Vibration Study of Metallic and Polyacetal Bearing

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Abstract- *Bearings are widely used in many automobiles and process industries, where they are subjected to high load as well as speed. Failure of such bearings in any one of the critical machine of process industry disrupts entire production process and leads to production loss. Monitoring and analysis of vibration signal generated by faults in the bearing helps to diagnose exact fault in bearing.*

This study deals with the performance behavior of tapered roller bearing and Polyacetal bearing with seeded defects of varying sizes. The time domain signals are captured using accelerometer as sensor and processed in MATLABR2013b.The increase in trend of kurtosis and RMS values showed the effect of defects on the performance of bearings.

Keywords- Kurtosis, RMS, Time-domain analysis, Vibrations.

I. INTRODUCTION

Metallic Bearings find wide spread domestic and industrial applications. In industrial applications, these bearings are considered as critical mechanical components and defect in such a bearing, unless detected in time, causes malfunction and may even lead to catastrophic failure of the machinery. Defects in bearings may arise during use or during the manufacturing process. Therefore, detection of these defects is important for condition monitoring as well as quality inspection of the bearings.

Polyacetal is also known as Polyoxymethylene (POM) is crystalline thermoplastic with high tensile strength, stiffness, resiliency, low coefficient of friction and very low moisture absorption. This broad range of useful properties in addition to its ability to retain properties over a long period under elevated temperatures, mechanical stresses and demanding environmental conditions make it an engineering plastic of choice for many applications.

Different methods are used for detection and diagnosis of bearing defects, one of the most common techniques is vibration measurements using Time Domain.

A lot of research work has been published on the vibration measurement technique. Some of these works have also been reviewed by researchers Tandon and Choudhary [1] presented the detailed view of different vibration measurements using time and frequency domain. A review on tribological studies of several unfilled polymers in water lubricated contacts was demonstrated by Golchin [2] in his research friction of unfilled polymers in water lubricated contact angle and relative energy difference with regard to water where an increase in water contact angle results in low friction. Attel Manjunath and D V Girish [3] in their research, the vibration response of new and defect Polyacetal deep groove ball bearing is compared. The FFT, RMS and Kurtosis are performed on each of the four bearings. The RMS value shoes that as load increases, the magnitude of the vibration response also increases also variation in the Kurtosis value shows the state of the bearing. In the research of the paper Break-away Friction of PTFE Materials in Lubricated Conditions authorized by G.F.Simmons[4]. He concluded that highest break-away frictions were found in Babbit than in PTFE based materials. Pure PTFE provided the lowest Friction levels. Also, increased loading resulted in slightly decreased break away friction. Research by author B. Prakash [5] of Tribological Behavior of Polymeric Material in Water Lubricated Contacts, different polymers like PTFE, UHMWPE, PET, PEEK and POM were tested for friction coefficient and concluded that the frictional behavior of polymers is influenced by both their wetability and solubility in water where generally an increased contact angle and relative energy difference in regard to water results in decreased friction.

P. De Baets and T.D. Nguyen [6] in ‘Effect of Shaft Roughness and Pressure on Friction of Polymer Bearings in water’ carried out the frictional behavior of four unfilled thermoplastic polymers using a water lubricated journal bearing. Dynamic friction curves as well as dynamic and break away friction maps have been obtained for different shaft roughness and pressure combinations. ‘Modelling and Contact Analysis of Composite Material (FRP) Lamination on Cylindrical Roller Bearing’ by Bhakti Sanjay Kate[7] In this work the compliance behavior of FRP composite is studied. A Finite Element model is developed using Ansys and the results obtained from the analysis are compared with the analytical results. Usage of FRP material on the inner side of outer race of the roller bearing holds good for a durable operation and reduces the weight of the bearing which positively affects the power usage of the engine.

The effect of vibration on perfect bearing can be considerably reduced by selecting the correct preload and number of balls [9]. The vibration monitoring technique is used to analyze various defects in bearing and it also provides early information in case of progressive defects[8]. Tri-axial vibration measurement was used to capture the signals and it was found that defect bearing has the strong effect on the vibration spectra [10]. In case of defect on the fixed ring the frequency spectrum generated appears at its multiples. If the defect is located on the inner ring or the ball, frequency spectrum is amplitude modulated. The more is the wear, higher are the amplitudes of the components. Low speed fault simulation tests were conducted with various defects on the bearing. This study gives the best frequency bandwidth for early detection of bearing defects running at lower speeds [11].

