Introduction to Tools and Techniques used for optimization of cutting parameters on average surface roughness and material removal rate during turning of Metal Matrix Composite

Bheem Singh Rajpoot
M Tech. Scholar, Production Engineering,
Marudhar Engineering College,
Bikaner, Rajasthan, India,
singh.bheem6@gmail.com

Dharma Ram Moond
Assistant Professor, Department of Mechanical Engineering,
Marudhar Engineering College,
Bikaner, Rajasthan, India.

Dr. Sharad Shrivastava
Assistant Professor, Department of Mechanical Engineering,
Birla Institute of Technology & Science, Pilani, Rajasthan, India.

Abstract-This research work investigate the effect of cutting parameters on average surface roughness and material removal rate during turning of Metal Matrix Composite using response surface methodology. In this research work an effort has been made to obtain the optimal values of cutting parameters in order to minimize the average surface roughness and maximize metal removal rate in turning of Metal matrix composite steel on CNC Lathe. The experimental studies are carried out under changing machining parameters like feed rate, depth of cut and cutting speed during turning of metal matrix composite. Response surface methodology based on the Face cantered design technique has been used for the development of mathematical models to predict average surface roughness and metal removal rate.

The conclusions of this work are:

1. Feed seems to be the most important and influential machining parameter that affect the average surface roughness followed by depth of cut and the cutting speed for metal removal rate.
2. The depth of cut has significant for both the average surface roughness and metal removal rate for the MMC steel.
3. The mathematical models developed clearly show that surface roughness increases with increasing the feed but decreases with increasing the cutting speed.

Keywords: *Response surface methodology, metal matrix composite, cutting speed, metal removal rate, surface roughness, feed rate.*

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1. Introduction

Surface finish is the method of measuring the quality of a Product. This chapter reveals the importance of surface excellence and cutting forces in machining. The surface finish of the machined work piece is greatly influenced by various factors such as machining parameters, work piece properties, cutting tool geometry and cutting phenomenon. Machining parameters such as feed, speed and depth of cut play a crucial role during machining. These have a major effect on production size, production cost and rate of production. The selected machining parameters should produce desired finish on the machined surface while using the cutting resources like cutting tool and machine tool to the full limit possible, uniform with the constraints on these resources. So it can be achieved by establish empirical relationship between machining condition and surface roughness indicators using design of experiments (DOE). The proposed work will be employed for investigating the effect of turning parameters on surface roughness in turning of Metal Matrix Composite steel. An effort has also been made to optimize the turning parameters for minimum surface roughness using response surface methodology.

A. Process Parameters

A process variable or process parameter is the current status of a process under control. There are three main process parameter i.e. depth of cut, cutting speed and cutting feed. These three dominating parameter are considered as process parameter in turning and milling operation.

B. Optimization

Process optimization is the method of adjusting a process to optimize parameters without disturbing some constraint. The most important objectives are minimizing cost, maximizing output, and efficiency. This is the major quantitative tools in industrial applications.

The goal of optimizing a process is to maximize the process specifications, keeping others within their limits.

C. Significance of topic

Machining is the metal shaping process used in manufacturing company. Worldwide investment in metal-machining processes continues to increase year after years. The machining is more expensive than other production process, viz. moulding, casting, and forming etc, but it is often justified for precision requirement.

Metal cutting is one of the most important manufacturing processes in material cutting. Metal cutting can be defined as the cutting of metal from a work piece in the form of chips in order to obtain a finished product with desired size, shape, and surface roughness. There are

different methods of metal cutting such as turning, grinding, milling etc.

Turning is one of the commonest among these methods. Turning is the process of machining external cylindrical and conical surfaces [4]. In this process the work material will held in the lathe chuck and rotated. The tool is held firmly in a tool post and moved at a constant rate along the axis of the bar, removing a layer of metal to form a profile.

In manufacturing industries, manufacturers focus on both the quality and productivity. To increase the productivity, computer numerically control machine tools have been used during the past many years. Surface roughness is the important parameters to determine the product quality. These can be categorized as controllable factors like feed rate, depth of cut, spindle speed and nose radius and uncontrollable factors like tool geometry and material characteristics of both tool and work piece.

