A Review on Optimization of Cutting Parameters for Tool life and Surface Roughness in Turning Process

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Abstract: The influence of cutting parameters within the turning process primarily affects the surface roughness and machining time of product. Surface roughness is a vital issue at the purpose of read quality of product. The important cutting parameters in turning process mainly cutting speed, feed rate, depth of cut, spindle speed have an effect on the surface finish of the finished material. This study is the optimization of cutting parameters in turning process using response surface methodology. Response surface methodology could be a powerful tool of optimization. A specially designed central composite design of response surface is employed to analyse the impact of cutting parameters through data. The analysis of variance (ANNOVA) is employed to determine the input parameters considerably have an effect on the performance characteristics. The analysed data is employed to find out optimum cutting parameters level.

Keywords- Response surface methodology, surface roughness, tool life, cutting speed, feed, depth of cut etc.

1. Introduction

In a turning operation, it is an important task to select cutting parameters for achieving high cutting performance. Usually, the desired cutting parameters are determined based on experience or by use of a handbook. However, this does not ensure that the selected cutting parameters have optimal or near optimal cutting performance for a particular machine and
environment. To select the cutting parameters properly, several mathematical models [10] based on statistical regression techniques or neural computing have been constructed to establish the relationship between the cutting performance and the cutting parameters. Then, an objective function with constraints is formulated to solve the optimal cutting parameters using optimization techniques. Therefore, considerable knowledge and experience are required for using this modern approach. Furthermore, a large number of cutting experiments has to be performed and analysed in order to build the mathematical models.

1.1 Surface roughness and Tool life

Surface roughness and tool life plays a vital role in deciding about the productivity in global manufacturing. Surface roughness and tool life is one of the important quality control parameter for evaluating of production process. Efficient turned component improves many functional attributes like excellent tolerance, less tool wear, fatigue strength or creep life, load bearing capacity, corrosion strength and frictional
resistance etc. [1,2] Surface roughness determines how a real object interacts with its environment.

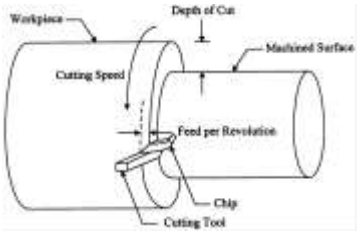

Fig 1. Basic turning operation [10]

1.2 Response Surface Methodology (RSM)

Response surface methodology is a specialized DOE technique that may be used to detail and optimize transfer functions of a DFSS project. The method can be used in the optimization phase of the DFSS algorithm. Response surface methodology (RSM) is a combination of statistical and optimization methods that can be used to model and optimize designs. It has many applications in design and improvement of products and processes. And it is a fundamental method to derive the relationship between the different parameters affecting the process.

RSM works by applying different designed experiments to obtain a polynomial model of the process keeping the independent variable as the system output which is minimized. A comprehensive algorithm of the calculations involved. These approaches comprise a systematic method of scheduling experiments as well as gathering and analysing records with a near optimum use of resources. The most widely employed methodologies for surface roughness prediction terms of machining parameters are the Response
Surface Methodology (RSM). The various forms of regression analysis concentrate on using existing data to predict future results. It is used to examine the relationship among several factors and the results. Regression is applied to create models to predict the results when combinations of factors interact under various conditions. It is one of the most widely used statistical tools because it provides a simple method of establishing a functional relationship among variables. The relationship is expressed in the form of an equation connecting the response or dependent variable (y), and one or more independent variables, x1,x2,x3,……..xn.

2. Literature Review

Saini et al. (2014) [1], investigated Optimization of Multi-Objective Response during CNC Turning using Taguchi-Fuzzy Application. In this research work CNC turning operation is carried out using L27 Taguchi orthogonal arrays on Aluminum alloy 8011with carbide insert and influence of CNC turning process parameters like Cutting Speed, Feed and Depth of Cut are analyzed for material removal rate and surface roughness.

Rao et al. (2013) [2], studied Influence of cutting parameters on cutting force and surface finish in turning operation. This research showed that significance of influence of speed, feed and depth of cut on cutting force and surface roughness while working with tool made of ceramic with an Al2O3+TiC matrix (KY1615) and the work material of AISI 1050 steel. Taguchi method was used for the experiments. Analysis of variance with adjusted approach has been adopted.

Durairaj et al. (2013) [3], investigated Parametric Optimization for Improved Tool Life and Surface Finish in Micro Turning using Genetic Algorithm. This paper deals with CNC Micro turning of Inconel 600 alloy with titanium carbide coated tool. Machining is done in DT-110 integrated multiprocessor micro machine tool. Micro turning is carried out with full factorial experiments with various combinations of cutting parameters such as speed, feed and depth of cut and output parameters such as the tool wear and the surface roughness are measured.

