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A novel weak-fault detection technique for rolling element bearing based on vibrational resonance

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ABSTRACT

Weak fault detection, as a key step in the condition-based maintenance, is a significant but difficult issue because the fault signals are usually submerged in strong background noise. Contrary to traditional denoising and filtering methods, vibrational resonance (VR), as well as stochastic resonance (SR), is an effective way to detect weak signals by utilizing high-frequency interferences or random noise on purpose. In this paper, we investigate the application of VR to weak bearing fault detection. In order to enhance the detection performance, we construct an array of bistable systems based on VR by injecting different high-frequency sinusoidal interferences. Considering the frequency of fault signal which is usually greater than 1 Hz in practice, the frequency-shifted and rescaling transform method is adopted. Levenberg-Marquardt algorithm is utilized to optimize the system parameters, which is different from the most existing evolutionary algorithms. The proposed VR-based method is validated by simulation data, bearing data with single implanted fault and bearing data with multiple naturally-developed faults. The experimental results show that, compared with bistable SR system, this method by using an array of bistable systems based on VR is more practical to enhance the detection performance of bearing weak faults.

Keywords: vibrational resonance, weak fault detection, bearing, Levenberg-Marquardt algorithm.

1. Introduction

Bearings are the typical rotating components, they are widely used in many rotating machineries. The unexpected failure of bearings may lead to high economic loss and huge potential security

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