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FAULT DIAGNOSIS OF BEARING FOR WEAR AT INNER RACE USING ACOUSTIC SIGNAL

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ABSTRACT

Bearing are the most important component in rotating machine, so their carrying capacity and reliability affect overall machine performance and productivity. This paper presents the Acoustic signal based technique for fault detection of bearing and severity of defect. So to avoid this, bearing must be healthy through out the machining process. To achieve this task bearing must be checked properly and fault must be detected before failure occurs. Several fault detection techniques are available by using vibration and acoustic signal. Signal processing of the acoustic signal is done by using FFT. The proper methodology is selected for this experimental work. The analyses are done on bearing at different conditions. The bearing with balls is attached to the motor shaft. A mike is used to record the acoustic signals generated by the bearing assembly. The acoustic signals generated by the bearings are recorded by placing the mike in front of the rotating bearing. In this way we are analyzing the effect of wear on the spectrum of acoustic signals and developed a method to identify such defects.

KEYWORDS: FFT, ACOUSTICS SIGNAL, FREQUENCY

1. INTRODUCTION

Nowadays, manufacturing companies are making great efforts to reduce costs and improve quality in order to maintain their competitiveness in the global marketplace. It is recognized that significant cost savings and profitability can be achieved by higher equipment availability, reliability, and maintainability. In order to accomplish this goal, it is necessary to implement an effective machinery maintenance program. The most important and expensive task in terms of labor time and cost in machinery maintenance is fault detection and diagnostics. Without accurate identification of machine faults, maintenance and production scheduling can not be effectively planned; the necessary repair work cannot be optimally scheduled. In addition, accurate fault detection and diagnosis is essential for reducing troubleshooting and repair time. As a result of correct and fast fault diagnosis, machine availability may be improved significantly. Bearings are essential components of most rotating machinery. The majority of the problems in rotating machines are caused by faulty bearings. Vibration and acoustic analysis is widely used in machinery diagnostics. There are many analytical techniques, which have been fully developed and established over the years for processing vibration and acoustic signals to obtain diagnostics information about processing bearing faults. Time and frequency are two basic constraints for extracting the information. The fault detection procedure for time or frequency methods is usually based on visual observation of the contour plots. The propagation of fault can be monitored by observing changes in the features of the distribution in the contour plots. Using vibration analysis on rotating machinery enables the early detection of faults before breakdown. This will reduce economical losses to production and equipment, saving industry millions of dollars in machine down time. The evaluations of the changes in vibration response, critical speeds and stability of a machine have become an important part of most maintenance predictive programs. This will enable the condition monitoring and diagnostic of a machine; therefore repairs can be planned and performed economically. Acoustic signal analysis has been extensively used in the fault detection and condition monitoring of rotating machinery. Many schemes predictive maintenance and machinery diagnostic systems use the condition machine to identify and classify faults through the analysis of vibration signals.

2. FAULT DIAGNOSIS OBJECTIVES

In our work we shall develop a technique to diagnose the faults in rotating components (such as bearings) of machine. An experimental setup is being developed to acquire the acoustic signal of rotating components. Different types of faults will be introduced in rotating components. Acoustic signal corresponding to the fault will be recorded. These signals will be processed using digital signal processing techniques in Matlab environment. Depending on the characteristics of the raw acoustic signal obtained from experiment, conventional filters based on Fourier Transform, Continuous Wavelet Transform (CWT) and other techniques will be used to extract the useful information. By using these functions original acoustic signal can be expanded in terms of ortho-normal basis function of sine and cosine waves of infinite duration; however the Continuous Wavelet Transform can do it for finite duration as well. One of the great advantages of using wavelet transform is that the time information is not lost. The problem undertaken has practical importance in operation, on-line inspection, failure prediction and maintenance of rotating components.

3. ACOUSTIC SIGNAL

Acoustics is the interdisciplinary science that deals with the study of sound, ultrasound and infrasound (all mechanical waves in gases, liquids, and solids). The science of acoustics spreads across so many faces of our society - music, medicine, architecture, industrial production, warfare and more. Art, craft, science and technology have provoked one another to advance the whole, as in many other fields of knowledge. Acousticians had extended their studies to frequencies above and below the audible range, it became conventional to identify these frequency ranges as "ultrasonic" and "infrasonic" respectively, while letting the word "acoustic" refer to the entire frequency range without limit.

