Volume : 4 | Issue : 10 | Special Issue Oct- 2015 • ISSN No 2277 - 8179

FAULT DIAGNOSIS OF SELF ALIGNING BALL BEARING AT VARIOUS SPEEDS USING FREQUENCY DOMAIN

Engineering

KEYWORDS: Roller Bearing, Bearing Fault Simulator System, vibration, Self aligning ball bearing.

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ABSTRACT

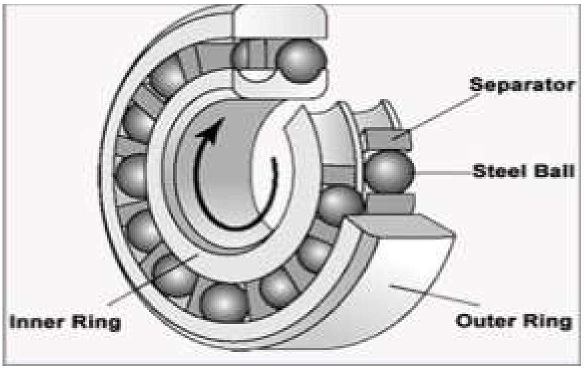
Dynamic equipments, in their vast majority, have rolling bearings in their components. Measurement and analysis of the values of rolling bearing's vibration, on time, represent a safe and effective measure for identifying the state of wear of bearings, and to predict the evolution of their technical condition and of the entire equipment. The fault diagnosis of self aligning ball bearing at different speeds is the main concern of the study. The main objective of this experimentation is to find the defects in the faulty bearings and compare them with the healthy bearing. This paper presents the detection of causes which lead to the damage of rolling bearing by using bearing condition signature spectrums in frequency domain and root mean square values of acceleration in time domain, by measuring its housing vibrations mounted in a test rig. A test bench consists of a motor and a shaft attached along with two different bearing housings with rotor disc at the centre giving constant loading. The particular imperfections are considered as defect in outer race, inner race and ball element and vibrations are recorded for five speeds. It is clear from both the time domain and frequency domain signals that for the same defect size the maximum vibrations are produced by the bearing with ball defect and then by the outer race fault and lastly minimum by the inner race faulty bearing.

INTRODUCTION

The major industries in this developing world are using the roller bearing element as the important part in different machines. The working of these machines is totally dependent on the condition of the bearing. The basic objective of the any bearing is to reduce the friction between the mating parts of the machine. The condition of the bearing is totally dependent on the maintenance of bearing. The maintenance of the bearing includes the checking of temperature, wear, lubrication, vibrations, noise etc. The most common and maximum participating factor in making unhealthy operation of machine is the vibration of the rolling element i.e. spherical ball or cylindrical roller. Moreover the various cracks, spalls and wear of the inner and outer race of the bearing also cause vibrations [1-3]. For continuous and longtime operating machines it is necessary to check the condition of the bearing without stopping the working of machine. The system of measuring the vibration in this study works without affecting the machines operation. Piezoelectric accelerometer is the basic device used for measuring signals in time domain and frequency domain. It has also ability to measure vibration velocity, shock pulse, and power spectrums of the bearing during working. The comparison of the working of the healthy bearing with the used bearing helps in detecting the level of fault. In this conditioning monitoring system the basic elements used for measurement are handy data collector, vibration analyzer and intelligent online system.

Self Aligning Ball Bearing

The bearing used in this study is self aligning ball bearing with 1205 number. This bearing is most widely used bearing in the industry due to its good performance at high speeds and light to medium range radial loads and slight angular misalignments. The inner and outer race of the bearing is in the form of circular arcs with radius slightly greater than the radius of the balls [4]. It has advantages of silent operation and small startup torque. The cage is made up of the pressed steel. In this experiment the inner ring is tapered from shaft side as it is fitted with shaft with the help of the adapter sleeve. The inner ring is tapered by machining operation [5].The grip of the bearing with the shaft is made with the help of the adapter sleeve. The effect of the speed on the vibration has great significance to represent vibration signal. So, the input parameters which can be used are speed, rotor weight, bearing type. [6-8]



EXPERIMENTAL SETUP

The experimental setup is shown in figure 2. The main parts in the setup are the rotor mass, piezoelectric transducer, bearing housing, vibration scanner, motor, and computer. First of all the data to be collected is built in program and uploaded to the vibration scanner instrument via cable. Then the instrument collects the vibration signals from the

Fig. 2. Experimental setup
1.Rotor mass, 2.Peizoelectric transducer, 3.Bearing housing, 4.Vibscanner, 5.Motor, 6.Computer for acquisition of data

bearing housings to collect vibration signals in the terms of the overall velocity, displacement spectrum and mach spectrum. The signal is recorded in the vibration scanner instrument and then downloaded in the computer via cable. The vibration signals are then displayed in the computer in the form of graphs to show the variation of the signals.

