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Analysis of Fault Diagnosis of Bearing using Supervised Learning Method

Ashish Goyal[1*], Rajeev Kumar [2], Mayur Rajeshwar Randive [3*],Tarsem Singh[4*]
[1,3] *(Department of Mechanical Engineering, Lovely Professional University, Phagwara, Punjab, India)*
[4] *(Department of Mechanical Engineering, Chandigarh University, Chandigarh, Punjab, India)*
[2] *(Department of Mechanical Engineering, Lovely Professional University, Phagwara, Punjab, India)*

Abstract: *Bearings faults are one of the prime reason of dissection of rotating machines. Thus detection and diagnosis of mechanical faults in bearings is very fateful for the reliable operation. Any industry want an efficient predictive maintenance techniques in order to optimize the management of resources and improve the economy of the plant by reducing unnecessary costs and increasing the level of safety. This study is centred around shortcoming determination of fault diagnosis of bearings using predictive maintenance techniques. A test bench which has a motor and a shaft attached along with two different type of bearing that are faulty bearing and healthy bearing. The vibration response are acquired and analyzed for the various defects of bearings. The particular imperfections are considered as crack in outer race or inner race with rough surface and corrosion pitting in ball element. After performing the experiment, comparison will be done between the experimental data which has a input for the omnitrend software. The result show that the when we compare all the condition than we use as a automated diagnosis of bearing. It is also observed that severe vibration occur under the bearing with the ball with corrosion pitting and when the speed is increases then all the defective bearings stop to rotate.*
Keywords: *Predictive Maintenance Techniques.*

I. INTRODUCTION

Rolling bearings are high precision, low cost but commonly used in all kinds of rotary machine The motivation behind why bearing is utilized is that first it can exchange minute or power. Besides and possibly more imperative is that it can be traded effortlessly and advantageously when its broken.. In It is also possible to amount the shaft directly with housing. However, when this mechanism has some problem, the only possibility to recover the function of this system is to replace the housing or the shaft. From the mechanical engineer perspective, both of them are not only very expensive but also time consuming to manufacture a new housing or shaft with the same parameters [1]. However when the bearings are used between them, the situation will be different. Regularly there is no relative movement in the middle of shaft and inner ring or the outer ring with housing. So it has less possibility for the shaft or housing to be worn out. Usually the bearing first cracks and then the shaft or housing is broken [2]. On the off chance that the above circumstance happens it is truly simple to make sense of it: simply purchase another bearing from the market with the same parameter and replace it. That's why bearing are so often used. Roller bearings are usually used for applications requiring exceptionally large load-supporting capabilities, which cannot be feasibly obtained using ball bearing assemblies. To prevent an complete error condition monitoring of a rotating machinery help in the detection of faults in the nick of time before getting the condition worse [3]. Vibration in the bearing can create noise and put down the quality of a product. The function of an entire system can work incorrectly because of the equable vibrations in the bearings results in downtime to the system and financial loss to the customer. Rolling bearings defects can be classified as point and variable defects [4]. The vibrations are created because of geometrical blemish over the bearing components and these blemish are caused by irregularities over the manufacturing process as well as during wearing and tearing. The distributed defects produced, roughness or waviness or misaligned races and off-size rolling elements [5]. Similarly local defects consist of cracks or corrosion pitting and spalls on the rolling surfaces. When a defect on a bearing element comes in contact with another surface if generates impulse which can cause resonance in the bearing as well as machine. During the rotation of bearing the impulses will occur now and again with some frequency which can determine the location of the defect can be on the inner race, outer race or over the rolling element [6]. The resonance created by the impulses can be checked by a vibration transducer placed over the bearing house. The vibration transducer which is attached with the Vibs-Canner evaluates the vibration when the bearing is rotating. When the defects on the one surface

comes in contact with another surface an impulse is created which produces resonance in the system. The vibrating signals is separated to single resonance and then demodulated and spectrum is calculated [7].
The experimental data is based on the frequent-domain vibration signals. And the data is taken on the different condition and different rpm and different type of bearing. We do comparison between the condition after the comparison we find some frequency which have more amplitude in the term of displacement spectrum [8]. Then we can find the faulty condition easily with impression in the bearing by the software.

