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Vibration signal analysis using wavelet transform for isolation and identification of electrical faults in induction machine

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Abstract

Condition monitoring is used for increasing machinery availability and machinery performance, reducing consequential damage, increasing machine life, reducing spare parts inventories, and reducing breakdown maintenance. An efficient condition monitoring scheme is capable of providing warning and predicting the faults at early stages. The monitoring system obtains information about the machine in the form of primary data and through the use of modern signal processing techniques; it is possible to give vital information to equipment operator before it catastrophically fails. The suitability of a signal processing technique to be used depends upon the nature of the signal and the required accuracy of the obtained information. Therefore, in this paper, signals obtained from monitoring system have been processed using wavelet transform (WT) with suitably modified algorithms to extract detailed information for induction machine fault diagnosis. The results of this investigation depict that the application of WT for processing and analysis of the vibration signal to different frequency regions in time domain improves the extraction of the information that can enhance the ability of the system for diagnosis.

Keywords: Induction machine; Fault; Condition monitoring; Diagnostic; Vibration; Signal processing; Wavelet transform

1. Introduction

Predictive maintenance by vibration monitoring of electrical machine is a scientific approach that becomes the new route to the maintenance management [1–4]. Electrical machines, even new ones, generate some level of vibration [5–12]. Small levels of ambient vibrations are acceptable. However, higher levels and increasing trends are symptoms of abnormal machine performance. Machine vibration analysis becomes one of the important tools for machine faults identification. There are two types of analysis: time domain and the frequency domain. The frequency domain analysis is more attractive one because it can give more detailed information about the status of the machine whereas; the time domain analysis can give qualitative information about the machine condition. Generally, the machine vibration signal is composed of three parts: stationary vibration, random vibration, and noise. Traditionally, Fourier transform (FT) was used to perform such analysis. If the level of random vibrations and noise are high, inaccurate information about the machine condition is obtained. Noise and random vibrations may be suppressed from the vibration signal using signal processing techniques such as filtering, averaging, correlation, convolution, etc. Sometimes random vibrations are also important because they are related to some types of machine faults hence, there is a need to observe these vibrations also.

Martin [13] has demonstrated the limitation of using FT approach for bearing damage monitoring. The traditional treatment of vibration spectrum fluctuations is the averaging, which may tend to hide some features of short duration. The alternative approach to such non-stationary vibration signal is the wavelet transform (WT), which can provide the useful information about any signal in time domain with different bands of frequencies. WT gives variable time resolution for

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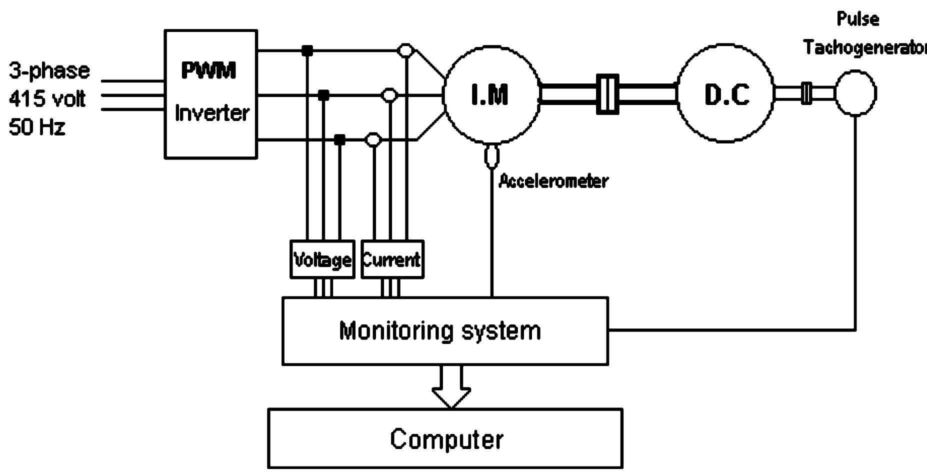

Fig. 1. Schematic diagram of the monitoring system.

different frequency bands rather than short term FT (STFT), which gives constant resolutions. This paper, therefore, presents the application of WT for processing and analysis of vibration signals that can be used for induction machine fault diagnosis. Different experiments have been performed for different types of faults at different operating conditions. The on-line analysis of the acquired signals has been performed using C++, while MATLAB has been used to perform the off-line analysis.

2. Experimental set up

For the purpose of vibration data collection, a fast, high accuracy, computerized on-line monitoring system has been indigenously developed as shown in Fig. 1. All the tests have been carried out on a test set-up. This laboratory setup consists of a 3.7 kW, four pole, three-phase cage induction machine, mechanically coupled with a 5 kW DC generator for loading. The setup was developed to measure the frame vibrations (accelera-

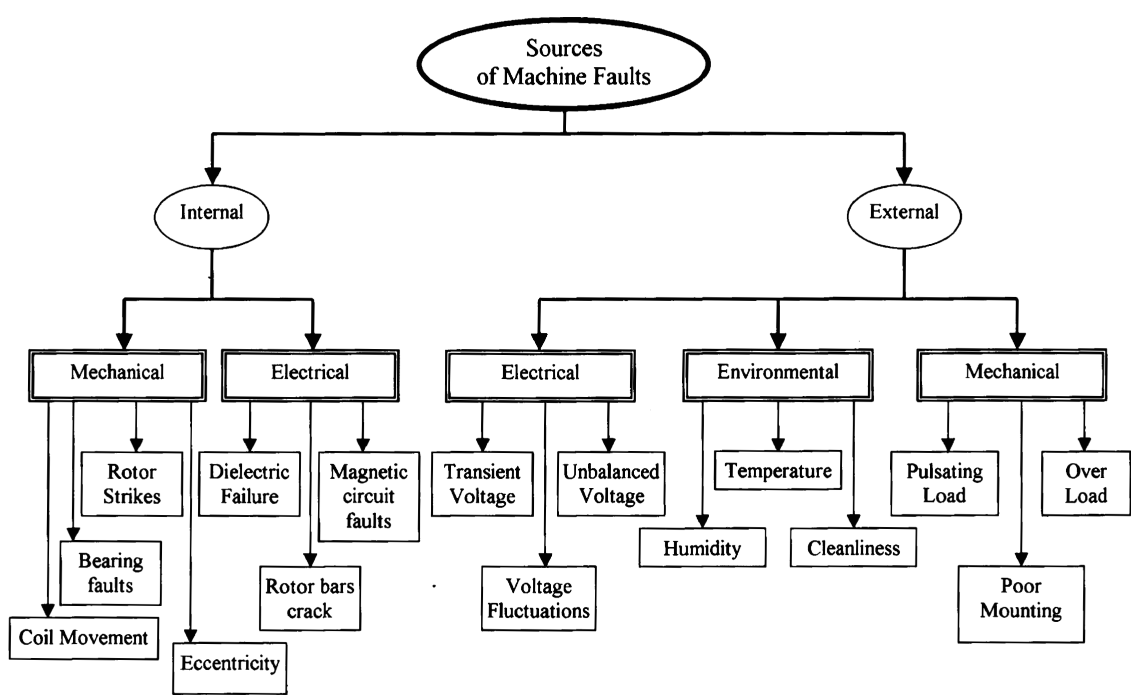

Fig. 2. Sources of induction machine faults.