Mechanical Systems and Signal Processing 25 (2011) 3078–3088

Contents lists available at ScienceDirect

Mechanical Systems and Signal Processing

journal homepage: www.elsevier.com/locate/ymssp

Identification of bearing faults using time domain zero-crossings

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ARTICLE INFO

Article history:
Received 5 February 2011
Received in revised form
25 May 2011
Accepted 3 June 2011
Available online 25 June 2011

Keywords:
Bearing faults
Vibration signal
Zero-crossing

ABSTRACT

In this paper, zero-crossing characteristic features are employed for early detection and identification of single point bearing defects in rotating machinery. As a result of bearing defects, characteristic defect frequencies appear in the machine vibration signal, normally requiring spectral analysis or envelope analysis to identify the defect type. Zero-crossing features are extracted directly from the time domain vibration signal using only the duration between successive zero-crossing intervals and do not require estimation of the rotational frequency. The features are a time domain representation of the composite vibration signature in the spectral domain. Features are normalized by the length of the observation window and classification is performed using a multilayer feedforward neural network. The model was evaluated on vibration data recorded using an accelerometer mounted on an induction motor housing subjected to a number of single point defects with different severity levels.

1. Introduction

The vital tasks performed by electric machines and the financial commitment of operators require efficient monitoring and fault diagnosis schemes that are capable of early detection and identification of defects. The major electric machine faults include bearing defects, stator faults, broken rotor bar and end ring, and eccentricity-related faults [1]. These faults may lead to increased vibration and noise levels. Fault detection can be realized by monitoring machine vibrations, acoustic emissions, or motor current. Almost 50% of all motor faults are bearing related [1,2]. Bearing faults can be categorized into outer race defects, inner race defects, ball defects, and cage defects. Condition monitoring using vibration data has been successfully used for detection and identification of bearing faults [3].

The majority of machine monitoring algorithms employ complex algorithms to extract a representative set of features from the spectral domain [4] or wavelet coefficient domain [5,6] to address the composite structure of machine's vibration. Some approaches perform diagnosis using statistical parameters [7] such as the root mean square, kurtosis, crest factor, etc. In [8], the remaining useful life of the machine is predicted using the vibration signal of a partially degrading bearing. Many approaches propose combining time domain features with others extracted from the frequency domain [4] to better approximate the vibration signature for better diagnosis which explains the popularity of wavelet coefficients in detection of bearing faults. Most of the previous feature extraction techniques export the recorded vibration data to a more powerful computational unit to carry on the analysis and classification. Advances in micro-electro-mechanical systems (MEMS) and the development of low power signal processing techniques and diagnosis algorithms have enabled the development of sensor nodes that are capable of performing feature extraction and classification without exporting the recorded data to a remote node.

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doi:10.1016/j.ymssp.2011.06.001