II. Articial Neural Network

Artificial neural networks have become as an necessary tool for fault detection. The recent review in neural network have a promising alternative for various fault detection methods. We can use this ann network for a further research work. Advantages of neural network:

It is data driven self-adaptive method as it can adjust with respect the data without any specification of function for the model. They are universal functional approximators in neural network as they can approximate any function with an accuracy. These are non linear methods which make an them flexible in creating real complex relationship. They have capability to estimate posterior probabilities which gives base for installing classification rule and perform statistical analysis. Thus, we used the Artificial Neural Networks due to their capability of learning and generalization which makes them ideal for fault detection and error classification.

III. Experimental Setup And Data Acquisition

Experimental are carried on a test apparatus to produce preparing and test data. The rig is connected to the vibs- canner which have piezoelectric transducer vib 6.140 which is mounted on the bearing house when we acquire signal on the bearing. A variety of faults are simulated on the bearing at various speeds and various loads. Different parameters of bearing utilized for the study are recorded in Table 1. Accelerometers are utilized for getting the vibration signals from different stations on the apparatus. Signatures for healthy bearings operation establish the baseline data. This baseline data can then be used for comparison with signatures obtained under faulty conditions. After collecting the vibration signals, salient features are accumulated and compiled to form a feature vector which is fed to omnitrend Software to train it. The data are collected for different fault conditions of bearings. Various defects considered in bearing components are as show in figure 2. A variety of faults on bearings are simulated on the rig at different rotor speed 250, 500, 750, 1000, 1250 and 1500 rpm with different condition no load, one load and two load.The horizontal response and vertical response is taken by the sensor with these condition.

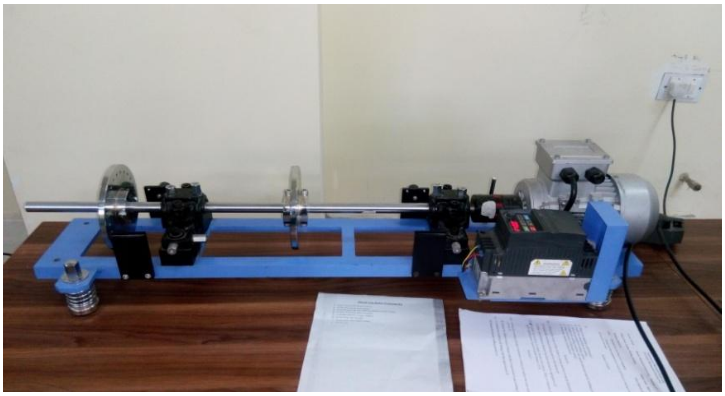


Fig.1. Bearing Fault Simulator System

Preparing/test information are created utilizing holding on for bearing with various faults and without fault. The following faults are introduced in the bearing:
(a) Outer race with crack and rough surface (Figure 3)
(b) Inner race with crack and rough surface (Figure 3)
(c) Ball with the corrosion pitting (Figure 3)
(d) Combination of the crack with the inner, outer and ball
The following cases are considered for acquiring training data:
from the data acquisition system:
(a) Healthy bearings (HB).

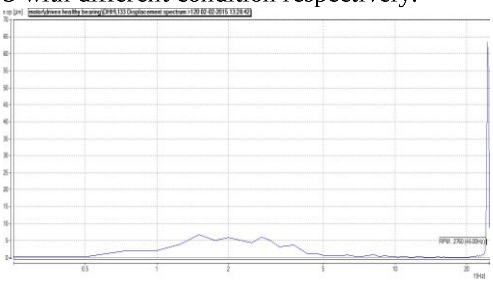
(b) Bearing with outer race crack (BORC).
(c) Bearing with inner race crack (BRIR).
(d) Ball with corrosion pitting (BCP).
(e) Combined bearing defects (CBD).

Parameters	Value
Bearing Specification	6205
Outer race diameter	52mm.
Inner race diameter	25 mm.
Ball diameter	7.94
Ball number	8
Contact angle	0°
Clearance	C3 Type

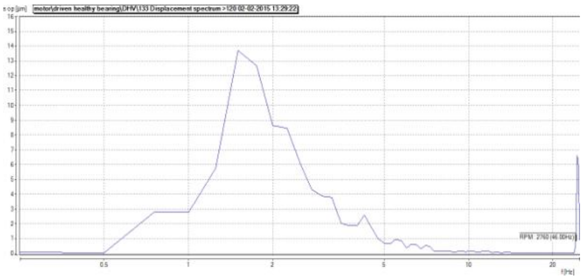
Table 1. Parameters of Bearing used for experiment

