Robust and automatic diagnosis of rotating machine faults by long-term spectral analysis

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Abstract

Although it is now recognised that the most effective methods for diagnosing rotating machines are based on the analysis of the cyclo-stationary content of the vibration signal, they can nevertheless be classified into two main families. The first group includes temporal indicators combining statistical moments of the signals, possibly filtered around the orders of interest. These methods, both simple and global, are effective when the fault is prevalent in the signal. The second method consists of those which analyse the spectra (1st or 2nd CS orders) of the vibration signal more directly. These methods often allow earlier detection, but require precise knowledge of the frequency channels likely to carry the defects.

In contrast to these approaches, this paper propose to study the distribution of the frequency channels whose amplitude presents the strongest macroscopic evolution. As could be done via the analysis of a spectrum cascade, we determine the channels showing a suspicious trend in a robust way, by classifying them according to a rank statistic. For each frequency channel thus identified, we evaluate the distance that separates it from the harmonic families corresponding to the characteristic frequencies of the fault. This distance provides a variable whose distribution we study to diagnose the machine.

This new strategy is innovative from several points of view. Firstly, it combines the qualities of the two families of pre-existing methods, benefiting simultaneously from the precision of a spectral observation and the simplicity of a global method, without the need to know a priori the frequencies carrying the fault. Furthermore, this new strategy differs from others in that it is intrinsically necessary to study a measurement campaign rather than a single signal. This apparent limitation is alliviated by the increase in our storage and processing capacities, and favors the hope of combining the diagnostic (signal-oriented) and prognostic (data-oriented) approaches in the same analysis step.

The approach will be presented through an ageing campaign of aeronautical epicyclic gear trains. Although such gear faults are linked to well-known characteristic frequencies, their signature happens to be carried by a specific combination of these frequencies, whose orders are unpredictable apriori.

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