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PII: S0263-2241(17)30129-X
DOI: http://dx.doi.org/10.1016/j.measurement.2017.02.033
Reference: MEASUR 4618

To appear in: *Measurement*

Received Date: 27 April 2016
Revised Date: 14 February 2017
Accepted Date: 17 February 2017

Please cite this article as: C. Mishra, A.K. Samantaray, G. Chakraborty, Rolling Element Bearing Fault Diagnosis under Slow Speed Operation using Wavelet De-noising, *Measurement* (2017), doi: http://dx.doi.org/10.1016/j.measurement.2017.02.033

Rolling Element Bearing Fault Diagnosis under Slow Speed Operation using Wavelet De-noising

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Abstract: Rolling element bearing is widely used in rotating machines and any bearing defect therein can severely affect the overall machine performance. Vibration monitoring is often used to detect bearing faults. However, some rotor dynamic systems operate at very slow speed such as the slewing bearing used in dumpers, rolling mills, and cranes etc. At slow operating speed, the fault related signal features get smeared / masked due to slip, vibration of other machine parts, noise and disturbances. Thus, it becomes very difficult to identify the bearing characteristic frequencies (BCFs) from the vibration signature. In this paper, a novel diagnosis scheme based on envelope analysis and wavelet de-noising with sigmoid function based thresholding is used to extract the fault related symptoms from noisy vibration signatures of defective ball bearings operating at slow speed. The vibration signal is assumed to be composed of a deterministic part representing large scale features, a stochastic part and noise components. After sigmoid function based thresholding of the wavelet coefficients, a Bayesian estimator is used to obtain an approximation of the large scale features in the signal. The uncorrelated noise component in the signal is removed whereas the high-frequency structural ringing of the bearing induced due to impacts with the faults is retained in the large scale features. The envelope spectrum of the large scale features is used for fault diagnosis. The developed diagnosis scheme is tested using the experimental data collected from a machine fault simulator system.

Keywords: *Bearing characteristics frequency, Wavelet de-noising, sigmoid function based thresholding, Deterministic/Stochastic decomposition, Low/Slow speed operation.*

1. Introduction

Rolling element bearings are important parts of many rotating machinery. Fault in a rolling element bearing can severely affect the machine performance. Therefore, various condition monitoring tools have been developed to diagnose rolling element bearing faults. The primary parts of a rolling element bearing are few rolling elements, an inner race, an outer race and a cage. Faults in any of these parts can lead to series of impacts whenever a rolling element comes in contact with a fault. The impulses generated by these impacts excite the entire system that includes bearing housing, sensors and structure on which the bearing is mounted. These fault induced impulses repeat themself at the BCFs. The fault diagnosis schemes developed for rolling element bearings primarily seek to identify the existence of periodic impacts at the BCFs which are buried within noise [1]. Most often, vibration signatures from the bearing housing are employed for this purpose.

The rolling element bearing fault diagnosis schemes can be broadly time based, frequency based and time-frequency based. There are abundant literatures in diagnosis of rolling element faults using analysis of vibration signal [2-4], acoustics signal [5-6], motor current signal [7-8] and so on. One of the easiest approaches to detect periodic events in a signal is the Fast Fourier Transform (FFT). However, it is usually difficult to clearly

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