Available online at
www.ijacskros.com

Indian Journal of Advances in Chemical Science

Indian Journal of Advances in Chemical Science S1 (2016) 142-145

LabView based Bearing Failure Prediction Using Data Acquisition System

Vinayak V. Kulkarni[1]*, M. M. Nadakatti[1], A. A. Deshpande[2]

[1]Department of Mechanical, KLS Gogte Institute of Technology, Belgaum - 590 008, Karnataka, India.
[2]Department of Mechanical, KLS Gogte Institute of Technology, Belgaum - 590 008, Karnataka, India.

Received 28th March 2016; Revised 6th May 2016; Accepted 10th May 2016

ABSTRACT
Machines are required to manufacture simple fans to complex ships, for a variety of functions. One of the elementary challenges presently faced in today's industries is the identification of machine faults before a critical/catastrophic level is reached. The machines should work to their fullest capacity for the intended period of usage in optimum condition complying with all the recommended parameters. This would mean reduction in unforeseen downtime, cost, and productivity and elimination of catastrophic failure altogether. To achieve these objectives an optimum maintenance plan has to be devised based on the type of industry machines used, funds available, quality of finished products, etc. Bearings are most the essential components of any machine, which exhibit number of parameters such as speed, temperature, vibration, noise, wear, and tear. Any machining problem identified well in advance by the variation in these bearing parameters over a period. A minor investment toward predictive and preventive maintenance monitoring system can avert premature failures, machine degradation, unforeseen stoppages, and production loss. This would result in increased profits, safety, proper working of the machine for the intended duration of its life. This paper proposes an algorithm to predict bearing degradation using LabVIEW.

Key words: *LabVIEW, MATLAB, Data acquisition system, Vibration signature analysis.*

1. INTRODUCTION

The average life span of bearing is in minutes, but may vary significantly depending on the usage and hence is not enough to count working minutes. One of the crudest methods is to run the bearing until failure, and then struggle to repair to make them fit for further service. This method of procedure can be very expensive in terms of machine destruction and production loss and in addition can cause hazards to personnel.

Condition monitoring (CM) is a method used for determining the working state and fitness of a machine for the purpose of detecting possible failures before they turn into functional failures. The CM process consists of uninterrupted data collection, interpretation, and diagnosis and data analysis. CM is a part of predictive maintenance which is a widely used in maintenance philosophy also known as condition-based maintenance.

In CM of rotating machinery, one of the most popular tools used is vibration analysis. By measuring the vibration in rotating machinery, it is possible to identify usual faults such as misalignment, looseness, unbalance, bent shaft, cracked shaft, motor faults, and other defects.

Although these faults are common, they take place basically in high-speed machinery (>650 rpm). There is limited information on faults which occur exclusively in low-speed machinery, other than those initiated by rolling element bearing defects. Several research works have been published on the diagnosis of rolling element bearing defects. The applications areas of CM are roller bearing element of steam turbines, shaft bearings of wind turbines, mining machines, etc.

The objective of this research is to study CM of the roller element bearing defects using vibration signature analysis data under various loads and speed. Furthermore, to develop an interactive menu driven software tool to acquire data, analyze, and predict bearing failure well-in-advance so that catastrophic failures, downtime, production loss, accidents, hazards to personnel, etc., could be avoided.

2. LITERATURE REVIEW

CM became well-known in the 1960's and since then this technology has rapidly developed especially in the last two decades or so with the advent of high-speed computers, internet, and reliable sensors. Even the operating cost of all the hardware and associated software has reduced considerably.

