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Condition Monitoring and Fault Diagnosis of Rolling Element Bearing

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Abstract: Rolling element bearings (REB) find widespread domestic and industrial applications. Proper function of these appliances depends on the smooth and quiet running of the bearings. In industrial applications these bearings are considered as critical mechanical components and a defect in such a bearing, unless detected in time, causes malfunction and may even lead to catastrophic failure of the machinery.[1] Defects in bearings may arise during the manufacturing process as well as over using and weathering of the bearings. Therefore detection of these defects is important for condition monitoring as well as quality inspection of bearings. Different methods are used for detection and diagnosis of bearing defects; they are classified as vibration and acoustic measurements, temperature measurements and wear debris analysis. The purpose of this study is to monitor the condition and diagnosis of fault that may occur in rolling element bearing.[1]

Keyword: REB, bearings, mechanical components, bearing defects.

I. INTRODUCTION

A bearing is a machine element that allows one part to support another and the main function of a bearing is to reduce the friction between the two or more machine components. The rolling element bearing is a bearing which carries a load by placing rolling elements like balls or rollers between two bearing rings called races. Rolling element bearings are the most crucial part in any of the appliances weather it may be any small domestic appliance like mixer grinder or washing machine or any heavy industrial machine. Proper function of these appliances and machineries depend on smooth and proper functioning of these bearings. Defects may cause a huge loss in industries and may get dangerous for mankind too. Therefore detection of these defects should be done before the failure occur using condition monitoring as well as quality inspection of bearings. One such method of detecting this fault in the bearings is through sensing the vibration signals generated by them. This arrangement would contain a shaft connected with the rolling bearing, a vibration sensor, a controller and software to display the results. The movement of the bearing will make the shaft rotate which will generate vibration signals. The vibration sensor will sense the vibration signals and convert them into analog form. Now this analog signal will be fed to the controller which will perform various controlling actions and convert this analog signal into digital signal. The software called LABVIEW will receive this digital signal and do the comparisons between the normal vibration signal and the faulty vibration signal and the results will be displayed accordingly.

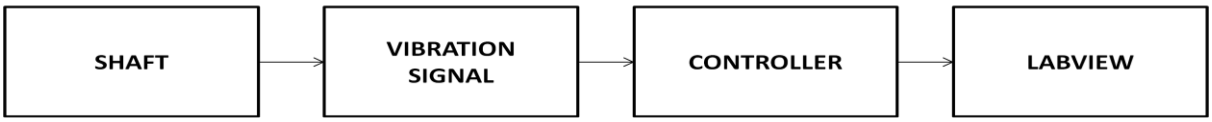

Fig.1 Steps in Condition Monitoring and Fault Diagnosis of Rolling Element Bearing

II. LITERATURE SURVEY

The literature survey describes various methods for condition monitoring and fault diagnosis of rolling element. A brief description of analyzing the bearing defect proposed by different authors is given below:

A. Choudhury and D. Paliwal (2016) have proposed that frequency B-spline (fbsp) wavelets have been applied in the work for detection of localized defects in the inner race of a rolling element bearing. The theoretical response from the bearing system due to an inner race defect coupled with additive noise of varying magnitude form the simulated signal. Methodology of defect detection includes three steps. Firstly, wavelet transformation of noisy vibration signal has been obtained using fbsp wavelets with appropriate parameters. Then, maximum wavelet coefficients were retained from the result of transformation on which a threshold level was applied. Finally fast Fourier transformation was applied on

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these retained coefficients to identify the presence of components at characteristic frequency corresponding to the defect location. The results show that the method could specifically identify bearing defects even from noisy vibration signals.

Cedric Peeters et al. (2017) have proposed that the detection and diagnosis of incipient rolling element bearing faults is not an undemanding task and signal analysis of vibration measurements therefore often incorporates the use of various complex processing techniques. One of the key steps in the processing procedure in the proper separation of the bearing signal from other influencing sources like shafts or gears. The cepstrum essentially groups the deterministic multi-harmonic signal content in a cepstral peak at the corresponding frequency for easy removal of the discrete frequency peaks.

