Fault Prediction in Ball Bearing by Using analytical wavelet transform (AWT)

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***Abstract*— The real-time condition monitoring is an advanced technique that predicts the real conditions of operation of the machinery. A predictive maintenance program includes various rotating machinery condition monitoring techniques of the machine to determine the conditions of failure. Over the past few years there has been a major technological developments related to digital system, including innovations in both hardware and software. In the present work, an experiment is carried out with a customized test setup where the seeded defects are introduced in the inner race and outer race of a radial ball bearing. The relationship between the acquired vibration data and their relation with the seeded defect is found in this paper. When experiment is performed on the test setup designed for Fault prediction, Analytical Wavelet Transform proved an effective tool for the analysis of vibration signal. In this work, AWT followed by the Power Spectral Density is implemented on vibration signals of a defective radial bearing.**

Keywords*— Analytical wavelet transform; Fault Prediction; Power spectrum; Advance Digital Signal Processing

I. INTRODUCTION

Predictive maintenance using vibration monitoring of rotating machine is a scientific approach to the maintenance management. Any kind of Rotating machine, even new machine generate some level of vibration. Small levels of vibrations are acceptable. However, higher levels and increasing trends are symptoms of abnormal machine performance. There are many different condition monitoring methods do exists for different type of rotating machine.[1-8]. Machine vibration analysis is one of the important tools for rolling bearing faults identification. In many cases the vibration analysis is used to detect the presence of even minute fault in the ball of bearing, but due to the high spin rate of ball in bearing it becomes difficult to study the vibration signals generated by the ball [9].

For vibration analysis a variety of sensors could be used to collect measurements from a rotating machine for the purpose of condition monitoring and fault monitoring. A real time vibration measurement and analysis instrument could monitor a variety of failures.

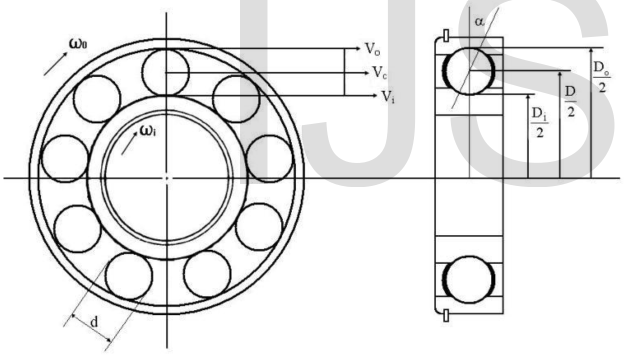
For the purpose of detecting such fault-related signals, many diagnostic methods have been developed so far. These methods to identify faults in rotating machines, may involve several different types of fields of science and technology [10- 11].

The goal of this paper is to present new design tools and new fault prediction technique using Analytical Wavelet Transformation and Power spectral Density for detection of fault in the rolling bearing element of induction motor

II. ROLLING BEARING FAULT

The major common faults of rolling bearings include corrosion in inner race, outer race and rolling elements, fatigue pitting and cage damage. In many cases indentation is also observed in inner and outer race due to high friction and lack of lubrication. Any faults of inner race, outer race and rolling elements will cause modulation phenomenon. When machine is in working condition and any fault is present in the rolling bearing it will generate a mechanical impulse and of higher amplitude as compared with the healthy bearing.

For a particular bearing geometry, inner race, outer race and rolling element faults generate vibration spectra with unique frequency components. These frequencies, known as the defect frequencies, are functions of the running speed of the motor and the pitch diameter to ball diameter ratio of the bearing. Outer and inner race frequencies are also linear functions on the number of balls in the bearing. Given the geometry of the bearing in Fig. 1, for an angular contact ball bearing in which the inner race rotates and the outer race is stationary.



III. FAULT IDENTIFICATION APPROACH

Real time vibration measurement and analysis instrument is one important tool for rolling bearing faults identification. There are two types of analysis: time domain and frequency domain. The frequency domain analysis is more attractive because it can give more detailed information about the status of the machine. Time domain analysis can give qualitative information about the machine condition. Generally a machine vibration is a stationary signal composed of random vibration and noise. But whenever we get any data for the vibration analysis one information is always lost , for instance let us understand this by taking an example, if we acquire the data of amplitude and time , the information about frequency is lost and if we take data of frequency and time then the information of amplitude is lost . So in order to overcome this problem Analytical Wavelet analysis is used which is derived from Wavelet Analysis. Traditionally, fast Fourier transform (FFT) is used to perform such analysis. If the level of random vibrations and the 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 applications such FIR filters, averaging, correlation and convolution [14].

In this case study, a diagnostic system for identification of bearing failures was developed. In the first stage the virtual instrument system was developed in MATLAB software. In the second stage Programming is done for the AWT and then power spectral density on the raw vibration signal.

IV. EXPERIMENTAL SETUP

The test setup consists of a fixed 1440 rpm electric induction motor (220 V A.C.1/4 Horse power, 50Hz) attached with Bearing test rig and Accelerometer (ADXL335) on the bearing housing. Laptop connectivity with accelerometer is established via ARDUINO Uno Microprocessor. Data is collected at the sample rate of 1600Hz and 1800 sample data for each bearing is collected and analyzed in MATLAB.

V. RESULTS

After performing the various test on the different specimen of seeded faults of rolling ball bearing (SKF 6004) the following results are obtained. The first figure will illustrate the raw vibration data acquired by the accelerometer and then final power spectral density figures are shown for healthy and the faulty bearing having various kinds of faults.