Makadia and Nanavati [], Design of experiments has been used to study the effect of the main turning parameters such as feed rate, tool nose radius, cutting speed and depth of cut on the surface roughness of AISI 410 steel. A mathematical prediction model of the surface roughness has been developed in terms of above parameters. The effect of these parameters on the surface roughness has been investigated by using Response Surface Methodology (RSM). Response surface contours were constructed for determining the optimum conditions for a required surface roughness. The developed prediction equation shows that the feed rate is the main factor followed by tool nose radius influences the surface roughness. The surface roughness was found to increase with the increase

in the feed and it decreased with increase in the tool nose radius. The verification experiment is carried out to check the validity of the developed model that predicted surface roughness within 6% error.

Nayak et. al. [5], concluded the multi objective optimization of machining parameters during dry turning of IASI 304 Austenite stainless steel was done. Three imp characteristics MRR, cutting force and surface roughness were measured.

Beraneka and Kolarikb [6], concluded that Design of experiment was done to optimize the turning parameters like cutting speed, depth of cut and feed of duplex steel. Duplex steels during machining are generally prone to mechanical strengthening Feed rate and cutting speed have statistically significant effect on surface roughness parameters Ra, Rz where increase of factors effect increase surface roughness but then feed rate is set to level 0.1 mm/rev factor cutting speed has smaller effect.

Mahesh et. al., [7], An experiment has been conducted to observe the significance of process parameters and influence of the radial rake angle of the tool in end mill cutter. Mathematical model has been developed to predict surface roughness in terms of machining parameters such as spindle speed, feed rate, radial, axial depth of cut, and rake angle of cutting tool. The second-order mathematical models, in terms of the machining parameters, have been developed using Response surface methodology (RSM). The experiment is conducted on aluminum Al 6063 by HSS end mill cutter, the surface roughness is measured by using Surf tester SJ- 201.

Sarvanakumar and Kumar [8], The influence of machining process parameters such as cutting speed (X1, m/min), feed rate (X2, mm/rev), and depth of cut (X3, mm) on the output parameters such as material removal rate and surface roughness can also be optimized. Relationship between material removal rate and input parameters and between surface roughness and input parameters are arrived through Minitab software. These regression equations are solved using genetic algorithm tool called user interface method and the optimum combinations of input parameter for input parameters for maximum material removal rate (MRR) and minimum surface roughness (Ra) had been arrived using mat lab software. The optimum combination of input parameters for maximization of material removal rate is found to be cutting speed 79.99m/min, feed rate 0.25mm/rev, depth of cut 0.1mm and best fitness value is 2122.23 mm3/min. and the optimum combination of input parameters for minimization of surface roughness found to be cutting speed 79.9m/min, feed rate 0.15mm/rev, depth of cut 0.1mm and Best fitness for minimization of surface roughness is 0.69 μm.

Aouici et. al., [9] The effects of cutting speed, feed rate, work piece hardness and depth of cut on surface roughness and cutting force components in the hard turning were experimentally investigated. Four-factor (cutting speed, feed rate, hardness and depth of cut) and three level fractional experiment designs completed with a statistical analysis of variance (ANOVA) were performed. Mathematical models for surface roughness and cutting force components were developed using the response surface methodology (RSM). the ranges for best cutting conditions are proposed for serial industrial production are feed force (Fa) and the cutting force (Fv) are strongly influenced by the depth of cut, (56.77%) and (31.50%) respectively. On the opposite, the cutting speed has a very small influence (0.14%). The best surface roughness was achieved at the lower feed rate and the highest cutting speed.

Yang and Tarng [10], This paper has discussed an application of the aguchi method for optimizing the cutting parameters in turning operations. As shown in this study, the Taguchi method provides a systematic and efficient methodology for the design optimization of the cutting parameters with far less effect than would be required for most optimization techniques. It has been shown that tool life and surface roughness can be improved significantly for turning operations. The confirmation experiments were conducted to verify the optimal cutting parameters. The improvement of tool life and surface roughness from the initial cutting parameters to the optimal cutting parameters is about 250%.

3. Conclusion

In this work, attempt has been made to present a literature review on optimization of cutting parameters of different engineering materials for surface roughness in turning process. From literature, it is observed that Surface roughness is the most significant response parameter at the point of view quality of the product so most of the researchers have taken it into study. Input parameters (Controllable factors) such as cutting speed, depth of cut, feed rate, and spindle

speed are mainly taken for study. From this study, it is found that feed rate is the most significant parameter for surface roughness and optimal combination of Input parameters is important for good surface finish and tool life.

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