Accepted Manuscript

Diagnosing of rolling-element bearings using amplitude level-based decomposition of machine vibration signal

Jacek Dybała

PII: S0263-2241(18)30412-3
DOI: https://doi.org/10.1016/j.measurement.2018.05.031
Reference: MEASUR 5532

To appear in: *Measurement*

Received Date: 21 May 2017
Revised Date: 21 January 2018
Accepted Date: 7 May 2018

Please cite this article as: J. Dybała, Diagnosing of rolling-element bearings using amplitude level-based decomposition of machine vibration signal, *Measurement* (2018), doi: https://doi.org/10.1016/j.measurement.2018.05.031

Diagnosing of rolling-element bearings using amplitude level-based decomposition of machine vibration signal

Jacek Dybała

Warsaw University of Technology, Institute of Vehicles, ul. Narbutta 84, 02-524 Warsaw, Poland,
E-mail address: jdybala@simr.pw.edu.pl

Abstract

In the last few decades there has been a significant development in the use of vibration measurement and analysis for monitoring the condition of rolling-element bearings. Although a lot of vibration diagnostic techniques have been developed, in many cases these methods are quite complicated to use and are time consuming. They are even impractical in real-world applications or are only effective at later stages of damage development. One of the main reasons for the ineffectiveness of many diagnostic approaches is the fact that in complex industrial environments the vibration signal of the rolling-element bearing may be covered or concealed by other vibration sources, such as gears. As a result, the development of methods for extracting an informative bearing signal from a machine vibration signal is one of the most important topics in diagnosing rolling-element bearings operating in complex industrial environments.

This paper presents the diagnostic approach enabling early detection of a rolling-element bearing fault at the low-energy stage of its development. A key element of this approach is the completely automatic method of amplitude level-based signal decomposition, which enables an extraction of an informative bearing signal from a machine vibration signal. In order to perform a bearing fault-related feature extraction from a low-energy component of a vibration signal, the spectral analysis of the empirically determined local amplitude is used.

The practicability and the effectiveness of the proposed approach have been tested on simulated and real-world vibration data. Tests of the devised approach give better results than the classical method and show that this approach is appropriate and effective at identifying bearing damages at early stages of their development.

Keywords: Condition monitoring, Rolling-element bearing diagnostics, Vibration signal, Signal decomposition, Damage detection, Damage identification

1. Introduction

Rolling-element bearings constitute one of the most important elements in rotating machines. Although modern rolling-element bearings have a relatively high reliability and durability, bearing faults are one of the major reasons for breakdown of industrial machinery. As a result, there is a need to monitor the bearing's health condition and bearing diagnosing is one of the most important topics in machine condition monitoring. The aim of diagnostic research is detecting the bearing defect early enough so that the machine operator is warned of the possible failure of the machine. Early detection of faults in rolling-element bearings can reduce unpredicted failures and production stoppages, thus providing a significant reduction in costs while keeping production efficiency at the highest possible level.

In contrast to thermal monitoring methods that detect bearing failure at the late stage of development (often on the verge of catastrophic technical condition), appropriate analysis of machine vibration makes possible detection of most bearing faults at much earlier stages of the degradation of the bearing condition. There are two major groups of diagnosing methods using vibration signals: time-domain and frequency-domain analysis methods. Classical time-domain analysis uses characteristic features of the vibration signal, such as root mean square and kurtosis. Since the appearance of a series of impulses causes an increase in the value of these features, a significant growth of feature values can indicate the occurrence of damage in the bearing, but does not define the type of the bearing fault [12, 19]. Analysis in the frequency domain allows not only detection of the bearing damage but also recognition of the type of damage. Each time a defect on one surface of a bearing element hits another surface a short-time pulse is generated.