The mechanism for the formation of surface roughness is complicated and process dependent. Several factors influence the surface roughness obtained in a CNC turning operation. These can be categorized as controllable factors like feed rate, spindle speed, and depth of cut and uncontrollable factors like tool geometry and material characteristics of both tool and work piece [6].

The estimation of cutting parameters like cutting speed, feed rate and depth of cut is very important for analyzing the effect of these parameters on surface roughness.

Manufacturing companies have long depended on the skill and experience of shop-floor machine operators for proper selection of machining conditions and cutting tools. Due to inadequate knowledge of the complexity, an improper decision may cause high production costs, low machining quality and high tool wear. Proper selection of cutting conditions and parameters for achieving a desired surface finish is not an easy task. To overcome these problems, a number of studies have been carried out to investigate and formulate the effect of machining condition for prediction of surface roughness.

2. TOOLS AND TECHNIQUE USED FOR OPTIMIZATION

A. Response Surface Methodology

Response surface methodology is a statistical method that uses quantitative data from appropriate experiment to determine and simultaneously solve the multivariate equation. This method is used to determine the optimum contribution of factors that yield a desired response and describes the response near the optimum. It also exhibits how a specific response is affected by changes in the level of factors over the specified level of interest. RSM consists of a group of empirical techniques used to the evaluation of relations existing between a collection of controlled experimental factors and measured responses, according to selected criteria. If the model contains coefficients for main effects, coefficients for quadratic effects and coefficients for two factor interactions, a full factorial design with all the factors at three levels would provide estimation of all the necessary regression parameters. However, these full factorial three level designs are costly to run as the number of runs increases with the number of factors. Therefore, special designs are used to help the experiment to fit second order model to the response with the number of runs.

B. Design of experiments

A number of experiments required, mainly depends on design of experiment. Thus, it is important to have a well designed scheme of the experiment, so that number of experiments required can be minimized. In this research, the design suggested by RSM based on face centred design (FCD) has been implemented to analyze the effect of independent process parameters on surface roughness indicators.

C. The analysis of variance (ANOVA) test for regression

In statistics, ANOVA is a collection of statistical models, and their related procedures, in which the observed variance is divided into components due to different variables. Effect plots visualize the impact of each factor combination and identify which factors are most influential. A statistical hypotheses test is needed in order to determine of any of these effects are significant. Analysis of variance (ANOVA) consists of simultaneous hypothesis tests to determine if any of the effects are significant.

D. Test specimens

Turning is one of the most commonly employed operations for producing cylindrical parts. In the present research work test specimens in the form of round bar of dimensions $\emptyset 24 \times 150\ mm$ have been used for the exexperiment.

The Chemical composition of test samples obtained by spectral analysis

Alloy Element	wt %
B4C	2
Mg	1
Si	0.6
Cu	0.25

Fe	0.2
Cr	0.17
Zn	0.09
Ti	0.01
Mn	0.01
Al	Bal.

E. Machine tool for turning

The CNC becomes very common in factories and are capable to enhance product quality as well as productivity.

Keeping in view the above, all the turning experiments on the Al 6061 alloy have been carried out on HYTECH PUNE MODEL NO: 4-CL T100 lathe. The CNC machining centre equipped with continuously variable spindle speed up to 3000 rpm and a 2 HP motor drive was used for experimentation.

F. Cutting tool for turning

Due to high machinability of metal matrix composite a large number of cutting tools were available as options required for the turning. Single point Tungsten Carbide tool (TCT) was selected as the cutting tool for the experiment.

G. Surface roughness measurement

Surface roughness is considered an index of component quality. It measures the finer irregularities of the surface texture. In this research, a portable surface roughness tester (Model No TR 210 manufactured by Beijing TIME High Technology Ltd., Beijing City, China) has been used to measure surface roughness indicators of finished work pieces. The constants for surface roughness tester for all the measurements of work pieces were standard ISO 97R, 0.8 mm cut-off, least count of 0.001µm. The measurements were repeated at three different locations of the finish work piece in the direction of the tool movement. Finally, the mean of surface roughness values were considered for the particular trial.

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