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High frequency vibration analysis in drilling of GFRP laminates using candlestick drills

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Abstract

The vibration signal contains a lot of information closely related to the tool performance in drilling the composite material. However, due to the limit of the frequency response characteristics of piezoelectric accelerometer, the monitored vibration signals used in researches were usually below 10 kHz. Thus, the high frequency vibration signal was ignored. Drilling experiments of Glass Fiber Reinforced Plastic (GFRP) laminates were carried out utilizing candlestick drills in this article. The high frequency vibration signals of ten candlestick drills with different drill tip geometry parameters were analyzed and compared in time domain, frequency domain and in bispectrum. The results revealed that there was high frequency vibration signal above 10 kHz in the process of drilling GFRP laminate. These signals were sensitive to the changes of the drill tip geometry parameters. The changes of the bispectrum energies of these signals could reflect the changes of the cutting performances and the delamination factors for the drills.

Keywords: Glass fiber; Laminates; Drilling; Vibration signal; Geometry

1. Introduction

In the previous experimental analysis and research of the vibration signal in drilling process, the detection of the tool state was usually achieved by studying the time and frequency domain characteristics of the low frequency vibration signal. This kind of detection was mostly based on the tool wear condition. EL-WARDANY et al presented a study on monitoring tool wear and failure in drilling using vibration signature analysis techniques, and also investigated the effect of different types of wear on the vibration power spectra in both the transverse and the thrust directions. The discriminant features for the tools were sensitive to drill wear and breakage and relatively insensitive to cutting conditions and sensor location [1]. Harun et al analyzed the vibration signals in time domains by short-time Fourier transform (STFT) to detect the tool wear mechanism. He found all failure occurred at 600 Hz when the tool became worn, blunt, and fractured. From his research, it can be found that STFT is a simple, quick, and sufficient vibration signal analysis method for tool condition monitoring [2]. Dimla provided a way of on-line metal cutting tool condition monitoring. The