Fig. 2. Bearing With Inner Race Crack And Outer Race Crack And Corrosion Pitting

Frequency responses are obtained at various speeds and with different load conditions with considerations of all cases in a phased manner. The frequency responses at 1500 rpm with one loader conditions are shown in Figure 3 with different condition respectively:

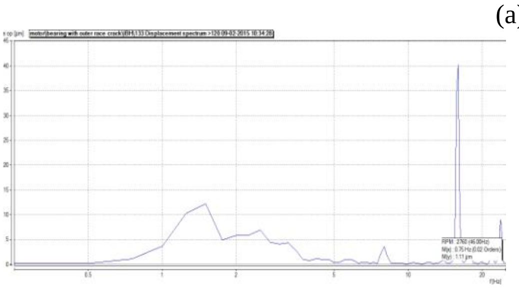


Horizontal Response

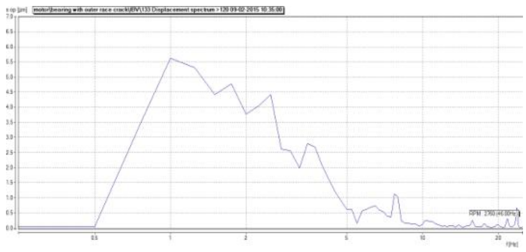


Vertical Response

(a) Healthy Bearing

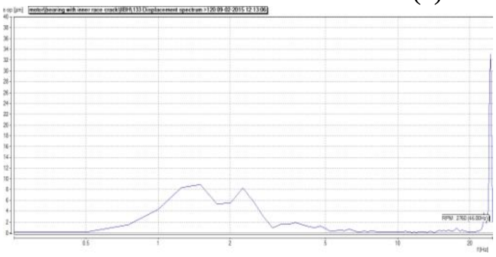


Horizontal Response

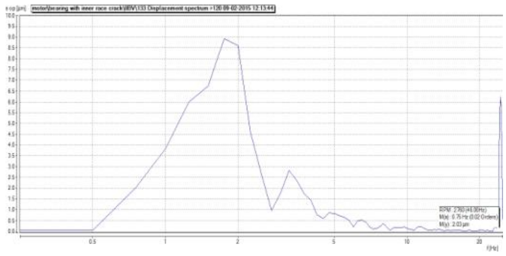


Vertical Response

(b) Bearing With Outer Race Crack

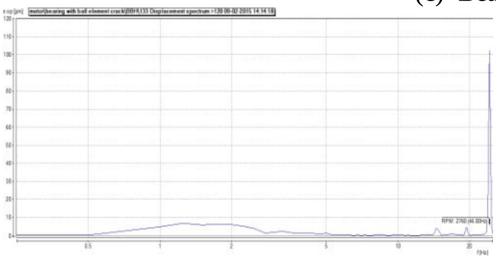


Horizontal Response

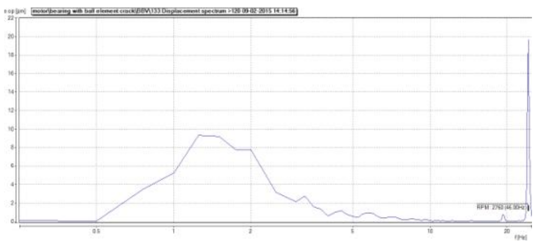


Vertical Response

(c) Bearing With Inner Race Crack

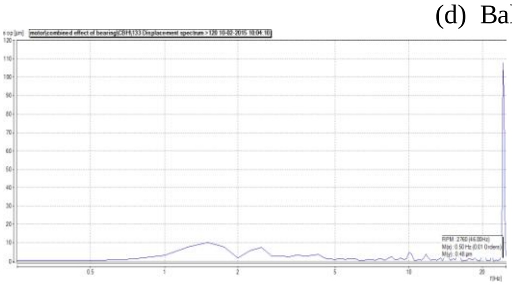


Horizontal Response

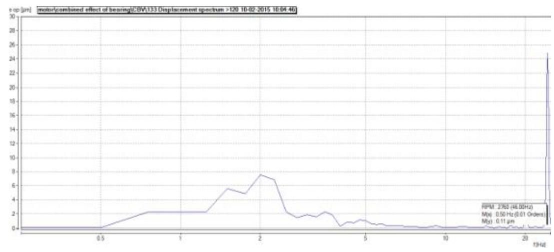


Vertical Response

(d) Ball With Corrosion Pitting



Horizontal Response



Vertical Response

(e) Combined Bearing Effect

Figure 3 Vibration Signal From Various Bearing Conditions At 1500 rpm With One Loader