Time Domain Analysis is a record of what happened to parameter of the system with respect to time. The Time Domain is a perspective that feels natural and provides physical insight of the vibration. It is essentially useful in analyzing impulsive signals from bearings, gear defects and truncated signals from looseness. It reveals the severity of the vibration in term of overall amplitude. However, the individual components of complex signals are difficult to determine. The details of the time domain analysis are furnished in the later sections.

II. EXPERIMENTAL SETUP

The experimental bearing test rig is designed and fabricated to identify the presence of defects on a radially loaded Metallic and a Polyacetal bearing by vibration analysis technique is shown in Figure 1. Considering the shaft subjected to bending moment the diameter of the shaft is found to be 20mm which is supported by two ball bearings on either side. This shaft is driven by Motor (1HP) through a Belt Drive and the test bearing is placed between the two supported ball bearings within the housing. For capturing vibration signals from the test rig a provision is made to mount the Accelerometer on the opposite side of load applied on the housing. Bearing Vibrations is captured with DYTRAN 3041A21080, sensitivity quartz 97.1mV/g accelerometer. Data is recorded by LabVIEW, via an acquisition card, NIUSB6001, configured at a sampling frequency of 10 kHz.

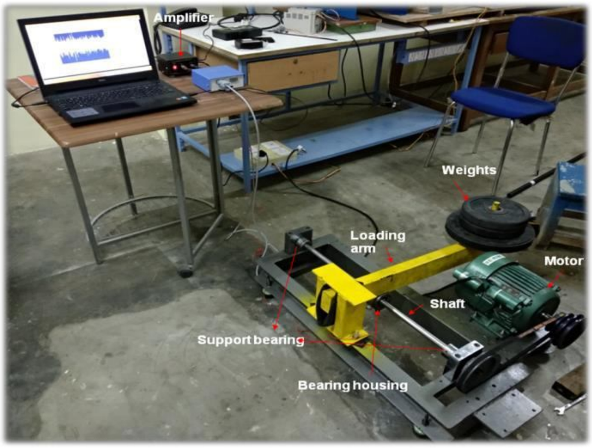


Figure 1. Experimental Setup

Figure 2. Bearing Housing Connected to Accelerometer

Table 1. Details of Polyacetal and Metallic Bearing

Parameters	Polyacetal	Metallic
Number of balls/rollers	9	15
Outer Diameter, mm	52	47
Inner Diameter, mm	20	20
Width, mm	14	15.25
Contact Angle, β	0	45

III. PROCRUITMENT OF DEFECT

In this paper, Vibration Study on Metallic and Polyacetal Bearing is carried out. The two different methods are used to create the defects on Polyacetal and Metallic bearings. To have clear surface finish on the Metallic bearing we used Laser Cutting Technique to induce the defect. Since the Polyacetal bearing cannot be done in the same method we selected the drilling method by using Universal Milling Machine to induce the defect.

The defect on polymer bearing is done on both inner race and outer race of the polymer bearing. The drilled hole is of following depth 0.5mm and 0.75mm is made on polymer bearing surfaces of inner ring and outer ring keeping the drilled hole diameter of 4mm and cutting tool speed was kept constant for all varying depth of 800rpm. The defect of metallic bearing is done by laser cutting technique on the outer ring and on inner surface roller of a metallic bearing. The length of cut is 10mm, width of 3mm of the bearing and the depth is varied for the study cases of 0.04mm, 0.08mm and 0.128mm on the outer rings of the bearing and on the rollers of bearings.

