Prediction of Cutting Forces by using Machine Parameters in end Milling Process

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Abstract

Cutting forces produce deformations along cutting tool which is one of the mechanical machining errors, so that cutting force during a milling operation can be simulated in tool geometry during cutting condition and workpiece, then studying this forces to estimate by using a values which is produce from longitudinal component of the cutting force, then the results accuracy between experiment and predict cutting force is 92%.

الخلاصة

تعتبر قوى القطع من اهم الاسباب التي تؤدي الى حصول تشوهات في عدة القطع والتي تعتبر واحدة من اخطاء التشغيل الميكانيكي لذا فأن قوى القطع في عملية التفريز يمكن تمثيلها في الشكل الهندسي للعدة من خلال ظروف القطع والمشغولة. وقد تم دراسة هذه القوى لغرض التنبؤ بها حيث استخدمت القيم الناتجـة والتي تم الحصول عليها من المركبات الطولية المؤثرة لقوى القطع مما ادى الى الحصول على تقارب بين القوى التي تم التنبؤ بها والقوى التي تم الحصول عليها من الجانب العملي وكانت الدقـة بينهـا 95% .

Introduction

For a long time, manufacturing engineers and researchers have been realising that in order to optimise the economic performance of metal cutting operations, efficient quantitative and predictive models that establish the relationship between a big group of input independent parameters and output variables are required for the wide spectrum of manufacturing processes, cutting tools and engineering materials currently used in the industry [1]. Furthermore, it has been observed that the improvement in the output variables, such as tool life, cutting forces, surface roughness, etc., through the optimisation of input parameters, such as feed rate, cutting speed and depth of cut, may result in a significant economical performance of machining operations [2].

One of these output variables that may have either direct or indirect indications on the performance of other variables such as tool wear rate, machined surface characteristics and machining cost, is cutting forces. Many researchers have conducted studies on predicting cutting forces produced in machining operations using theoretical and analytical approaches [3-5]. The problem with these approaches is that they are based on a big number of assumptions that are not included in the analyses. This may reduce the reliability of the calculated cutting force values found by these methods.

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In addition, these approaches may be successfully applicable only for certain ranges of cutting conditions.
The present study considers the effect of simultaneous variations of four cutting parameters (cutting speed, feed rate, radial depth of cut and axial depth of cut) on the behavior of cutting forces. For this purpose, the genetic network (GN) is utilized.

1. Models for cutting force

In minimizing cutting force, a mathematical model developed by using a genetic network is presented. In Figure (1) the function implements a genetic algorithm – back propagation network hybrid function. A population of neural networks is evolved to find the one network that is optimally capable of learning the relationships in the training set.

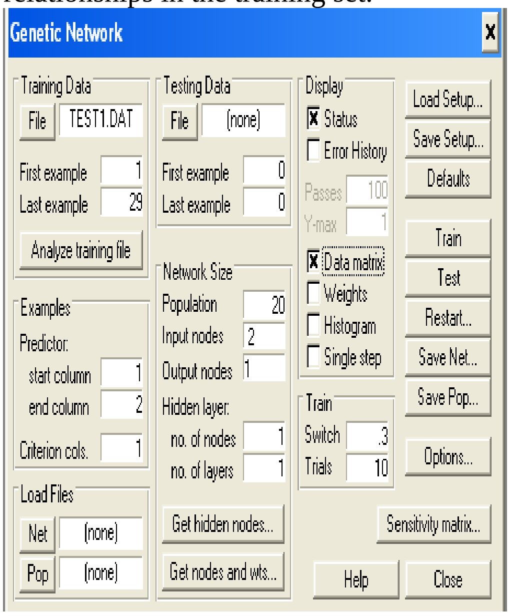

Figure (1): Genetic Network

The population of networks is trained using the back propagation rule. Networks are rated for fitness according to how well they have learned, over a selectable number of iterations. Networks are then mated with a probability proportional to their fitness level, exchanging structural information, and producing a new population of networks. [6]
Since cutting force prediction in terms of cutting speed, feed rate, radial and axial depth of cut is of main interest, neurons in the input layer correspond to cutting speed, feed rate, radial and axial depth of cut. Output layer corresponds to cutting force. [7]

