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Detecting dominant resonant modes of rolling bearing faults using the niching genetic algorithm

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ABSTRACT

In this paper we propose an improvement of methods for adaptive selection of frequency bands containing transients which indicate the presence of the dominant resonant modes of rolling bearing faults using niching genetic algorithm optimization. The main aim of this approach is to diagnose the condition of the bearings and to be able to recognize faults on various parts of bearings and possible combinations of faults. Because the vibration signals corresponding to faults on bearings are typically transients with a wide frequency range occurring around the excited mechanical resonant modes and drowned in the acquired vibration signals, it is necessary to emphasize these excited transients using a matched bank of filters. The dominant resonant modes of a bearing and the system modes produced from fault source are usually unknown, and so there is a need for robust global search methods able to deal with non-linear problems with multiple optima. Instead of applying an optimization method repeatedly for every optimum, non-dominated extensions of the genetic algorithm can be applied only one time to find and maintain multiple optimal solutions. The efficiency of the proposed approach – niching genetic algorithm with fitness sharing – was evaluated using vibration signals acquired on four tapered roller bearings with defined combinations of seeded faults.

1. Introduction

Vibration analysis is an important method used for monitoring the conditions of rotating machines. The main task is to recognize possible faults on components exposed to load, and thus to prevent damage to the machine and the related costs. Rolling bearings are components that have a high probability of causing mechanical breakdowns, and their condition is therefore often analyzed when a relevant vibration signal is acquired. Depending on the actual bearing operation conditions and the severity of the defects, the vibrations emitted by bearing faults are usually non-stationary (transient), spread over a large frequency range, and drowned in the acquired vibration signal [1]. Vibration signals corresponding to faults on a particular part of the bearing are characterized by typical repetitive shock frequencies that are modulated by excited resonant modes of the bearing and system modes produced from the fault source.

Many techniques are available for diagnosing the condition of bearings. Widely used techniques are envelope or cepstrum analysis [2,3]. A problem in recognizing a possible bearing fault or a combination of faults using these techniques is that the resonant modes excited by the bearing may not be known. In practice, when these techniques are used, the

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