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OPTIMISATION OF PROCESS PARAMETER IN TURNING OPERATION USING TAGUCHI METHOD

Abhay Shantinath Patil,
Department of Mechanical Sandwich,
Indira College of Engineering and Management, Pune. Parandwadi, Pune.
abhaypatil101096@gmail.com

Prof. Nitin Ulmek
Department of Mechanical Sandwich,
Indira College of Engineering and Management, Pune. Parandwadi, Pune.

ABSTRACT

Turning process is the one of the methods to remove material from cylindrical and non-cylindrical parts. In any machining process, it is most important to determine the optimal settings of machining parameters aiming at reduction of production costs and achieving the desired product quality.

The material removal rate has been identified as the quality traits and assumed to be directly linked to productivity. There are three important cutting parameters namely, cutting speed, feed rates and depth of cut, which has been considered during the turning operation. An Orthogonal array has been constructed to determined the signal-to-noise (S/N) ratio.

According to experimental results, depth of cut is determined to be the most important factor on material removal.

The objective of this study is to illustrate the procedure adopted in using Taguchi Method to a turning operation. Depth of cut, Spindle speed, Feed rate and Tool Material were used as the process parameters.

Keywords – taguchi method, turning process, S/N ratio, DOE, ANOVA, Surface roughness, response variable.

I. INTRODUCTION

Turning is a machining process used to obtain the desired dimension of round metal. The main target in present industrial era is to produce low cost quality product with required dimensions in an optimum time. Therefore, the optimum cutting parameters are to be recognized first.

In the present investigation, a single characteristics optimization model based on Taguchi method employed to determine the best combination of the machining parameters such as cutting speed, feed, depth of cut and nose radius to attain the minimum surface roughness and maximum MRR simultaneously.[5]

Machining parameters in metal turning are cutting speed, feed rate and depth of cut. Hence our aims to study the effect of changes in parameter over the surface finish of material. Also to get different combinations of parameters in order to get good surface finish. During going through the process we will study the Taguchi Method. [12]

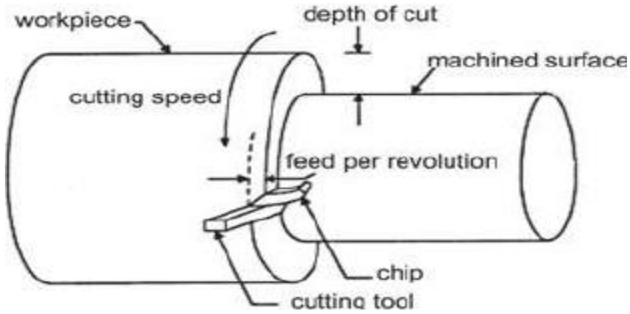

Fig. 1 Turning Process

In turning, the speed and motion of the cutting tool is specified through several parameters. These parameters are selected for each operation based upon the workpiece material, tool material, tool size, and more. Turning parameters that can affect the processes are:

A. Turning Parameter

a) Cutting speed - The speed of the work piece surface relative to the edge of the cutting tool during a cut, measured in surface feet per minute (SFM).

b) Spindle speed - The rotational speed of the spindle and the work piece in revolutions per minute (RPM). The spindle speed is equal to the cutting speed divided by the circumference of the work piece where the cut is being made. In order to maintain a constant cutting speed, the spindle speed must vary based on the diameter of the cut. If the spindle speed is held constant, then the cutting speed will vary.

c) Feed rate - The speed of the cutting tool's movement relative to the work piece as the tool makes a cut. The feed rate is measured in mm per revolution.

d) Depth of cut - The depth of the tool along the radius of the work piece as it makes a cut, as in a turning or boring operation. A large depth of cut will require a low feed rate, or else it will result in a high load on the tool and reduce the tool life. Therefore, a feature is often machined in several steps as the tool moves over at the depth of cut. [7]

II. LITERATURE REVIEW

Literature study is required to understand the correct objective of the project work. The past research work gives the better idea and clear contain of cognition. It helps us to reach to a particular destination. The goal is “Optimization of turning process parameters using Taguchi Method”.

Taguchi method provides a systematic and efficient methodology for the design optimization of the cutting parameter with far less effect than would be required for most optimization techniques.[3]

III. TAGUCHI METHOD

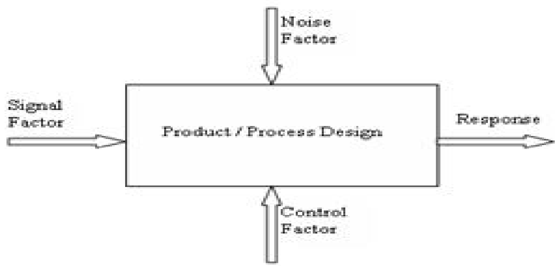

Fig.2. Product/process diagram

The Taguchi method is used for producing high quality product at minimum cost. This method is a conventional method. This method designs the experiment in an efficient & effective manner and analysis the process influencing parameter in lesser time. It is a modified method in design and analysis compared to traditional design and is widely used in making quality improvements. This is performed or done to find the suitable combination of parameters with the varying responses. Taguchi method is a powerful tool to design optimization for quality. It is used to find the optimal cutting parameters such as cutting speed, feed rate, depth of cut and nose radius, etc. as the overall cost can be reduced. This experiment gives some background of optimization technique applied to various turning processes for improving surface roughness.[6]

A large number of experimental works has been done when the process parameters are increased along with their levels. To solve this, Taguchi method is used with a design of orthogonal arrays to study the all parameters. He proposed optimization in three steps; system design, parametric design and tolerance design.[4]

System design

It is the development of a system to function under an initial set of nominal conditions. System design requires scientific and engineering knowledge.

