METHODOLOGY OF MACHINING TIME PREDICTION IN END MILLING OPERATION USING VARIANCE ANALYSIS

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ABSTRACT: A series of experiments has been designed to classify the characteristics of machining factors for a given material in end milling procedure. The purpose of this research is to develop a better understanding of the significance from spindle speed, cutting feed and cutting depth towards machining time. The study will provide an understanding of the problem in handling the machined surface when cutting parameters adjusted to obtain a certain machining time value. The machining time play an important role in influencing manufacturing productivity rate. Therefore, this study is considered useful for the improvement of manufacturing industries. The study has been done which includes the effects from spindle speed, cutting feed and depth of cut that are capable to predict the value of machining time at 45% reliability.

KEYWORDS: *Machining time, ANOVA, Numerical control, End milling*

1.0 INTRODUCTION

The purpose of this research is to study the effect of various cutting parameters in end milling operation towards machining time. For that reason, researcher needs to established experimental procedures and analyzed data using multiple regression technique.

An end mill is a type of milling cutter, a cutting tool used in industrial milling applications. End mills are used in milling applications such as profile milling, tracer milling, face milling, and plunging. In a milling operation, the work piece is moved around the stationary cutting tool, the tool is moved across the stationary material, or some combination of the two. In any case, material is removed from the work piece by the rotating tool. The types of features which used to require a specially ground form tool are now being created using new surfacing and multi-axis technology. However, in some instances it is more cost effective to have a form tool made for large production runs as mentioned by Todd, R.H., Allen, D.K, & Alting, L. (1994).

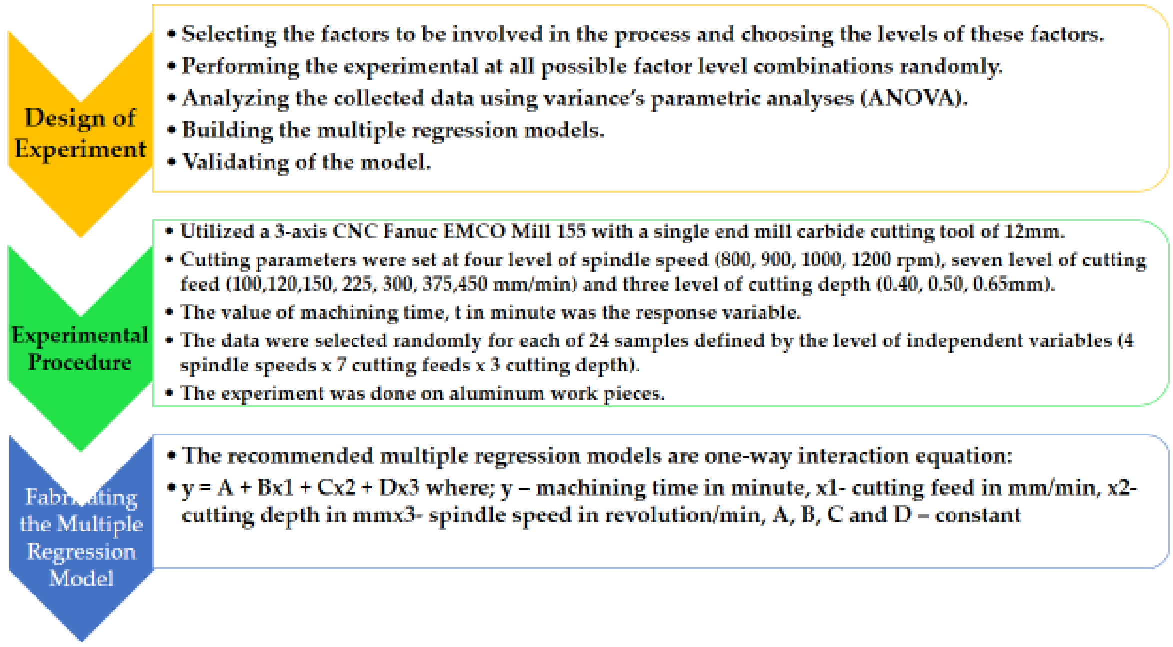
Numerical control (NC) refers to the automation of machine tools that are operated by abstractly programmed commands encoded on a storage medium, as opposed to manually controlled via hand wheels or levers, or mechanically automated via cams alone. Modern machines often combine multiple tools into a single cell. Arnold (1956) stated that a number of different machines are used with an external controller and human or robotic operators that move the component from machine to machine.