*Corresponding Author:
E-mail: vk@git.edu
Phone: +91-9972454903

Dube *et al*., [1] discussed the vibration response of the rolling element bearings to the defects on outer race, the inner race, and rolling element. Kurtosis is evaluated for different cases of bearing and finally showed that the vibration-based CM is successful in detecting the faults in bearings. Marinkovic *et al*., [2] presented some advantages of standard and portable data acquisition (DAQ) equipment using LabVIEW software and showed their application in common experiments of tribology. Experiment with porous sliding bearing is discussed and concluded that classical way of experimental investigation compared with that using DAQ with virtual instrumentation interface by LabVIEW software is more flexible which can modify during experiments realization. Nadakatti *et al*., [3] discussed the application of knowledge-based CM, which uses displacement, velocity, and acceleration as an input data for checking vibration severity and depending on vibration severity remedial action are initiated at the appropriate time. Systematic approach and different steps for establishing knowledge-based CM program using vibration characteristic are discussed and concluded that in conjunction with artificial intelligence cost-effective and user-friendly CM application can be used by the industries for effective maintenance management. Nadakatti *et al*., [4] developed a program in VISUAL BASIC for checking of various causes of vibration, i.e., unbalance, misalignment, worn out gears, eccentric journal, mechanical looseness, etc. The application will be detecting specific cause. Finally, concluded that monitoring vibration level it is possible to get the information about machine by combining it with artificial intelligence in the particular expert system and knowledge-based system. Kim *et al*., [5] presented a comparative experimental study on the application of the ultrasound technique for CM of rolling element bearings having low speed and conventional vibration measurements with faults on inner race. With the statistical parameters extracted from time domain signal and enveloped spectra in the frequency domain the effectiveness of the ultrasound technique is presented. In this work, SKF (NJ 2204) cylindrical roller bearing is used. Minute scratch defect was obtained on the inner race. The small defect with width 1 mm and depth of size 20 µm were used to assess the detection capability of incipient failures. The equipment used is an accelerometer, DAQ card and a laptop computer with LabVIEW (NI). The signal processing and analysis was achieved with use of MATLAB for feature extraction and enveloping and concluded that ultrasound signal is more sensitive than acceleration signal for detecting localized defect in bearings.

3. BEARING FAULTS AND SOURCES OF VIBRATION

A rolling-element bearing is composed generally of two rings, In between which a set of balls or rollers rotate in raceways. Largely in all cases, bearing failures are the result of material weakness of the bearing. Under normal operating conditions, failure begins with small cracks, located inside the surfaces of the raceway and rolling elements. Rolling contact bearings represent a complex vibration system whose components, i.e., rolling elements, raceway (inner and outer) and cage - interact to generate complex vibration signatures. Although rolling bearings are manufactured using high accuracy machine tools and under strict purity and quality controls, like any other manufactured part they will have degrees of imperfection and generate vibration as the surfaces interact through a combination of rolling and sliding. The cyclic impacts between the components of the bearing and the faulted surfaces cause the cracks to propagate gradually and expand, cause vibration amplifications and noise levels [6]. The cyclic stressing of the dented area causes the some small fragments of the material chip out, which produce a phenomenon known as flaking [7]. The pattern of the vibration signal consists in a series of oscillations which repeat every cycle in a moving component over the fault [8]. The recurrence frequency of the impact depends on the position of the fault. The fault can be on the inner race, the outer race or the rolling element. The typical construction and sizes of a ball bearing are shown in

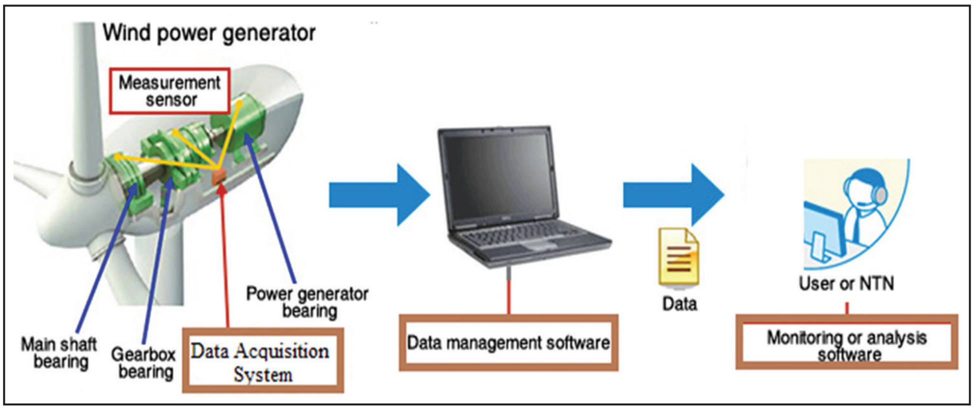

Figure 1: Data flow from condition monitoring of bearings.

