 1	Level 3
8	Level 3	Level 2	Level 1
9	Level 3	Level 3	Level 2

TABLE III: LAYOUT OF EXPERIMENTAL DESIGN ACCORDING TO L_9 ARRAY

Trial No.	A Cutting Speed (rpm)	B Feed (mm/rev)	C Depth of Cut (mm)	Surface Roughness (microns)	S/N Ratio
1	190	0.044	0.2	1.63	-4.26
2	190	0.088	0.4	2.16	-6.70
3	190	0.132	0.6	2.83	-9.04
4	300	0.044	0.4	2.09	-6.40
5	300	0.088	0.6	2.69	-8.61
6	300	0.132	0.2	2.11	-6.50
7	500	0.044	0.6	2.91	-9.28
8	500	0.088	0.2	1.90	-5.58
9	500	0.132	0.4	2.40	-7.60

IV. Analysis Of Variance

Analysis of variance is standard is a standard technical technique to interpret experimental results. It is extensively used to detect differences in average performance of groups of items under investigation. It breaks down the variation in the experimental result into accountable sources and thus finds the parameters whose contribution to total variation is significant. Thus analysis of variance is to study the relative influences of multiple variables, and their significance. The importance of ANOVA is to determine two estimates of population variance viz., one based on between samples variance and the other based on within sample variance. Then said to estimates of population variance are compared with F-test. At pre-determined level of significance, the null hypothesis is rejected, otherwise accepted.

For this ANOVA table is prepared. In this ANOVA table, the sum of squares (SS) due to independent variable and the sum of squares due to error is separately given. Degree of freedom (DOF) is the number of way one can select the components for a set up under restriction. In the case of analysis, there is loss of one degree in sum of squares due to regression. Mean sum of squares (MSS) are obtained by dividing SS by the DOF, each for regression and error. The MSS related to error is called as variance.

TABLE IV: RESULTS OF ANOVA

Factors	Degree of Freedom	Sum of Squares	Mean Square	% Contribution	F-Ratio
Cutting Speed (rpm)	2	1.17	0.59	3.225	0.0834
Feed (mm/rev)	2	1.94	0.97	5.348	0.13720
Depth of Cut (mm)	2	19.028	9.514	52.451	1.34569
Error	2	14.14	7.07	38.977	
Total	8	36.278	4.535		

V. Conclusions

In this study, the Taguchi method is used to study the effect of parameters like cutting speed, feed and depth of cut on the surface roughness of mild steel in turning and to find out optimum combination parameters at which lower surface roughness value is obtained. In this study, at cutting speed (190 rpm), feed (0.044mm/rev) and depth of cut (0.2 mm) the lower value of surface roughness is obtained. Hence in this study, $A_1B_1C_1$ is the best combination.

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