Parametric design

The objective here is to select the optimum levels for the system parameters such that the final product is functional, exhibits a high level of performance under a wide range of conditions. The design should be robust enough against noise factor which cause variability. Noise factors are those that are difficult to control or are too expensive to control. Control factors are those parameters that can be set and maintained (design features).

Tolerance design

When parameter design is not sufficient for reducing the variation, the last phase is tolerance design. Narrower tolerance ranges must be used for those design factors whose variation leads a large negative influence on the output variation. To fulfil these specifications, expensive components and processes are usually needed. Because of this reasons production and operations costs increases due to tolerance design increases.[2]

A. Designing of experiment

The design of an experiment includes the following steps-

1) Selection of proper independent variables.
2) Selection of number of levels setting for each independent variable.
3) Selection of proper orthogonal array.
4) Assigning the independent variables to each column.
5) Conducting the experiments.
6) Analyzing the data. [6]

B. Orthogonal array

While there are many standard orthogonal arrays available, every array is meant for a specific number of independent design variables and levels. For example, if one wants to perform an experiment to understand the influence of 4 different independent variables with each variable having 3 set values that is level values, then an L9 orthogonal array might be the right choice. The L9 orthogonal array is use for understanding the effect of 4 independent factors each having 3 factor set or level values. This array assuming that there is no interaction between any two factors while in many situations, no interaction model assumption is valid, there are some other cases where there is a clear evidence of interaction.[10]

C. S/N Ratio Analysis

Taguchi recommends the use of S/N ratio to measure the quality characteristic deviation from the desired values. The term 'Signal' represents the desired value (i.e. mean) for the response and the term Noise' represents the undesired value (i.e. SD).

Therefore, S/N ratio is the ratio of the mean to SD. Usually there are three categories of quality characteristic in the analysis of S/N ratio, i.e. the larger-the-better, the smaller-the-better, and the nominal the-better. Regardless of the category of the quality characteristic, a greater S/N ratio corresponds to better quality characteristic. S/N ratio for each level of process parameter was computed based on the smaller-the-better S/N analysis for the surface roughness. The experiments were conducted aiming at determining the effect of machine tool condition, in term of vibration amplitude, on surface roughness of the work piece. [1]

The values of S/N ratio, η, corresponding to the average surface roughness of each run calculated using the Equation: $\eta = -10 \log [(\Sigma\ yi\ 2)/n]$ Where η is the S/N ratio, yi is surface roughness measurements in a run, and n is the number of replicates. S/N ratio is based on the Taguchi smaller the-better loss function, as the idea is to minimize the response, i.e. surface roughness. The S/N ratio is a summary statistic which indicates the value and dispersion of the response. [9]

The S/N ratio characteristic is divided into three categories namely

Smaller-the-Better

This category of S/N ratio is selected when the characteristic like circularity, surface roughness, power consumption, etc. are required to minimize.

Larger-the-Better

This case is opposite to the smaller the better case. This category of S/N ratio is selected when objective function is to maximize the characteristic like Material Removal Rate.

Nominal-the-Best

When a specified value is most desired, meaning that neither a smaller-the-better nor a larger-the-better value is desirable.

D. Analysis of variance (ANOVA)

The main aim of ANOVA is to investigate the design parameters and to indicate which parameters are significantly affecting the output parameters. ANOVA can be useful for determining influence of any given input parameter from a series of experimental results by design of experiments for machining process and it can be used to interpret experimental data. Analysis of variance (ANOVA) is a collection of statistical models, and their associated procedures in which the observed variance in a particular variable is partitioned into components attributable to different sources of variation. In its simplest form, ANOVA provides a statistical test of whether or not the means of several groups are all equal, and therefore generalizes t-test to more than two groups. ANOVA is used in the analysis of comparative experiments, those in which only the difference in outcomes is of interest.

Taguchi recommends analyzing the mean and S/N ratio using two dimensional response graphs, instead of ANOVA. The analysis of means (ANOM) is a statistical approach that is based on determining the mean S/N ratios for each design factor and each of its levels. [8]

IV. RESPONSE PARAMETERS

a. Surface Roughness

Roughness is a measure of the texture of a surface. It is quantified by the vertical deviations of a real surface from its ideal form. If these deviations are large, the surface is rough; if they are small the surface is smooth. Roughness is typically considered to be the high frequency, short wavelength component of a measured surface. Surface roughness is an important measure of product quality since it greatly influences the performance of mechanical parts as well as production cost. Surface roughness has an impact on the mechanical properties like fatigue behavior, corrosion resistance, creep life. [11]

Factors influencing surface roughness in turning

1. Cutting parameters i.e. feed, cutting speed and depth of cut
2. Vibration
3. Material of work piece
4. Rigidity of the system consisting of machine tool, fixture cutting tool and work
5. Material and sharpness of cutting tool
6. Type of coolant used.

b. MRR (Material removal rate)

MRR is defined as the material removed per unit time. Speed, feed and depth of cut together determine the material removal rate. [13]

V. CONCLUSION

Taguchi optimization method revealed that cutting speed should be kept at the highest level, while both feed rate and depth of cut should be kept at the lowest level. Taguchi method provides a systematic, efficient and easy-to-use approach for the cutting process optimization.

The optimal combination of low feed rate and low depth of cut is beneficial for good surface finish.

Surface Roughness

The most significant factor are feed and depth of cut followed by speed. Also lubricant has significant effect in obtaining better finish.

Material Removal Rate

Depth of cut and feed is the significant factor followed by speed.

Taguchi method for experimentation and also ANOVA and signal-to-noise ratio are used to study the performance characteristics in turning operation. It was found that the primary factor affecting the material removal rate is feed rate, subsequently followed by speed and depth of cut.

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