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Novel adaptation of the demodulation technology for gear damage detection to variable amplitudes of mesh harmonics

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ABSTRACT

In this paper, a novel adaptive demodulation technique including a new diagnostic feature is proposed for gear diagnosis in conditions of variable amplitudes of the mesh harmonics. This vibration technique employs the time synchronous average (TSA) of vibration signals. The new adaptive diagnostic feature is defined as the ratio of the sum of the sideband components of the envelope spectrum of a mesh harmonic to the measured power of the mesh harmonic. The proposed adaptation of the technique is justified theoretically and experimentally by the high level of the positive covariance between amplitudes of the mesh harmonics and the sidebands in conditions of variable amplitudes of the mesh harmonics. It is shown that the adaptive demodulation technique preserves effectiveness of local fault detection of gears operating in conditions of variable mesh amplitudes.

1. Introduction

Local tooth damage produces short-duration impacts that add modulation effects to the meshing vibration, and in turn generate a higher level of sidebands (SB) around the mesh harmonics [1]. The vibration demodulation analysis has been widely investigated [1–14] detecting local tooth damage, such as cracks, pitting, etc. However, previous works have not considered how the technique works with the time synchronous average (TSA) [15] of vibration signals under conditions of variable amplitudes of the mesh harmonics and their surrounding sidebands [1]. The variation in mesh amplitudes deteriorates the diagnostic effectiveness of the method [8].

An original method and a new diagnostic feature were proposed [8] for conditions of variable mesh amplitudes. The method is based on the high level of positive covariance between amplitudes of the mesh harmonics and their surrounding SB: amplitudes of the SB vary in proportion to amplitudes of the mesh harmonics. This positive covariance for non-TSA raw vibrations was found [8] theoretically and experimentally for the first time.

The diagnostic feature proposed in Ref. [8] is based on the normalized sum of SB and estimated on the non-TSA *raw* vibrations. However, in order to increase the signal/noise ratio and perform effectively differential gear diagnosis, it is generally preferred to perform demodulation on the TSA signals.

Therefore, the problem is to improve the classical demodulation technique based on the TSA gear vibrations in conditions of variable mesh amplitudes. This problem is not investigated in the existing literature nor has the covariance between amplitudes of the sidebands and the mesh harmonics for the TSA gear vibrations been investigated.

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