Figure 2. The balls are fixed and held together by a cage which prevents the contact between the balls and ensures a uniform distance between them.

4. EXPERIMENTAL SETUP

Using DAQ System parameters and LabVIEW, NI MyRio, USB, Ethernet, and much more. LabVIEW provides the simplest solution for communicating with any of these protocols. In this paper, an experimental setup is explained, and a solution is deduced where LabVIEW and DAQ systems communicate among themselves as shown in Figure 3.

The test bearing single row deep groove roller bearing is placed on the non-drive end side, and a double row self-aligning ball bearing is placed toward the drive end side. The loading arrangement is placed between these two bearings. A hydraulic loading arrangement is used to load the bearing. A piezo-electric accelerometer (multiple single axis accelerometers having sensitivity ranges from 5 to 100 mV) is mounted on the housing of the test bearing. The accelerometer is connected to NI-CDAQ-9174 board, the output of which is connected to a computer. The computer contains the relevant hardware and the software LabVIEW to acquire the data, store it and display the signal on front panel. In the test rig, the bearing is mounted at the end of the shaft and is loaded in the radial direction by the action of hydraulic ram. To obtain vibration response of rolling element bearing for detection of faults.

The procedure for the experimentation is as follows:

i. Accelerometer is mounted/fixed using wax at bearing housing.
ii. Accelerometer is connected through the cables to the NI-CDAQ 9174 board to a suitable port, the output of which is connected to the computer.
iii. The computer contains relevant hardware and software (LabVIEW-2012) to acquire the data, store it and display the signal on the front panel in the form of wave graph and numerical indicator.
iv. Block diagram window contains the circuit

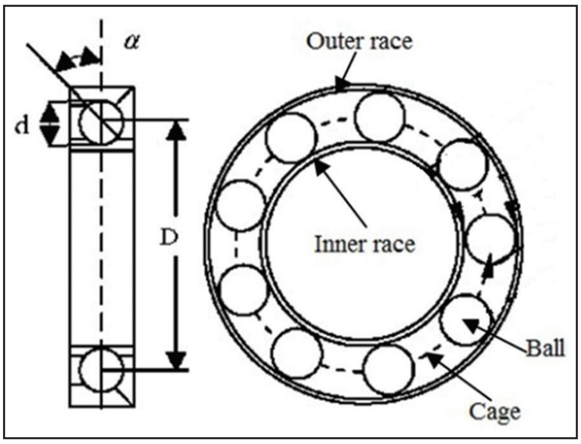

Figure 2: Main bearing dimensions and characteristic fault frequencies.

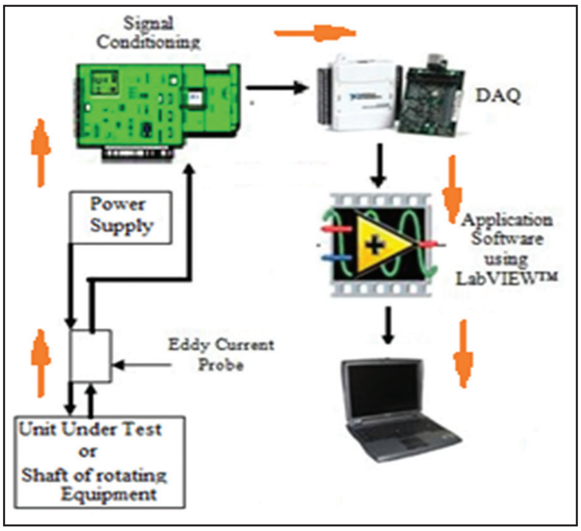

Figure 3: The flow of data integrated with data acquisition and LabVIEW.

Figure 4: Experimental set up for vibration testing of bearing.