3. Experimental Work

The current study is concerned with investigating the effect of four factors (cutting speed, feed, axial and radial depth of cut) on the cutting force generated when end milling of modified AISI P20 tool steel with coated carbide inserts. Generally, AISI P20 is a chromium-molybdenum alloyed steel which is considered as a high speed steel used to build moulds for plastic injection and zinc die-casting, extrusion dies, blow moulds, forming tools and other structural components. The modified form of AISI P20 is distinguished from normal P20 steel by the balanced sulphur content (0.015%) which gives the steel better machinability and more uniform hardness in all dimensions. Modified AISI P20 possesses a tensile strength of 1044MPa at room temperature and a hardness ranging from 280 to 320 HB. The workpiece used in this study was prehardened and tempered to a minimum hardness of 300HB. The approximate chemical analysis is shown in Table 1.

Table 1: Chemical analysisof modified Aisi

C	**0.38**
Si	**0.30**
Mn	**1.50**
Cr	**1.90**
Mo	**0.15**
S	**0.015**
Fe	**Balance**

The cutting tool used in this study is a lead-positive end milling cutter of 32mm diameter. The end mill can be equipped with two square inserts whose all four edges can be used for cutting. The tool inserts were made by Kennametal and had an ISO catalogue number of SPCB120308 (KC735M). In this study, only one inserts per one experiment was mounted on the cutter. The coating is accomplished using PVD techniques to a maximum of 0.004mm thickness.

The 29 experiments were performed in a random manner on predgport provided by Kistler. Each experiment was repeated three times using a new cutting edge every time to obtain very accurate readings of the cutting force. A cutting pass was

3. Results and discussion

From the predicted cutting force results by using genetic network model ,
One can easily notice that the response cutting force is affected significantly by the feed rate follwed by the axial depth of cut and then by the radial depth of cut, and lastly, by the cutting speed. Generally, the increase in the feed rate, axial and radial depths of cut will cause the cutting force to become largere. Table

CNC machining as shown in Figure (2).

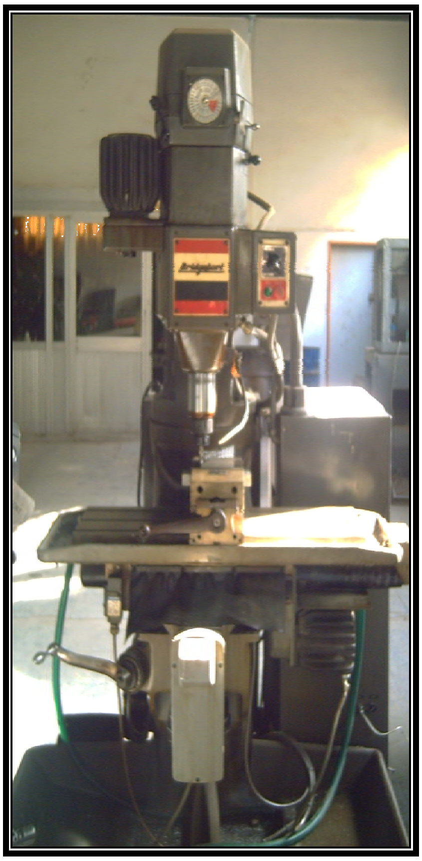

Figure (2): CNC Milling Machine

Each experiment was stopped after 85mm cutting length. Meanwhile, the data about cutting force component *F*y, was acquired with the aid of a piezoelectric cutting force dynamometer 2 shows the cutting force values received by experimentation and the values predicted by the first order model, were randomly divided into two data sets- the training set and the testing set. The training set contained 19 samples which were used to build a prediction model, as shown in table (3) and the testing set contained 10 samples which were used to test the flexibility of the prediction model as shown in table (4). It is clear that the predicted values are very close to the experimental readings. This indicates that the obtained linear model is able to provide, to a great extent, accurate values of cutting forces

The experimental and predicted data for cutting force are represented in Figure 3 which explain the accuracy of predicted cutting force value after testing 29 experiment.

4. Conclusions

The present work has reached the following conclusions

1. The feed rate was the most dominant cutting condition on the cutting force, followed by the axial depth, radial depth of cut and then by the cutting speed.
2. The prediction accuracy of the cutting force values in this research when (GN) are used is 92%.
3. Genetic network (GN) has proved to be a successful technique that can be used to predict the longitudinal cutting force produced in end milling.

5. References

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