Optimization of Cutting Parameters of Turning Process for Surface Roughness of AISI D2 Steel Using Taguchi Method

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Abstract- **This study focuses on optimizing turning parameters based on Taguchi Design of Experiment to minimize surface roughness. After studying lot of research work process parameters have been selected (Cutting speed, feed rate, depth of cut and nose radius). This paper leads to method of work-piece and tool material selection. This paper also dictates about the methodology to be followed for conducting experiment and the results expected after completion of experimental runs.**

Index Terms- **Optimization, Turning Process, Taguchi method, Design of Experiment, Process parameters.**

INTRODUCTION

Automotive industries uses conventional machining processes such as turning, drilling, milling, shaping and planning and others to manufacture automotive components. Although each machining process has their own importance but turning is a versatile and useful machining operation. Turning has specific feature of producing complex geometric surfaces with acceptable accuracy and surface properties. Due to this feature of turning, it is the most important operation and is widely used in most of the manufacturing industries. Turning is common machining process in most of the production industry. Turning in the lathe is to remove extra material from the work-part to produce a cone-shaped or cylindrical smooth surface finish on the metal. During turning process the work is made to rotate about the lathe axis, and the tool is fed parallel to the lathe axis. Different shapes and design features such as holes, grooves, threads, tapers,

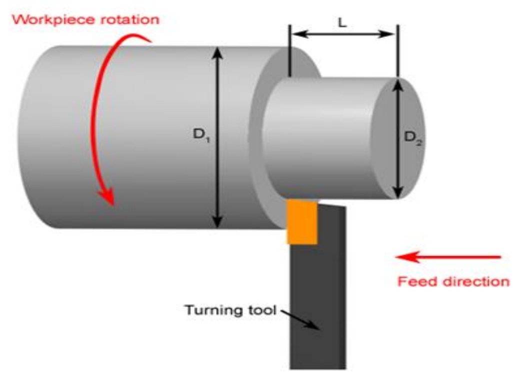

Figure 1: Turning process

various diameter steps, and even contoured surfaces can be imparted on work-piece by Turning process. Turning possess high tolerances and surface finishes, thus it is easy for adding precision rotational features to a component whose basic shape has already been formed. The three primary controlling parameters in normal turning operation are cutting speed, feed rate and depth of cut. Optimization of these parameters results in achieving the minimum machining cost and production time. Better surface finish is the most required properties of machined parts where customers never compromise. Surface roughness is the main characteristic to define surface quality. It requires attention both from industry staff as well as in R&D team, because this greatly influences machining performances. Surface roughness is mainly due to process parameters such as tool geometry (i.e. nose radius, edge geometry, rake angle, etc.) and cutting conditions (feed rate, cutting speed, depth of cut, etc.). The optimal selection of the process parameters can be introduced during early stage of the product and process development to achieve the quality product with cost effectiveness. The aim of this project work is to optimize by surface roughness of engineering components by turning process. To obtain the result of minimum surface roughness, the material used for the investigation is AISI D2 (cold work tool steel). Thus, the surface roughness is planned to be measured and observed the optimal cutting parameters for better surface finish.

LITERATURE SURVEY

Prasad et al. (2014) focused on the influence of process parameters on surface roughness when work-piece material, Inconel 718 was dry turned using cubic boron nitride (CBN) tool. They considered cutting speed (50, 60 & 70 m/min), feed rate (0.103, 0.137 & 0.164 mm/rev) and depth of cut (0.50, 0.75 & 1.00 mm) as input and surface roughness as response parameter. They employed Taguchi design L9 orthogonal array and artificial neural network approach for optimization of roughness parameter. They concluded that surface roughness was more sensitive to feed rate followed by cutting speed and depth of cut.

Ozel et al. (2007) carried out finish turning of AISI D2 steels (60 HRC) using ceramic wiper (multi-radii) design inserts for surface finish and tool flank wear investigation. For prediction of surface roughness and tool flank wear multiple linear regression models and neural network models were developed. Neural network based predictions of surface roughness and tool flank wear were carried out, compared with a non-training experimental data and the results thereof showed that the proposed neural network models were efficient to predict tool wear and surface roughness patterns for a range of cutting conditions. The study concluded that best tool life was obtained in lowest feed rate and lowest cutting speed combination.