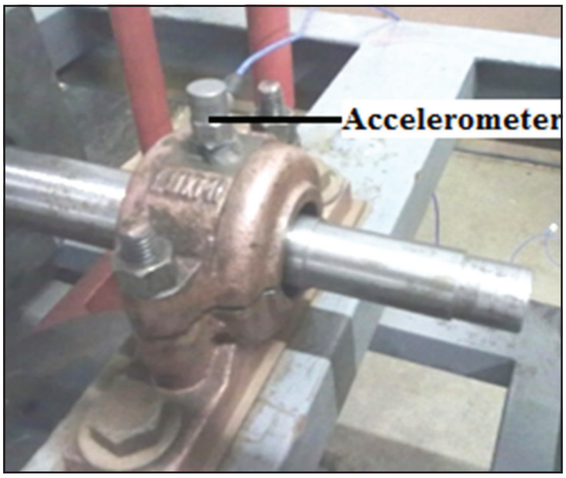

Figure 5: Accelerometer and mounted on bearing housing.

connection diagram for acquiring accelerations, Fast Fourier Transform data.

v. Collect vibration data by operating the bearings at various loads and speeds.

vi. Analyze the vibration data using time-domain and frequency - domain techniques.

5. CONCLUSION

In line with the objective of this proposed research on bearing failure prediction, an experimental test rig was designed and developed. Necessary hardware such as DAQ, My RIO, LabVIEW, and MATLAB was procured, and the critical study was done. Currently, work is under progress on two fronts, First, collection of bearing vibration data under various loads and speeds conditions. The second part of research is to develop an interactive menu driven software tool to acquire data, analyze the signature and predict bearing failure well in advance so that catastrophic failures, downtime, production loss, accidents, and hazards to personnel, etc., could be avoided.

6. REFERENCES

1. A. V. Dube, L. S. Dhamande, P. G. Kulkarni, (2013) Vibration based condition assessment of rolling element bearings with localized defects, ***IJSTR,*** **2(4):** 149-155.
2. A. Marinkovic, A. Vencl, P. Wallace, (2007) Portable DAQ equipment with labview as a tool for tribology experiments and condition monitoring, SERBIATRIB 07, International Conference on Tribology, p105-108.
3. M. M. Nadakatti, A. Ramachandra, A. N. Santosh Kumar, (2007) Knowledge based condition monitoring through vibration parameters, ***Journal of Manufacturing Engineering, SME,*** **2(3):** 1-8.
4. M. M. Nadakatti, A. Ramachandra, A. N. Santosh Kumar, (2005) Knowledge based fault diagnosis of industrial machinery using vibration characteristics, ***Recent Trends in Maintenance Management,*** **20:** 137-143.
5. Y. H. Kim, A. C. C. Tan, J. Mathew, B. S. Yang, (2006) Condition monitoring of low speed bearings: A comparative study of the ultrasound technique versus vibration measurements, ***WCEAM,*** Paper 029, p171-180.
6. H. A. Toliyat, T. A. Lipo, J. C. White, (1991) Analysis of concentrated winding induction machine for adjustable speed drive applications - Part 1 (Motor Analysis), ***IEEE Transactions on Energy Conversion,*** **6(4):** 679-683.
7. H. A. Toliyat, T. A. Lipo, (1994) Transient analysis of cage induction machines under stator, rotor bar and end ring faults, ***IEEE Transactions on Energy Conversion,*** **10(2):** 241-247.
8. J. Antoni, R. B. Randall, (2005) On the use of the cyclic power spectrum in rolling element bearings diagnostics, ***Journal of Sound and Vibration,*** **281(1-2):** 463-468.

***Bibliographical Sketch**

Vinayak V. Kulkarni is currently working as Assistant Professor in Department of Mechanical Engineering at KLS's Gogte Institute of Technology, Belagavi. He has completed his M.Tech in Computer Integrated Manufacturing from RVCE, Bangalore. He has presented four papers till date in various International Conferences and Journals. He is presently working on LabVIEW software.