DRILLING PROJECTS BY TOOL CONDITION MONITORING SYSTEM (TCMS)

J. García Sanz-Calcedo[1], DR Salgado[1], A. González[2], O. Lopez[2], I. Cambero[1] and JM. Herrera[1]

[1]School of Industrial Engineering. University of Extremadura, Spain
[2]Universitary Center of Mérida. University of Extremadura, Spain

1. Abstract

The novelty of this paper is the signal processing method used to analyzed the monitoring signals. Different statistical parameters are obtained and then principal component analysis (PCA) is applied to reduce the number of variables in the proposed model. With the resulting components, an artificial neural network is trained to predict tool condition. The results show that the proposed method is well-suited for the task of tool condition monitoring in drilling.

2. Introduction

Drill wear is a very important issue in manufacturing processes, since it not only affects the surface roughness of the hole, but also influences tool life. Moreover, drilling is one of the most common operations in machining as in automobile or aircraft industries. It was reported that drilling accounts for nearly 40% of all the metal removal operations in the aerospace industry [1]. It makes that drill wear monitoring has gained considerable importance in manufacturing industry.

Tool wear monitoring methods can be classified in two categories, i.e. direct and indirect methods. With direct methods it is possible to determine tool wear directly, which means that these methods really measure tool wear as such. In spite of the many attempts direct methods such as visual inspection or computer vision etc. have not yet proven to be very attractive economically nor technically. This is probably the reason why many of the TCMSs proposed in literature are indirect methods.

Drill wear is a progressive process that takes place at the outer margin of the flutes of the drill due to the chip-workpiece contact at high temperatures [2], moreover, under constant cutting conditions drill failure can be consider a stochastic process. Among the main reasons for this consideration are the inhomogeneities in the workpiece and tool material, the irregularities in the cutting fluid motion and the unavoidable asymmetry introduced during the grinding of the cutting edges [3].

In this work, drill wear condition is monitoring based on spindle and feed motor current signals. The novelty of this paper is the signal processing method used to analyzed the monitoring signals. Different statistical parameters are obtained and then principal component analysis (PCA) is applied to reduce the number of variables in the proposed model. With the resulting components, an artificial neural network is trained to predict tool condition. The results show that the proposed method is well-suited for the task of tool condition monitoring in drilling.

3. Methodology

Drilling experiments were performed on a vertical drilling machine. The monitoring signals were acquired during machining taking into account an expected tool life. The workpiece material was C45 steel. Flank wear of the drills was consecutively measured after a number of holes were drilled. HSS drills with different diameters were used in the experiments.

The experiments were carried out over a wide range of cutting conditions to map the relationship between the input information (features from the monitoring signals and cutting conditions) and the output information.

4. Conclusions

This work presents a tool condition monitoring system for drilling using current signals and a multilayer neural network. The most important contribution of this work is that it is possible to reduce the dimensional space of the features without reducing the success rate of the proposed TCMS. In particular, applying PCA technique, feature dimension has been reduced in 50%, which reduced the computing time thanks to the dimensional reduction. The mean error obtained with the validation data is 11.2 %.

Another interesting result is that the variance, RMS and skewness for both the spindle motor current and feed motor current increase when feed increases. This effect has been also detected but with great magnitude when drill diameter increases. Moreover, it is important to notice that the increase in spindle motor current is linear until 0.35 mm of tool flank wear and that for greater wears this relationship becomes nonlinear.

5. Acknowledgements

The authors gratefully acknowledge the support provided by Schneider Electric for conducting the necessary experimentation and trough funding of the Government of Extremadura - Counseling of Economy, Trade and Innovation and the European Regional Development Fund (ERDF).

6. References

[1] S. Timoshenko and S. Woinowsky-Krieger (1991). *Theory of Plates and Shells*, 2nd ed. McGraw Hill, New York, 122–131.

[2] O.C. Zienkiewicz and J.Z. Zhu (1987). A simple error estimator and adaptive procedure for practical engineering analysis, *Int. J. Num. Meth. Eng.*, 24, 334–357.

[1] Subramanian K, Cook NH. Sensing of drill wear and prediction of drill life. ASME Journal of Engineering Industry, 1997, 99, p. 295–301.

[2] Ertunc HM, Loparo KA. A decision fusion algorithm for tool wear condition monitoring in drilling. International Journal of Machine Tools and Manufacture, 2001a, 41(9), p. 1347-

[3] Jantunen E. A summary of methods applied to tool condition monitoring in drilling. International Journal of Machine Tools and Manufacture, 2002 42, p. 997–1010.