3.1 FAST FOURIER TRANSFORM

The FFT is essence, decomposes or separates a waveform on function into sinusoids of different frequency which sum to the original waveform. It identifies or distinguishes the different frequency sinusoids and their respective amplitudes. The Fourier transform F(s) of function f(x) is expressed as

$$F(s) = \int f(x) \exp(-i\, 2\pi xs)\, d_o. \qquad (1)$$

Applying the same transform to F(s) gives

$$f(w) = \int f(s) \exp(-i\, 2\pi ws)\, d_s \qquad (2)$$

If F(x) is an even function of x, that is f(x) = f(-x), then F(w) = f(x). If f(x) is an odd function of x, that is f(x) = -f (-x), then F (w) = F (-x). When F(x) is neither even nor odd, it can often be split into even and odd parts. It is often useful to think of functions and their transforms are occupying two domains which are called as upper and lower domains.

4. METHODOLOGY

4.1 Design the system for acquisition of acoustic signal. A system has to be developed to record the audio signal in the frequency range of 20Hz to 20KHz. MIKE will act as sensor and will be interfaced with the computer. The acoustic signal will be recorded and stored in the computer for the different conditions.

4.2. **Processing of acquired acoustic signal.** The acoustic signal will be processed in MATLAB environment in order to improve the signal–to-noise ratio. Information of the fault in bearing i.e. having no defect, misalignment, looseness, missing ball, missing ball & looseness, misalignment &looseness and combined all these effects of the faults stated before will be extracted from the signal by plotting the scalogram of the signal.

4.3 Analysis of processed signal . The processed signal will be analyzed for fault detection in rotating components. A correlation of defects in terms of energy or operational frequency of rotating components can be our outcome

5. EXPERIMENTAL SET UP

In our project we are dealing with different conditions that are without fault, with fault on the bearing of the shaft assembly. Then also the arrangement is tested at varying speed conditions. The bearing which is mounted over the motor shaft is our main area of concern because from here we have to record our signal. A 200 watt motor drives the bearing arrangement. Speed of the motor can be adjusted by a regulator. A mike is used to record the acoustic signal generated by the bearing assembly. A signal of 1 second duration was recorded by using the mike. After this, this signal is processed through MatLab. By using the MatLab FFT is drawn for different conditios. The complete experimental setup for fault detection is shown in figure 5.1.

Fig 5.1 Experimental Setup

6.0 RESULT

After recording the signal in computer a low pass equiripple FIR filter is applied up to frequency of 500Hz. The following result has been taken by the experiments. These results are totally processed through the Matlab environment. These are mainly the graphs and scalogram of raw signals and processed signals respectively. The Fast Fourier Transform (FFT) for the experimental arrangement is shown in figure 3.4 below .In FFT spectrum the energy vs. frequency domain is drawn. In this energy means how many times the particular frequency is represented in the signal