IV. Result

Types Of Bearing ⇨	Healthy Bearing				Ball With Corrosion Pitting			
Response ⇨	Horizontal		Vertical		Horizontal		Vertical	
Parameter ⇨ / Loading ⇩	Frequency	Amplitude	Frequency	Amplitude	Frequency	Amplitude	Frequency	Amplitude
No Load	1.50	7.85	2.25	8.13	24.25	41.25	2.00	12.68
One Load	24.25	25.97	24.25	9.88	24.25	102.26	24.25	19.62
Two Load	24.25	36.79	24.25	22.30	24.25	98.85	24.25	13.29

Types Of Bearing ⇨	Healthy Bearing				Bearing With Outer Race Crack			
Response ⇨	Horizontal		Vertical		Horizontal		Vertical	
Parameter ⇨ / Loading ⇩	Frequency	Amplitude	Frequency	Amplitude	Frequency	Amplitude	Frequency	Amplitude
No Load	1.50	10.87	1.50	8.63	1.50	10.98	1.50	10.48
One Load	16.00	21.85	1.75	7.37	16.00	40.11	1.00	5.62
Two Load	24.50	53.49	24.25	20.44	24.50	65.34	24.50	18.76

Types Of Bearing ⇨	Healthy Bearing				Bearing With Inner Race Crack			
Response ⇨	Horizontal		Vertical		Horizontal		Vertical	
Parameter ⇨ / Loading ⇩	Frequency	Amplitude	Frequency	Amplitude	Frequency	Amplitude	Frequency	Amplitude
No Load	1.75	9.85	2.25	6.23	24.50	13.64	1.50	7.13
One Load	2.00	9.40	1.75	7.73	24.50	33.14	1.75	8.92
Two Load	24.50	15.56	24.50	7.50	24.50	39.60	2.00	11.84

Types Of Bearing ⇨	Healthy Bearing				Combined Bearing Defects			
Response ⇨	Horizontal		Vertical		Horizontal		Vertical	
Parameter ⇨ / Loading ⇩	Frequency	Amplitude	Frequency	Amplitude	Frequency	Amplitude	Frequency	Amplitude
No Load	1.75	11.69	1.25	9.09	24.25	30.39	2.00	8.80
One Load	24.25	27.94	24.25	22.26	24.25	107.73	24.25	24.92
Two Load	24.25	21.31	24.25	21.31	24.25	87.32	24.25	28.42

Table 2 Comparison Between the rpm's

In a shaft when an healthy bearing and bearing with corrosion pitting is attached to shaft and over the shaft at different rpm's like 250,500,750,1000,1250,1500 on varying loading conditions of no load, one load and two load. When the two bearings are mounted and a comparison between the two bearings is done over a frequency domain graph in the Omnitrend Software we concluded that at no load condition the low frequency will result in higher amplitude in both horizontal and vertical response. Whereas in one load and two load condition the higher frequency will result in higher amplitude in both horizontal and vertical condition. When we see the condition that the shaft have healthy bearing and bearing with the outer race crack at the varying condition no load, one load and two load. When we compare condition at the different rpm's than we see that at the one load and two load have high amplitude at the high frequency. When we see the condition of bearing with the inner race crack and healthy bearing mounted on the shaft, attached with motor than we see that at the different loading condition have high amplitude at the same frequency. And in the final when the combined effect of the bearing mounted of the shaft then higher amplitude is there at the one load condition. By this we conclude that at the one load condition have high amplitude in the case of ball with corrosion pitting and combined effect of the bearing at the horizontal response. When we apply the load on the shaft the vibration produces more in the bearing than we analysis the bearing at the different loading condition and excitation is occurred at the high frequency.

V. Conclusion

This study is cantered around the detection of bearing fault and classify them by machine learning method and comparison between the different condition of the bearing. Feature are extracted in the frequency-domain vibration signals by Vibs-Canner which have piezoelectric accelerometer vib 6.140 mounted on the bearing fault simulator system which have different type of bearing on it. The frequency- domain response observed different fault condition of bearing show the severe vibration occur under bearing with rough inner surface and ball with corrosion pitting. When we increase the speed of the shaft then the combined effect bearing sleeve sleep and not rotated without loading.

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