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Reliability estimation for cutting tools based on logistic regression model using vibration signals

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ABSTRACT

As an important part of CNC machine, the reliability of cutting tools influences the whole manufacturing effectiveness and stability of equipment. The present study proposes a novel reliability estimation approach to the cutting tools based on logistic regression model by using vibration signals. The operation condition information of the CNC machine is incorporated into reliability analysis to reflect the product time-varying characteristics. The proposed approach is superior to other degradation estimation methods in that it does not necessitate any assumption about degradation paths and probability density functions of condition parameters. The three steps of new reliability estimation approach for cutting tools are as follows. First, on-line vibration signals of cutting tools are measured during the manufacturing process. Second, wavelet packet (WP) transform is employed to decompose the original signals and correlation analysis is employed to find out the feature frequency bands which indicate tool wear. Third, correlation analysis is also used to select the salient feature parameters which are composed of feature band energy, energy entropy and time-domain features. Finally, reliability estimation is carried out based on logistic regression model. The approach has been validated on a NC lathe. Under different failure threshold, the reliability and failure time of the cutting tools are all estimated accurately. The positive results show the plausibility and effectiveness of the proposed approach, which can facilitate machine performance and reliability estimation.

1. Introduction

In modern manufacturing systems, machine tools are the major equipment and play a very important role. The malfunction of machine tools may result in the halt of the whole production and bring about tremendous financial losses. For example, in the case of complex installations such as automobile assembly lines, it can be as high as $20,000 per minute [1]. Therefore, manufacturers have been paying great attention to machine reliability improvement to reduce unexpected downtime and raise product quality [2,3].

A cutting tool is an important part of machine tools and its reliability influences the total manufacturing effectiveness and stability of machine tools. With an accurate estimate of tool lifetime, worn tools can be changed in time to reduce waste product and tools costs noticeably. It is even possible to guarantee a certain surface quality. Tool failure and lifetime is judged by its wear measurement described in several standards (ISO3685, ISO8688 and ANSI/ASME B94.55M) [4]. These

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