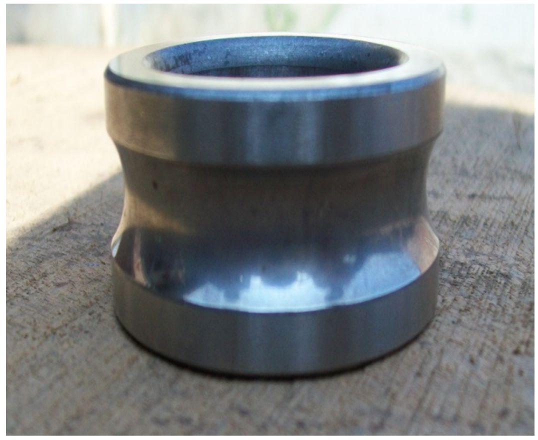

Fig 6.1(a): Bearing with no wear at inner race

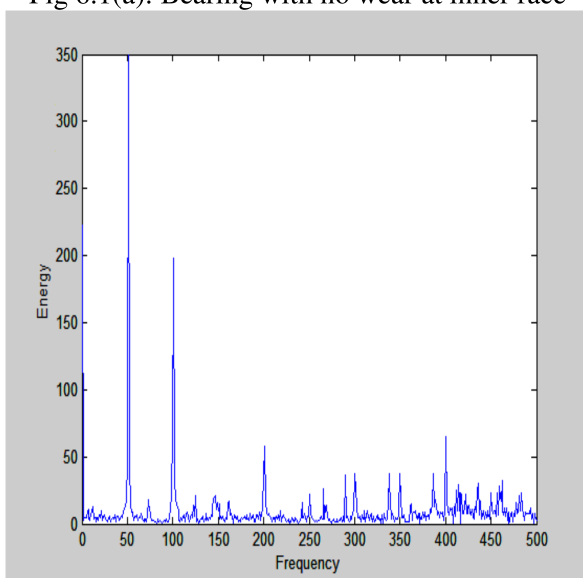

Fig 6.1(b): Bearing with no wear with corresponding FFT Spectrum

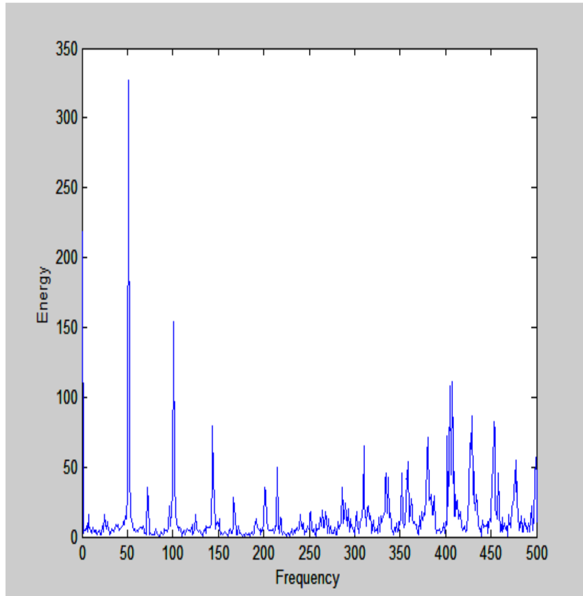

Fig 6.2: Bearing with small wear at inner race with corresponding FFT Spectrum.

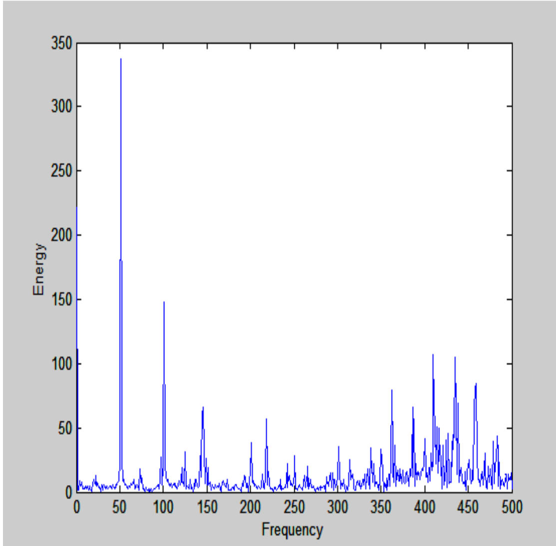

Fig 6.3: Bearing with wear big wear at inner race with corresponding FFT Spectrum.

As the speed over which frequency peaks is obtained is 1440 r.p.m. which can be converted in frequency as:1440/60 = 24 r.p.s
And it defines the frequency as:
24*8 = 192 Hz (as number of balls are 8) So now we can observe that wear increases the wave shows more disturbance (more up and down) this is because of increase in energy at each individual ball of the bearing because of the wear. So we can say after observing these graphs obtained from the DSO that as the wear increases on the shaft the peaks for the voltage are staggering in the time plot and there is also a significant rise in the frequency obtained in each vibration signal.

7.0 CONCLUSION

I. It is demonstrated that, although the environment influences acoustic signal for condition monitoring, it does not significantly reduce the extraction of useful diagnostic information. It has been demonstrated that acoustic condition monitoring can effectively be used for fault detection in bearing operation.
II. It is clear that the wavelet representation of the acoustic signals reveals the faults in bearing more precisely.

In vibration monitoring using acoustic signal have certain advantages over the conventional vibration measuring techniques. Firstly in this sensors do not alter the behavior of the machine due to its non contact nature. And time based

III. Information is not lost in wavelet based method of diagnosis.
IV. The method developed in the project can be used for the condition monitoring and for predictive maintenance of the many components.

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