Figure 3. Defect on Ployacetal Bearing

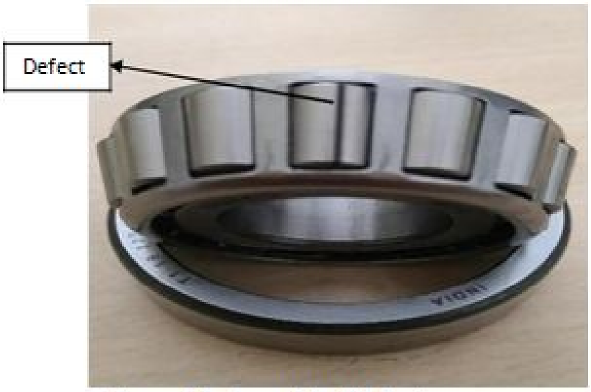
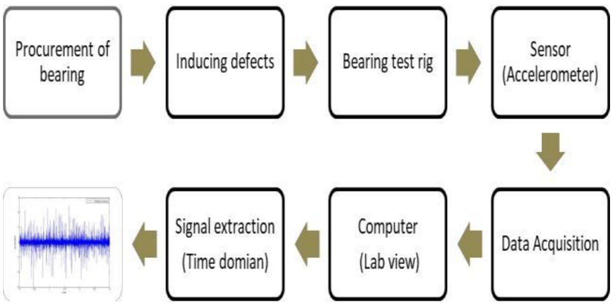


Figure 4. Defect on Meatllic Bearing

IV. EXPERIMENTATION



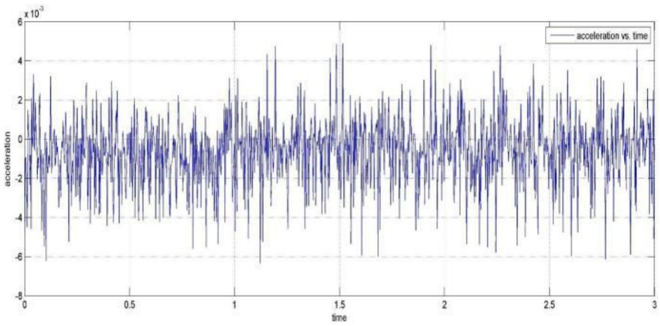
Experiments were carried on polyacetal and metallic bearings, a healthy polyacetal bearing with two inner race defects and two outer race defects. Similarly, a healthy metallic bearing with two roller defects and two outer race defects. Initially a healthy bearing was fixed in the bearing test rig and vibration signals were captured using an accelerometer. Then the healthy bearing was replaced with defective bearings for capturing vibration signals. Recording of signals were observed for two running condition for each bearing. The central radial load applied was 5% and 10% of the rated load of the bearing. And motor was made to run at 1440 rpm for metallic bearing and 750 rpm for polyacetal bearing.

V. RESULTS AND DISCUSSION

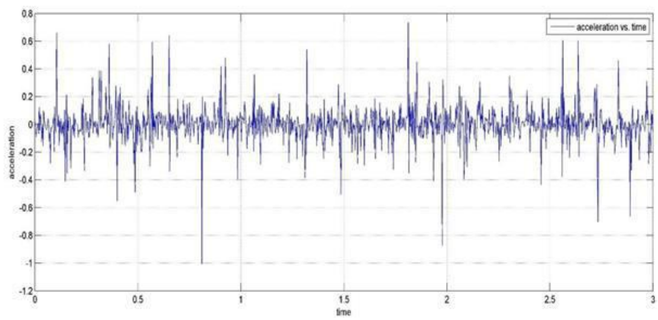
The vibration analysis or condition monitoring is based on the principle that all systems produce vibration. When a bearing is running properly, the vibrations generated are very small and generally constant. But, due to some of the dynamic process that act in the machine, defects develop causing the changes in the vibration spectrum.

Firstly, vibration signals obtained are transferred to MATLAB software to obtain the plots of each bearing. Then, the RMS values and Kurtosis values are computed using MATLAB.