Vibscanner device converts the analog signal to digital signal through ADC which is implanted in the vibscanner. The vibration signals are passed through the data transfer cable to the computer. It performs the analysis of the vibration signal by Omnitrend software and display the result.

There are two self aligning ball bearings taken to make comparison. One bearing is brand new with good lubrication and the second bearing is already used scraped bearing taken from certain machine and has certain defect on their parts which must be evaluated from the physical inspection only. The defect on the bearing from the physical inspection may be spalls, cracks, pits and wear on either or on both inner and outer race. New bearing of the same configuration has free from these defects. Dimensions of two bearings are same as given below. The experimental work done is to find the effect of cracks, spalls etc on the vibration behavior of the bearings and also the effect of the speed on the bearing vibration signal for healthy and unhealthy bearings. The bearing used is 1205 type and figure 3 shows the technical dimensions of the test bearing.

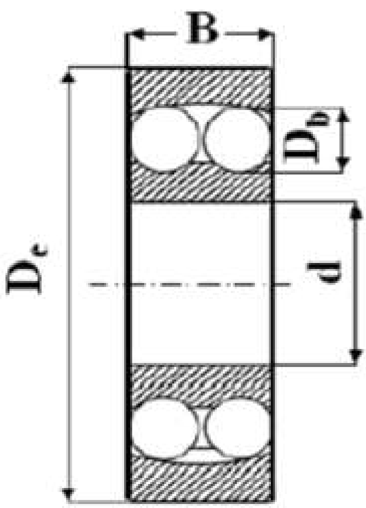


Fig. 3. Dimensions of self aligning ball bearing 1205 type [8]

There are different types of components used to construct the bearing fault simulator system. The traditional vibration test system consists of different types of independent measurement system, single result function, very poor testing result and is very expensive. Therefore, it has limited application in practical field. So the bearing fault simulator system is greatly used in practical field. It is developed with computer technology and virtual instrumentation. It is different from traditional instrument. Virtual instrumentation has effective functions like data acquisition, signal occurrence, data analysis, signal processing, input and output control etc. Virtual instrumentation is considered as standard software of instrument control and data acquisition.

In vibration monitoring system, used in this study different components like transducer vib 6.140, vibscanner, connecting cables and computer for analysis are available. For controlling of machines rotational speed, motor control unit is used. In this system, vibscanner is considered as hardware of the system. The omnitrend software is installed in the computer for processing of the vibration signal.

COMPUTATIONAL PROCEDURE

Table – I shows the dimensions of the test bearing under study. The Experimentation has been done at three different speed of 500 rpm, 750 rpm and 1000 rpm for two different combination one is with healthy bearing and the other one is by taking the faulty bearing. The vibration signals have been acquired for both the bearing and being compared for early detection of the fault in the bearing based on the mach spectrum. The accelerometer transducer has been mounted on the machine for acquiring the vibration signals at the horizontal position at the bearing housing for the good bearing and for the faulty bearing. Then the vibration signals have been acquired at different speed of the bearing. The vibration signals acquisition is done by the vibscanner then we fed the vibration signals into the computer. The analysis and comparison of vibration signals in time domain and frequency domain signals is carried out. After the comparison and analysis, the faulty condition of the bearing may be detected at the early stage by comparing the frequency domain with that of faulty bearing.

TABLE – 1: SIZES OF SELF ALIGNING BALL BEARING WITH TAPERED BORE

Size	Values
Outer diameter	52 mm
Inner diameter	25mm
Thickness	15mm
Ball diameter	7.2mm
Number of balls	24 balls

RESULTS AND DISCUSSIONS

The figure 4 represents the comparison of mach spectrum signal for new/healthy and for the ball defective bearing at rotational speed of 500 rpm. It represents the variation of the vibration in frequency domain. The comparison of mach spectrum signal for the faulty bearing at 750 rotational speeds and 1000 rotational speed has been represented in figure 5 and 6 respectively. Each graph contains the frequency domain at the inner, outer race for the healthy and for the faulty bearing having the ball defect. The figures (4-6) represents that the vibrations frequency increases at high speed as compared to low speed in both healthy and unhealthy bearings. Moreover the frequency of occurrence of vibration in unhealthy bearing is greater than of occurrence of vibration in unhealthy bearing is greater than healthy bearing. The maximum value of variation for unhealthy bearing with ball defect is X=48 Hz, Y=0.22 mm/sec, and for healthy bearing is X=16 Hz, Y= 6.02 mm/sec. So it is concluded from the above graphs that the vibration velocity for healthy is very fast as compared to unhealthy bearing and frequency of occurrence of vibration is lesser for unhealthy bearing but 3 times more for healthy bearing.