According to Hayajneh, M.T., Tahat, M.S., and Bluhm, J. (2007), cutting feed was the most dominant factor to determine the surface roughness. The value of surface roughness is very significant to measure the quality of surface finish. For those industries that related to machining environment, the quality of a product usually based on the value of surface finish. Previous studies showed that the quality of a product play a major role in determining the value of surface finish. However, there are many factors for manufacturers to consider other than surface roughness itself including time to produce a part. The production of product usually involved the time to machine a part as an indicator for production rate. Therefore, the machining time also play an important role in manufacturing. Hence, this study is considered beneficial for the improvement of manufacturing industries.

In statistics, analysis of variance (ANOVA) is a collection of statistical models, and their associated procedures, in which the observed variance is partitioned into components due to different explanatory variables as described by (Sidney, 1969).

2.0 METHODOLOGY

The research was conducted in 3 phases: design of experiment, experimental procedures and fabricating the multiple regression models. The following sections described the phases.



In this model, the decisive factor variable is the machining time,t and the predictor variables are spindle speed, cutting feed, and cutting depth. Because these variables are manageable machining parameters, they can be used to forecast the machining time in milling which will then enhance production rate. A statistical package SPSS 13.0 was used to carry out the regression analysis. In order to judge the accuracy of the multiple regression prediction models, percentage deviation φi and average percentage deviation φ were used.

3.0 RESULTS AND DISCUSSION

A total of 24 samples were used for experimental procedures. In order to analyze data by using statistical tools, the machining time for each particular sample was first established by using Fanuc EMCO Mill 155. The data set enclosed 24 samples were used to test the flexibility and validity of the regression model. The collected data were analyzed by using variance's parametric analyses (ANOVA) with machining time as dependent variable and spindle speed S, cutting feed F and cutting depth d as independent variables. The ANOVA model was first modified to comprise the main effects from independent variables only. The significance level was based on the P-value from ANOVA as:

Insignificant if $P > 0.10$
Mildly Significant if $0.05 < P < 0.10$ and
Strongly Significant if $P < 0.05$

A statistical model was created by regression function in SPSS 18.0 for testing data set. The R square value was 0.201, which meant that only 20.1% of the observed variability could be represented by independent variables. The Multiple R was 0.448, which meant that the correlation coefficient between the observed value of the dependent variable and the predicted value based on the regression model was moderate. The coefficients of independent variables were listed in regression coefficient values. Using these coefficients, the multiple regression equation could be expressed as mentioned in Eq. (1).

$$t = 42.618+(-0.077)F+(-24.525)d \quad (1)$$

The scatter plot between the observed time and the predicted time of all 24 samples indicated that the relationship between the actual and the predicted machining time were linear. The result of average percentage deviation (φ) showed that the testing data set (n=24) was 8.33%.This means that the statistical model could predict the machining time (t) with about 91.7% accuracy of the testing data set. The analysis indicated that feed rate and cutting depth factor were highly significant ($P<0.05$) while cutting speed was almost insignificant ($P>0.10$).The effect of cutting speed is less significant on the machining time.

4.0 CONCLUSION

A series of experiments was performed sequentially to characterize the factors that influence the machining interval in end milling process. The effect of spindle speed, cutting feed and cutting depth on machining time of aluminum was studied. The deviation between predicted and measured machining time values was within an error band of about 45%. The machining parameters investigated influenced the time to machine a particular work piece significantly. In general, the study shows that cutting depth is by far the most dominant factor.

5.0 REFERENCES

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