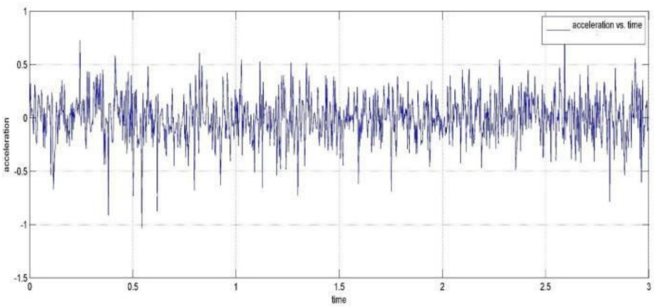
Behavior of metallic bearing



Plot 1: Behavior of Healthy Metallic Bearing for 5% rated static loading



Plot 2: Behavior of roller defected Metallic Bearing for 5% rated static loading



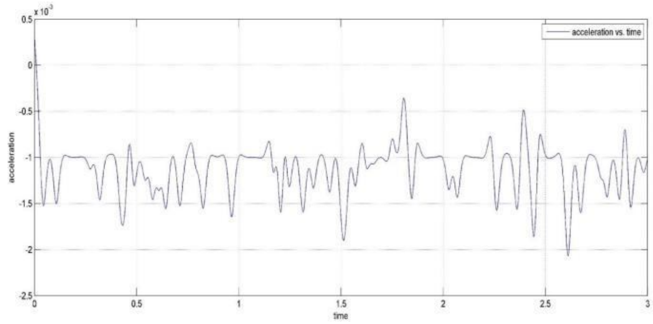
Plot 3: Behavior of outer ring defected Metallic Bearing for 5% rated static loading

Plot 1, plot 2 and plot 3 show the behavior of the metallic bearing for 5% of the rated load on healthy, roller defect (0.08) and roller defect (0.12) respectively. The amplitude ncreases as the depth of the defect increases. The amplitude for healthy bearing is around 0.5*10-3 whereas for defected bearing it is raised to 0.25 (for 0.08 mm defect depth) and 0.4 (for 0.12 mm defect depth.

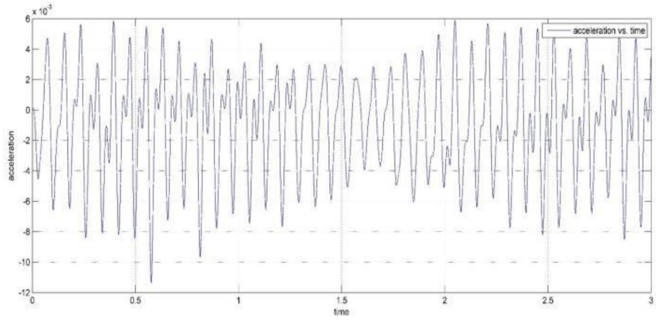
The amplitude behavior of the outer ring defect is same as that of roller defect. Here, the amplitude is much higher than the roller defect i.e 0.6 for the depth of 0.08 mm and 0.8 for the depth of 0.12 mm.

For 10% of the rated load the amplitude behavior is same as that of the 5% rated load.

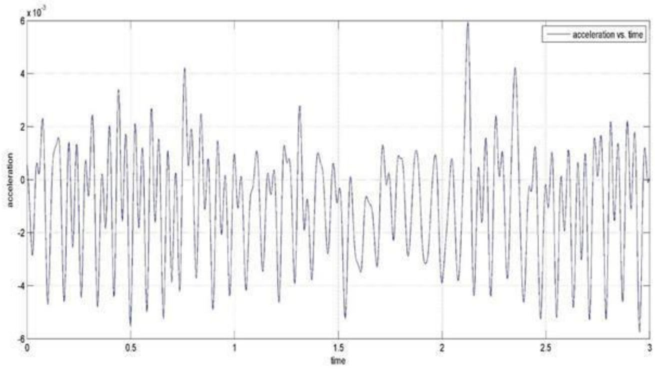
Behavior of Polyacetal Bearing



Plot 1: Behavior of Healthy Polyacetal Bearing under 5% rated static load



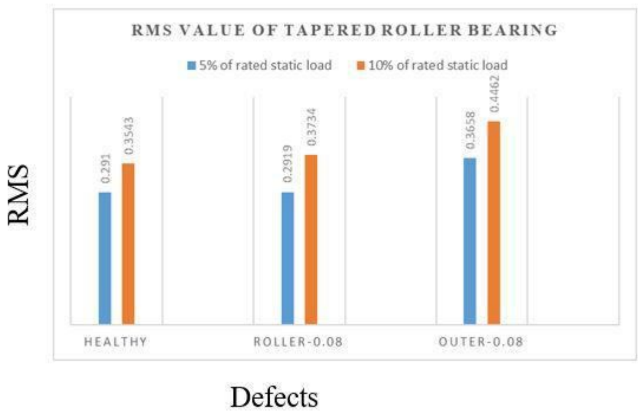
Plot 2: Behavior of Outer Ring Defective Polyacetal Bearing under 5% rated static load



