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Extraction of rules for faulty bearing classification by a Neuro-Fuzzy approach

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ABSTRACT

In this paper, a classification system of faulty bearings based on a Neuro-Fuzzy approach is presented. The vibration signals in the frequency domain produced by the faulty bearings will be taken as the inputs to the classification system. In this sense, it is an essential characteristic for the used Neuro-Fuzzy approach, the possibility of taking a great number of inputs. The system consists of several Neuro-Fuzzy systems for determining different bearing status, along with a measurement equipment of the vibration spectral data. In this paper, a special attention is focused on the analysis of the rules obtained by the final Neuro-Fuzzy system. In fact, a rule extraction process and an interpretation rule process is discussed. Several trials have been carried out, taking into account the vibration spectral data collected by the measurement equipment, where satisfactory results have been achieved.

1. Introduction

The detection of incipient faults is an essential task in order to avoid catastrophic failures. In order to detect these incipient faults different techniques based on vibration measurements, acoustic measurements, temperature measurements and wear debris analysis have been devised. Vibration measurements are one of the most widely used, and many studies [1–5] have been carried out. As it is well known, the bearings are a vibration source. Although they were geometrically perfect, the presence of radial or axial load generates a vibration response. However, when the bearings are defective this vibration is increased.

In fact, this vibration signal could be considered as an amplitude-modulated signal. The impact caused by the bearing defects produce a low-frequency modulating signal. Furthermore, the combination of the resonant frequencies of the bearing and the resonant frequencies of the mechanical system produce a carrier signal. It is important to point out that it could be determined a relationship between the different kinds of bearing defects and the frequency response in the low-frequency demodulated signal. In fact, certain frequencies could be associated to each kind of bearing defect. These frequencies depend on several geometrical parameters linked to the particular bearing and the shaft speed. Different types of defects can be found in bearings. Among them, the localized defects have presented great interest in the researcher community. The dominant mode of failure is spalling of the race way, caused when a fatigue crack appears below the surface until a piece of metal breaks away to leave a small pit or spall. Some researchers study the vibration response before and after a fatigue failure appears. The drawback of this approach is that it is quite time-consuming. Other

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