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Faults diagnosis of rolling element bearings based on modified morphological method

Yabin Dong [a,b,*], Mingfu Liao [a], Xiaolong Zhang [b], Fazhan Wang [b]

[a] Institute of Monitoring and Control for Rotating Machinery and Windturbines, Northwestern Polytechnical University, Xi'an 710072, People's Republic of China
[b] School of mechanical & electrical engineering, Xian University of Architecture & Technology, Xi'an 710055, People's Republic of China

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ABSTRACT

In order to effectively smooth noise and extract the impulse components in the vibration signals of defective rolling element bearings, a new modified morphology analytical method has been proposed. In this method, average of the closing and opening operator has been used as the morphology operator. Being the flat and zero adopted as the shape and the height of structure element (SE), respectively, the optimized length of SE is defined by a new proposed criterion (called *SNR* criterion). The effect of the new method is validated by both simulated impulsive signal and vibration signal of three defective rolling bearings with an outer, an inner and a rolling element faults and compared with Nikolaou's method. The result shows that the proposed method has the superior performance in extracting impulsive characteristics of vibration signals, especially for the high level noise signals, and can implement better in diagnosis of defective rolling element bearing.

1. Introduction

Rolling element bearings are one of the most important and common components in rotary machines, and their failures can cause both personal damage and economic loss, if the fault cannot be detected and diagnosed well in advance. Therefore they have received much attention in the field of vibration analysis as they represent an area where much can be gained from the early detection of faults. According to the statistics, about 90% of the faults occur in the surface of the inner race, outer race or rolling elements of the rolling element bearing, in particular most of them are local faults [1]. When a fault exists in one surface of a bearing, the vibration signal is characterized by the presence of periodic repetitive sharp peaks and further modulated by a number of harmonic frequencies. However, the interesting information is often contained in the periodicity of the impacts, rather than in the rest of the signal frequency content. So an effective signal processing method is desired to provide more evident information for fault diagnosis of rolling element bearings.

For the diagnosis of the rolling element bearing, many methods have been employed to extract this periodicity from the response signals. Envelope, wavelet transforms and cyclostationary analysis are the most applied ones [2–7]. In recent years, a new method, called morphological signal processing, has been studied widely. However, literature [8–10] review reveals that the research in one-dimensional (1-D) signals, especially in machine fault diagnosis, is limited. Nikolaou and Antoniadis [8] used a flat structure element (SE) with the length around 0.6 times the pulse repetition period to demodulate the fault signals. The result showed this method was more efficient for low noise signals than for high noise signals. Wang [9] proposed an improved morphological filter to extract the entire impulsive signals including fault frequency, natural frequency, and

* Corresponding author. Tel./fax: +86 29 82202538.
E-mail address: dyb_002@163.com (Y. Dong).

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