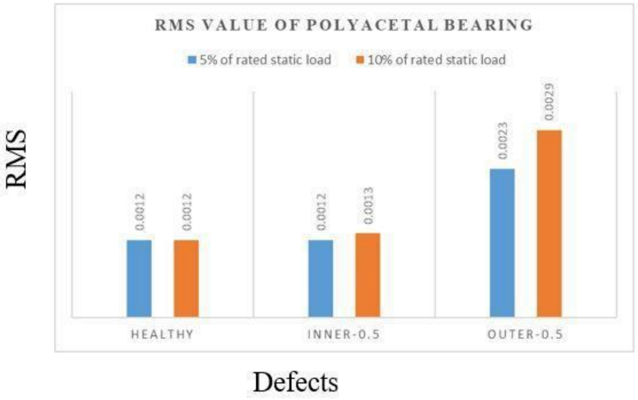
Plot 20 Behavior of Outer Ring Defective Polyacetal Bearing under 5% rated static load

The amplitude of polyacetal bearing varies in the similar fashion as that of metallic bearing. From the plots we can note that as the defect depth increases the amplitude also increases. Also, as the load is increased the amplitude of the plot also increases.

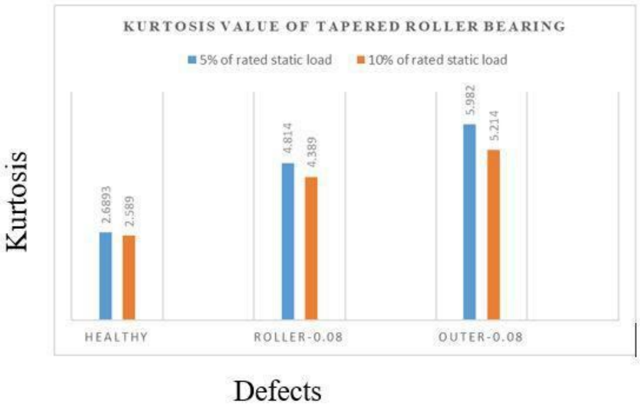
RMS and Kurtosis values



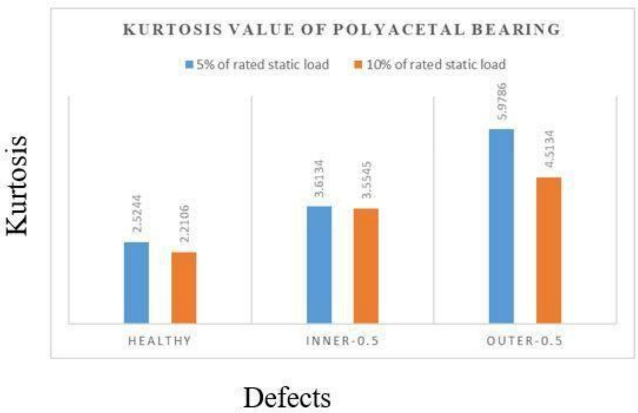
Graph 1 RMS values of Tapered Roller Metallic Bearing



Graph 2 RMS values of Polyacetal Bearing



Graph 3 Kurtosis values of tapered Roller Metallic bearing



Graph 4 Kurtosis of Polyacetal Bearing

The RMS value for healthy and defective bearings shows higher for higher radial loads. Also, it is found that RMS value is higher for outer race defect than the inner (polyacetal) or roller (metallic) defect and healthy bearing. This can be observed in the graph 1 and 2.

Kurtosis value shows the presence of defect in the bearing. This can be observed in the graph 3and 4. For healthy bearing the kurtosis value is less than 3 whereas for defected bearing the kurtosis value is between 3 to 7.

VI. CONCLUSION

The following conclusion can be drawn from the study

1) Vibration analysis is a powerful tool in predicting incipient failure, location and its severity of mechanical defects like unbalance, misalignment and bad antifriction bearing.

2) Time domain technique is a traditional tool and can explain the severity of damage in healthy and defect conditioned bearing.

3) From this study it is concluded that the defect on the outer ring can be identified easily in terms of increase in Kurtosis and RMS value.

4) This study depicts that amplitude of defective bearing is higher than healthy bearing.

VII. ACKNOWLEDGMENT

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