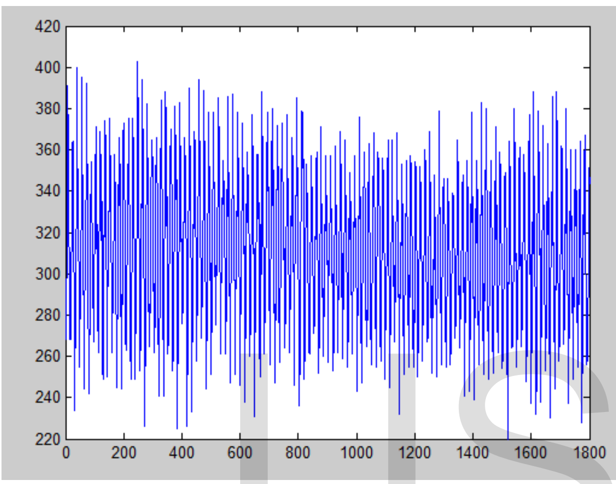


Fig 1: Raw Vibration signal

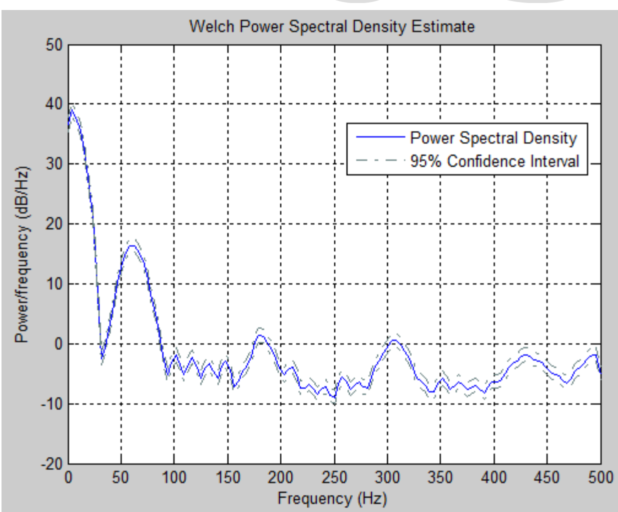


Fig 2.a : PSD of Healthy Bearing

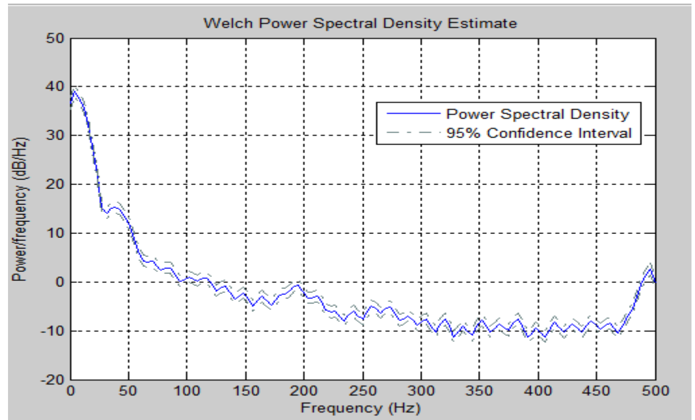


Fig 2.b : PSD of Rusty inner race

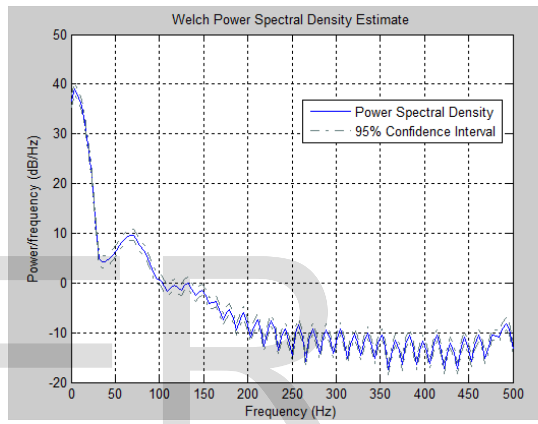


Fig 2.c : PSD of Indentation in inner Race

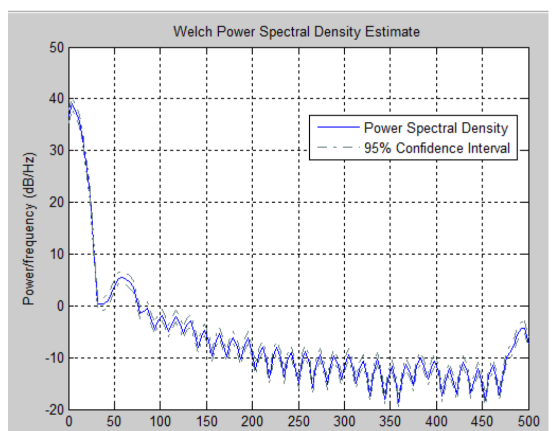


Fig 2.d : PSD of Indentation in outer Race

VI. CONCLUSION

As seen in the above experimental results we can clearly classify the Faulty bearing vibration data as compared with the healthy bearing. AWT and power spectral density (PSD) proved to be an effective tool for brief classification of fault and after studying the psd results one can also classify the category of fault and can predict the mean time before failure of the bearing , but these are out of scope of the paper .

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