Thamizhmanii et al. (2007) applied Taguchi method for finding out the optimal value of surface roughness under optimum cutting condition in turning SCM 440 alloy steel. The experiment was designed by using Taguchi method and experiments were conducted and results thereof were analysed with the help of ANOVA (Analysis of Variance) method. The causes of poor surface finish as detected were machine tool vibrations, tool chattering whose effects were ignored for analyses. The authors concluded that the results obtained by this method would be useful to other researches for similar type of study on tool vibrations, cutting forces etc. The work concluded that depth of cut was the only significant factor which contributed to the surface roughness.

Lin et al. (2001) developed a network to construct a prediction model for surface roughness and cutting force. Once the process parameters: cutting speed, feed rate and depth of cut were given; the surface roughness and cutting force could be predicted by this network. Regression analysis was also adopted as second prediction model for surface roughness and cutting force. Comparison was made on the results of both models indicating that adductive network was found more accurate than that by regression analysis.

Őzel and Karpat (2005) studied for prediction of surface roughness and tool flank wear by utilizing the neural network model in comparison with regression model. The data set from measured surface roughness and tool flank wear were employed to train the neural network models. Predictive neural network models were found to be capable of better predictions for surface roughness and tool flank wear within the range in between they were trained.

Pal and Chakraborty (2005) studied on development of a back propagation neural network model for prediction of surface roughness in turning operation and used mild steel work-pieces with high speed steel as the cutting tool for performing a large number of experiments. The authors used speed, feed, depth of cut and the cutting forces as inputs to the neural network model for prediction of the surface roughness. The work resulted that predicted surface roughness was very close to the experimental value.

Fnides et al. (2008) studied on machining of slide-lathing grade X38CrMoV5-1 steel treated at 50 HRC by a mixed ceramic tool (insert CC650) to reveal the influences of cutting parameters: feed rate, cutting speed, depth of cut and flank wear on cutting forces as well as on surface roughness. The authors found that tangential cutting force was very sensitive to the variation of cutting depth. It was observed that surface roughness was very sensitive to the variation of feed rate and that flank wear had a great influence on the evolution of cutting force components and on the criteria of surface roughness.

PROPOSED EXPERIMENT

The present study is devoted to the development of Taguchi and regression model for the analysis of the turning process. The objective of this research is to study the influence of controllable process parameters such as cutting speed, feed, depth of cut, tool nose radius on Surface roughness (Ra). There are, however, sufficient research works on the modeling and optimization of the turning process parameters still there is a scope of improvement as the new materials are developed. Finding out the main influencing significant parameters on surface roughness is the main motto of this work.

SCOPE

The study was aimed on the effect of spindle speed, feed rate, depth of cut and tool nose radius on the surface roughness of the work-piece. AISI D2 steel of hardness 60 HRC to be used as the work-piece material and the cutting tool (insert) to be Carbide coated. This experiment is carried out in dry condition. The surface roughness would be measured by using Mitutoyo SJ-201 surface roughness tester.

PROBLEM FORMULATION

Optimization of turning process parameters is usually a difficult work though knowledge of machining process and the specification of machine tool capabilities.

The selection of cutting parameters and their appropriate levels are very tough because the selected level of these parameters must be able to set in machine. Sometimes scratch marks or inaccuracies in cut are neglected. This leads to achieving high cutting performance.

EXPERIMENTATION

Experimental set-up: Experimental set-up is designed for evaluation and analysis of optimal cutting parameters for materials AISI D2 using a HMT NH22 precision lathe as shown in Figure 2.

Figure 2: HMT precision lathe

Experiment will be performed by turning a specimen of AISI D2 steel on a Precision Lathe at different cutting parameters of various levels. Figure 3 illustrates the turning process carried out on lathe for experimental runs.

Figure 3: Turning on NH22

For this experiment the specimen and insert material used during turning on conventional lathe are given below.

- Work-piece material used:- AISI D2
- Tool material:- Sandvik made carbide inserts of nose radii 0.4, 0.8 and 1.2 mm
- Environment:- Dry condition

Apparatus: Vernier caliber, Mitutoyo SJ-201 surface roughness tester

Expected result: The present work will be helpful to determine the influence of cutting parameters: cutting speed, feed, depth of cut and tool nose radius in dry condition on surface roughness. Application of Taguchi Design of Experiment and ANOVA will give the sequence in which these input parameters affect the turning process. Using MINITAB 18 software the mathematical regression model for surface roughness (Ra) can be generated which leads to evaluate the surface roughness in future experiments of different levels of turning parameters. Since AISI D2 is a tool material, its surface quality cannot be compromised and still lot of improvement is required in minimization of surface roughness. Thus this work will be helpful in optimizing surface roughness and improving productivity at a reasonable level of quality.

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