Farzad Hemmati et al. (2016) , in this paper they have given the effect of defect size, operating speed and loading conditions on statistical parameters of acoustic emission (AE) signals, using design of experiment method (DOE) , have been investigated to select the most sensitive parameters for diagnosing incipient faults and defect growth on rolling element bearings. A modified and effective signal processing algorithm is designed to diagnose localized defects on rolling element bearings components under different operating speeds, loadings and defect sizes. The proposed method is well suited for detecting the weak signal from a detective bearing signal where defect features are impulse like.

Kumar H.S et al. (2013) in their paper, vibration signals for 3 conditions of a deep groove ball bearing normal (N), defect on inner race (IR) and defect on outer race (OR) were acquired from a customized bearing test rig under one load and two speed conditions. Discrete wavelet transform (DWT) has been used for vibration signal analysis. Also various other wavelet functions were used to analyze the vibration signals and their performance has been evaluated.

M. S. Safizadeh and S. K. Latifi (2014). This paper presents a method for bearing fault diagnosis using the fusion of two primary sensors: an accelerometer and a load cell. A novel condition-base monitoring (CBM) system consisting of six modules: sensing, vibrations, signal processing, feature extraction, classification, high level fusion and decision making module has been proposed. Multiple different sensors mounted on bearings provide information that would not be available from the single sensors. The fusion of data from different sensors enhances fault detection and diagnosis by supplying complementary information.

Pankaj Gupta and M.K Pradhan (2016), in their article an attempt has been made to summarize the recent trends in search on vibration analysis of defects in rolling element bearing and techniques for fault detection in time, frequency and time-frequency domain. The high-frequency resonance technique is widely used technique in the frequency domain but has a limitation that when the damage is advanced, the defect frequency may be submerged in the rising background level of the spectrum. The time frequency domain approach is an effective signal processing technique for both stationary and non-stationary vibration signals. The wavelet transform is widely used technique in the time-frequency domain because it is capable of extracting weak signals.

S. Khanam et al. (2014) presented their work on the decomposition of the vibration signal by using discrete wavelet transform assisted by sym5 wavelet. Sym5 wavelet has a linear phase nature which maintains sharpness in the signal even when there is sudden change in the signal. The decomposed signal splits peak corresponding to the ball entry into and exit from the fault, enabling in an estimation of the defect size present in the bearing. The output of the proposed technique finds close correlation with the actual defect size measured from optical microscope with the maximum deviation in the result of 2.06%.

V. N. Patel et al. (2014), the vibrations generated by a deep groove ball bearing having multiple defects on races have been studied in this paper. The vibrations are analyzed in both time and frequency domains. The vibrations are analyzed in both time and frequency domains. The equations for time delay between two or more successive frequencies for impulse train and combination of two impulse trains have been established. Frequency spectra for single and two defects on either race of deep groove ball bearings are compared.

Zhipeng Feng et al. (2017), on their work emphasized on how to effectively extract the time varying fault frequency from non stationary vibration signals which is a key issue in rolling baring fault diagnosis. The concentration of frequency and time (ConceFT) method is used here to do the time frequency analysis. Based on this time frequency analysis method and considering the modulation feature of rolling bearing vibrations, the joint time varying amplitude and frequency demodulated spectra is proposed to reveal the time varying fault characteristic frequency. They are implemented via spectral Kurtosis and ConceFT methods.

III. CONCLUSION

Rolling element bearings play a very significant role in machineries as their function is to support another moving and rotating mechanical elements as well as to reduce friction between them. Defects in these bearings may cause a huge loss in industries, machineries and for humans too. Using the method of fault analysis and condition monitoring faults can be detected and repaired on time to prevent losses.

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