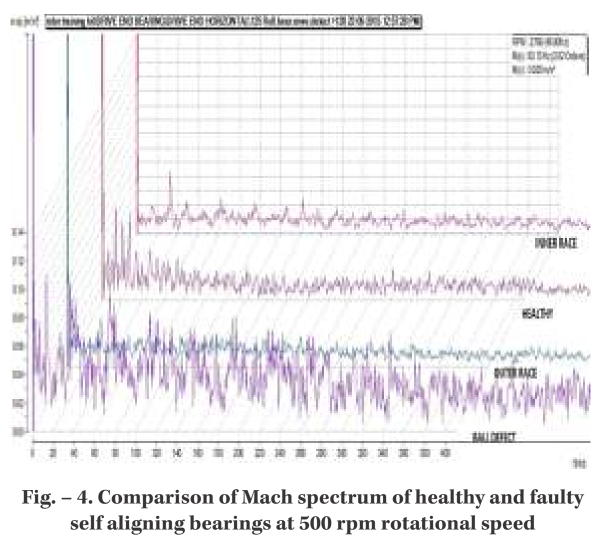


Fig. – 4. Comparison of Mach spectrum of healthy and faulty self aligning bearings at 500 rpm rotational speed

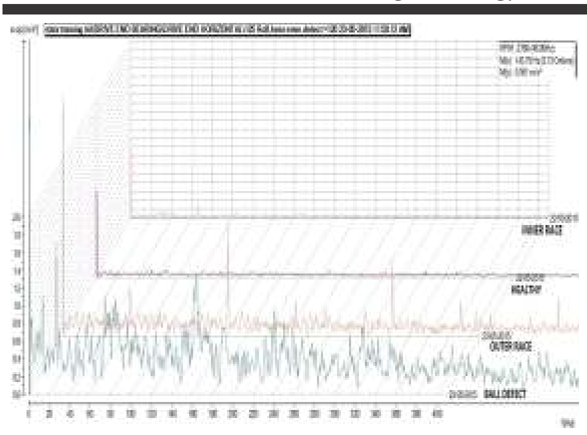


Fig. – 5. Comparison of Mach spectrum of healthy and faulty self aligning bearings at 750 rpm rotational speed

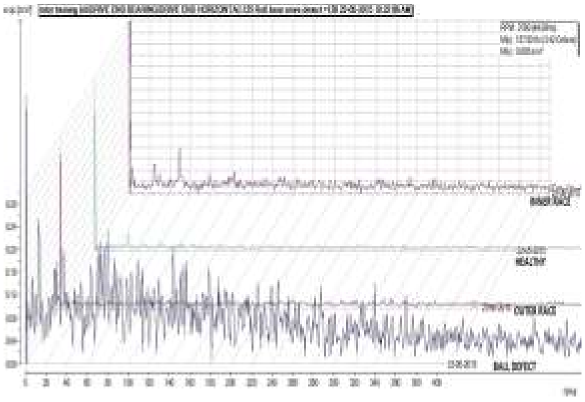


Fig. – 6. Comparison of Mach spectrum of healthy and faulty self aligning bearings at 1000 rpm rotational speed

CONCLUSIONS

The self aligning ball bearing is used in present study to represent the behavior of the vibration signal. The vibration signals in the terms of the mach spectrum and overall velocity is founded and compared. From the above graphs and results the conclusion is made that the vibration signals of the healthy bearing are totally different from the signals of the unhealthy bearing. The mach spectrum graph represents that the vibrations frequency more at high speed as compared to low speed and medium speed in both healthy and unhealthy bearings. But the frequency of occurrence of vibration in unhealthy bearing with ball defect is higher than healthy bearing. After ball defect outer race defect has slightly less vibration velocity as compared to ball defect bearing. And inner race defect has slightly less vibrations than the outer race bearing. In above results it is also shown that the overall vibration velocity increases with increase in speed and time. For healthy bearing it is visualized that the overall vibration for healthy bearing is low and for unhealthy bearing is very high.

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