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Diagnostics of gear faults based on EMD and automatic selection of intrinsic mode functions

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ABSTRACT

Signal processing is an important tool for diagnostics of mechanical systems. Many different techniques are available to process experimental signals, among others: FFT, wavelet transform, cepstrum, demodulation analysis, second order ciclostationarity analysis, etc. However, often hypothesis about data and computational efforts restrict the application of some techniques. In order to overcome these limitations, the empirical mode decomposition has been proposed. The outputs of this adaptive approach are the intrinsic mode functions that are treated with the Hilbert transform in order to obtain the Hilbert–Huang spectrum.

Anyhow, the selection of the intrinsic mode functions used for the calculation of Hilbert–Huang spectrum is normally done on the basis of user's experience. On the contrary, in the paper a merit index is introduced that allows the automatic selection of the intrinsic mode functions that should be used. The effectiveness of the improvement is proven by the result of the experimental tests presented and performed on a test-rig equipped with a spiral bevel gearbox, whose high contact ratio made difficult to diagnose also serious damages of the gears. This kind of gearbox is normally never employed for benchmarking diagnostics techniques. By using the merit index, the defective gearbox is always univocally identified, also considering transient operating conditions.

1. Introduction

Diagnostics is based on the characterization of mechanical system condition and allows early detection of a possible fault. Whatever the mechanical system, the evaluation of both the type and the fault position allows the reduction of the plant standstill time. Therefore, from an industrial point of view, a proper diagnostic approach reduces both the time and the costs required for repairing. These considerations have encouraged investments of resources in the diagnostic field.

Signal processing is an approach widely used in diagnostics, since it allows directly characterizing the state of the system. Several types of advanced signal processing techniques have been proposed in the last decades and added to more conventional ones. Since each technique is based on different theoretical background, also the results obtained are often different. Some techniques may be more suitable than others for a specific system or component, depending also on the environmental conditions. Therefore, it is important to choose techniques that are the most effective for the case and the situation under testing for a reliable mechanical analysis.

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