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Gear Fault Diagnosis Based on Optimal Morlet Wavelet Filter and Autocorrelation Enhancement

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Abstract : Condition monitoring is used to increase machinery availability and machinery performance, whilst reducing consequential damage, increasing machine life, reducing spare parts inventories, and reducing breakdown maintenance. An efficient condition monitoring system provides early warning of faults by predicting them at an early stage. When a localized fault occurs in gears, the vibration signals always exhibit non-stationary behavior. The periodic impulsive feature of the vibration signal appears in the time domain and the corresponding gear mesh frequency (GMF) emerges in the frequency domain. However, one limitation of frequency-domain analysis is its inability to handle non-stationary waveform signals, which are very common when machinery faults occur. Particularly at the early stage of gear failure, the GMF contains very little energy and is often overwhelmed by noise and higher-level macro-structural vibrations. An effective signal processing method would be necessary to remove such corrupting noise and interference. In this paper, a new hybrid method based on optimal Morlet wavelet filter and autocorrelation enhancement is presented. First, to eliminate the frequency associated with interferential vibrations, the vibration signal is filtered with a band-pass filter determined by a Morlet wavelet whose parameters are selected or optimized based on maximum Kurtosis. Then, to further reduce the residual in-band noise and highlight the periodic impulsive feature, an autocorrelation enhancement algorithm is applied to the filtered signal. The test stand is equipped with three dynamometers; the input dynamometer serves as the internal combustion engine, the output dynamometers induce a load on the output joint shaft flanges. The pitting defect is manufactured on the tooth side of a gear of the fifth speed on the secondary shaft. The gearbox used for experimental measurements is of the type most commonly used in modern small to mid-sized passenger cars with transversely mounted powertrain and front wheel drive: a five-speed gearbox with final drive gear and front wheel differential. The results obtained from practical experiments prove that the proposed method is very effective for gear fault diagnosis.

Keywords : wavelet analysis, pitted gear, autocorrelation, gear fault diagnosis
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