Optimization of Machining Parameter for Surface Roughness and Material Removal Rate in CNC End Milling Process

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Abstract— In CNC milling process, proper setting of cutting parameter is important to obtain better surface roughness. Unfortunately, conventional try and error method is time consuming as well as high cost. The purpose for this research is to develop mathematical model using multiple regressions and artificial neural network model for artificial intelligent method. Spindle speed, feed rate, and depth of cut have been chosen as predictors in order to predict surface roughness. The experiment is executed by using full factorial design. Analysis of variances shows that the most significant parameter is feed rate followed by spindle speed and lastly depth of cut. After the predicted surface roughness has been obtained by using both methods, average percentage error is calculated. The mathematical model developed by using multiple regression method shows the accuracy of 86.7% which is reliable to be used in surface roughness prediction. On the other hand, artificial neural network technique shows the accuracy of 93.58% which is feasible and applicable in prediction of surface roughness. The result from this research is useful to be implemented in industry to reduce time and cost in surface roughness prediction.

Key words: CNC milling, surface roughness, multiple regressions, artificial neural network

I. Introduction

The challenge of modern machining industries is mainly focused on the achievement of high quality, in term of work piece dimensional accuracy, surface finish, high production rate, less wear on the cutting tools, economy of machining in terms of cost saving and increase of the performance of the product with reduced environmental impact. End milling is a very commonly used machining process in industry. The ability to control the process for better quality of the final product is paramount importance [1].

The mechanism behind the formation of surface roughness in CNC milling process is very dynamic, complicated, and process dependent. Several factors will influence the final surface roughness in a CNC milling operations such as controllable factors (spindle speed, feed rate and depth of cut) and uncontrollable factors (tool geometry and material properties of both tool and work piece). Some of the machine operator using 'trial and error' method to set-up milling machine cutting conditions [1].

Fig. 1: CNC machining center

The CNC machine system is a computer control system, that computer control the whole system. This system called numeric control system. In the numeric control system dimension and the program can be given through the computer. This program written by operator. As compare to conventional machine the CNC machine can easily upgrade. Because In the conventional system the control is hard wired and therefore any modifications or addition in facility call for many changes in the controller which may or may not be possible due to limitations of basic configurations. As compared to this in a CNC system a bare minimum of electronic hardware is used while software is used for the basic function. That is why it is sometimes termed as software control. This assists in adding extra facilities conveniently without much problem and cost. Since these computers are dedicated type, they need comparatively much less storage and with the present cost and high reliability [2].

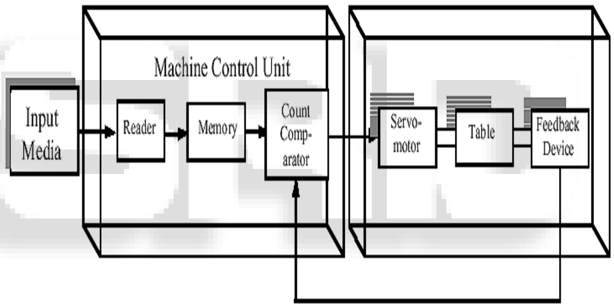

Fig. 2: Major components of a numerical control machine tool

A typical CNC system consists of the following six elements

1) Part program
2) Program input device
3) Machine control unit
4) Drive system
5) Machine tool
6) Feedback system

II. Taguchi techniques

It is a statistical method used to improve the quality of manufactured product. According to Taguchi "Quality is the loss imparted to society from the time a product is shipped." Science experimental procedures are generally expensive and time consuming we need to satisfy the design objective with minimum number of tests. Taguchi method involves laying out the experimental condition using orthogonal array. It is a specially constructed table which ensures that experiment design is both straight forward and consistent. By adopting this method number of analytical exploration needed to get the required design is significantly reduced. Hence testing time and experimental cost both are reduced.

Orthogonal array provides much reduced variance for the experiment resulting optimum setting of process control parameter. It is carried in three step approach i.e. system design, parameter design, tolerance design. In system design, scientific and engineering principles are used to generate a prototype of the product that will encounter functional requirements. Parameter design is to optimize the settings of process parameter values for enlightening performance characteristics. And in tolerance design, tolerances are set around the target a value of the control parameter identified in the parameter design phase and is done only when the performance variation attained by the settings identified in the parameter design stage is unacceptable. Taguchi also defined a performance measure known as the signal to noise ratio (S/N) and aims to maximize it by properly selecting the parameter levels [3].

III. ANOVA

The ANOVA was used to investigate which design parameters significantly affect the quality characteristic. The ANOVA is performed by separating the total variability of the S/N ratios into contributions by each of the design parameters and the errors. The total variability of S/N ratio is measured by the sum of the squared deviations from the total mean S/N ratio [4].

IV. TYPES OF MILLING OPERATION

A. Plain Milling:

Plain milling is the process of production on the Plain, Flat, and Horizontal; surface parallel to the axis of rotation of a plain milling cutter.

B. Side Milling:

Side milling is the operation on the production on a flat vertical surface on the side of a work piece by using side milling cutter.

C. Face Milling:

The face milling operation is performed by a face milling cutter rotated about an axis perpendicular to the work piece.

D. End Milling:

The end milling is the operation of production of the flat surface which may be verticle, horizontal, or at an angle in reference to the table surface. The cutter is used in an End mill.

E. Slotting:

The operation of production of Keyways, Grooves, and slots of varying shape and size can be performed in a milling machine by using a milling cutter, is metal slitting saw.

F. Straddle Milling:

The straddle milling is the operation of production of flat vertical surface on the both sides of a work piece by using two side milling cutter mounted on a same arbor.

G. Saw Milling:

The saw milling is the operation of production of narrow slots or grooves on a work piece by using saw milling cutter.

H. Gang Milling:

The gang milling is the operation of machining several surface of a work piece simultaneously by feeding the table against a number of cutters having same or different diameter mounted on the arbor of machine.

I. Angular Milling:

The angular milling is the operation of production of an angular surface on a work piece.

J. Form Milling:

The form milling is the operation of production of irregular counter by using form cutter.

K. Profile Milling:

The profile milling is the operation of production of an outline of a template or complex shape of a master diameter on a work piece.

L. Gear Cutting:

The gear cutting operation is performed in a milling machine by using a form relived cutter. The cutter may be cylindrical type or end mill type [5 & 6].

V. CONCLUSIONS

The approach presented in this paper is to develop mathematical models, based on experimental results for obtaining a surface roughness using the response surface methodology. The predicted surface roughness from the model is compared to the values measured experimentally.

The feed rate is a dominant parameter and the surface roughness increases rapidly with the increase in feed rate and decreases with increase in spindle speed, whereas the effect of depth of cut is not regular. This technique can produce accurate relationship between machining parameters and surface roughness. Surface roughness decreases with the use of carbide tool as compared to HSS tool. It was also observed that surface roughness decreases with the use of coolant.

GA has been used to estimate the optimum machining conditions to produce the best possible surface quality within the permissible bounds. Optimum machining parameter combinations for response variable is also tested through conformation experiments that show fairly good agreement with values obtained from GA.

This study can be extended to other machine tools by using more cutting parameters, tool geometries and different cutting tools and work piece materials.

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