

MODELLING OF TOOL LIFE, TORQUE AND THRUST FORCE IN DRILLING: A NEURO-FUZZY APPROACH

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Abstract

This paper presents the application of neuro-fuzzy approach for modelling tool life, torque and thrust force in drilling operation for set of given process parameters, namely cutting speed, feed rate and drill diameter. The proposed approach uses a hybrid-learning algorithm i.e., combination of the back-propagation gradient descent method and least squares method, to identify premise and consequent parameters of the first-order Sugeno-fuzzy inference system. The least square method is used to optimize the consequent parameters with the premise parameters fixed. Once the optimal consequent parameters are found, the back-propagation algorithm gradient descent method is used to adjust optimally the premise parameters corresponding to the fuzzy set in the input domain. The predicted tool life, torque and thrust force values obtained from neuro-fuzzy system were compared with the experimental data. This comparison indicates that the proposed approach can produce optimal knowledge base of fuzzy system for predicting tool life, torque and thrust force in drilling operation.

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Key Words: Tool Life, Torque, Thrust Force, Neuro-Fuzzy Approach, Drilling

1. INTRODUCTION

Drilling is a most commonly used machining operation in the manufacturing industry. Therefore, modelling of tool life, torque and thrust force in milling process plays an important role in the manufacturing industry. Several attempts were made, in past, to model tool wear and drill force by using experimental investigation approach and design of experiment method. Choudhury [1] used a regression model to measure the flank and corner wear of a drill bit. A regression model was developed by Xiaoli [2] for monitoring the tool wear based on current signal of spindle motor and feed motor. Ertunc [3] used the hidden Markov model for monitoring drill wear using cutting force signal. Liu [4] used the polynomial network for in-process prediction of corner wear in drilling. Force signal were considered to monitor on-line drill wear [5]. In recent years, the use of adaptive learning tools to construct the machining database for associating the cutting parameters with cutting performance has gradually been accepted as a reliable, effective modelling technique. This is because adaptive learning tools have an excellent ability to learn and to interpolate the complicated relationships between cutting parameters and cutting performance. A biologically inspired network called abductive network was adopted by Lee [6] to model the drilling operation. A back-propagation neural network (BPNN) has been used by various researchers to construct a prediction model of tool wear in drilling operation. In this connection work of Lin and Ting [7], Panda et al. [8], Singh et al. [9], Panda et al. [10] are significant. Tsao [11] utilized the radial basis function network (RBFN) and adaptive based radial basis function network (ARBFN) to predict flank wear. Recently, Tsao and Hocheng [12] used Taguchi method and radial basis function network (RBFN) for prediction and

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