Rolling bearing diagnosis based on H_∞ filter order tracking

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Abstract

The analysis of the squared envelope spectrum (SES) is one among the most used tools for bearing diagnosis. It can easily reveals the characteristic frequencies related to the bearing fault [1,2]. Actually, the envelope is estimated through a demodulation process in a selected frequency band. The proper choice of the latter is really challenging in a complex environment [3]. In addition to that, the frequency of the bearing fault is likely to be masked by deterministic components. This can jeopardize the efficiency of classical techniques [3–5]. In this paper, a new approach for bearing diagnostic is proposed. It is based on a recently proposed order tracking technique using the H_∞ filter [6]. In details, the method starts by computing the squared envelope (SE) of the raw signal over the full demodulation band without prior processing. Next, the SE is modeled in a state space using a Fourier series expansion. Last, an H_∞ estimator is designed to extract the amplitude of each harmonic related to the bearing fault signature. This estimator is well convenient to track the order of bearing faults, particularly in the presence of deterministic components (i.e. the noise). Since this noise is neither white nor Gaussian, the traditional Kalman filter order tracking is compromised [7–9]. Contrary to the Kalman filter, the H_∞ filter is based on the minimax optimization. The minimax approach leads to the minimization of the estimation error for the worst possible amplification of the noise signal. More interestingly, no prior knowledge about the statistical properties of the noise signals is required [10,11]. The efficiency of the proposed approach is demonstrated on simulated and real-world vibration signals in nonstationary regimes.

Keywords: H_∞ filter, state space modelling, order tracking, squared envelope, bearing diagnosis, vibration signal, variable speed condition.

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