# ANALYSIS OF FAULT DIAGNOSIS OF BEARING USING MACH SPECTRUM METHOD

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*Abstract:* **Direction upcoming are one of the most important reason of dismemberment of rotation machines. Thus the detection and diagnosis of mechanical faults in bearings is very fateful for the desired operation. Any industry seeks for 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 use of predictive maintenance techniques for the determination of faulty and healthy bearing on different positions. An apparatus consisting a test bench which has a motor and a shaft attached along with two different type of bearing like faulty bearing and healthy bearing. The vibration reaction are obtained and investigated for different positions of bearing. The particular imperfections are considered as that is non driven end and driven end of the bearing. After performing the experiment, comparison will be done between the experimental data which are the input for the omnitrend software. The result shows that when we compare all the condition than we will use as a automated diagnosis of bearing. It is also observed that severe vibration occur under the faulty bearing and when the speed is increases then all the defective bearings stop to rotate.**

*Keywords*: **Predictive Maintenance Techniques.**

## 1. INTRODUCTION

In rotary machines roller bearings are the most commonly and precisely used machine part. The bearing is used in machines because of various reasons but the main reason behind using a roller bearing is ‘it helps to reduce the friction and the effort to rotate or rolling between two relative machine parts’. Besides it can also operate advantageously when it is having some minor defects or it is broken. It also gives the advantage to connect the shaft directly to the given housings of various size and operating conditions. However, when any rotating system is failed or have some defect where the roller bearings are not used then changing the whole assembly or housing are some options to repair in some cases we are willing to change the entire shaft but these whole processes requires more attention and cost while to introduce a bearing in between will reduce the cost and the damage to the other machine parts. Usually there is no relative movement in the middle of shaft and inner ring or the outer ring with housing. So there is less possibility for the shaft or housing to be worn out. Usually the bearing first cracks and then the shaft or housing is broken. If the above conditions are considered then one can easily conclude that: simply replace the particular bearing with the same parameters from the market. That’s why bearing are so often used. Roller bearings are used for the high load bearing conditions and the rotating conditions. It is required to have a full observation on the rotating machines to prevent the complete error or before the conditions get worse. The quality of the product can get reduced due to the noise and the vibration created by the bearing. 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. The vibrations in the bearing are caused by the irregularities of the geometry or the surface of the contacting element. The distributed defects produced, roughness or waviness or misaligned races and off-size rolling elements. Similarly local defects consist of cracks or corrosion pitting and spalls on the rolling surfaces.

If these irregularities or the defects are come across with each other while operating conditions it can cause the resonance in those parts and in machine too. 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. A vibration transducer is fixed on the bearing housing to detect the resonance pulse generated in the bearing. 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.

The experimental data is based on the frequent-domain vibration signals. Various bearings, operating on various rpm and working conditions are used to collect the data. The comparisons are done in different frequencies and the velocities that are obtained from the setup. The faulty conditions can be detect easily by the software OMNI TREND.

## 2. SUPPORT VECTOR MACHINE

Support vector machine is a method based on statistical learning theory and useful for supervised machine learning method based on the statistical learning theory. It is a useful method for classification and regression in small-sample cases such as fault diagnosis. A simple case of two classes is considered, which is separated by a linear classifier. Triangles and squares stand for these two classes of sample points. Hyper plane H is the plane of separation which separate two classes $H_1$ and $H_2$ which are parallel in direction with respect to H and passes through the sample points to H in both the classes. The distance between $H_1$ and $H_2$ is vey less. The support vector machine produces a linear boundary between the two classes and represent in such a manner that the margin is maximized. which results in less amount of error. The nearest Sample points are used to represent the margin generally known as support vector. We can further proceed in the support vector machine.

## 3. EXPERIMENTAL SETUP AND DATA ACQUISITION

Trial are carried on a test mechanical assembly to deliver get ready and test information. The apparatus is associated with the vibs- canner which have piezoelectric transducer vib 6.140 which is mounted on the bearing house when we obtain motion on the bearing. A variety of condition are simulated on the bearing at various speeds. Distinctive parameters of bearing used for the study are recorded in Table 1. accelerometers are utilized for getting the vibration signals from different stations on the mechanical get together. Signatures for healthy bearings operation establish the baseline data. This baseline data can then be used for comparison with signatures obtained under faulty conditions. In the wake of gathering the vibration signals, notable gimmicks are collected and arranged to structure a peculiarity vector which is sustained to omnitrend Software to prepare it. The information are gathered for distinctive issue states of direction. Various position are considered in bearing components are as show in figure 2. A variety of position on bearings are simulated on the rig at different rotor speed 500, 750 and 1000 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.

**Figure 1 Bearing Fault Simulator System**

Planning/test data are made using hanging on for holding on for different Position. The accompanying condition are presented in the apparatus:

(a) Healthy bearing at driven end and healthy bearing at non-driven end

(b) Healthy bearing at driven end and faulty bearing at non-driven end

(c) Faulty bearing at driven end and healthy bearing at non-driven end

(d) Healthy bearing at driven end and faulty bearing at non-driven end

The following cases are considered for acquiring training data:

From the data acquisition system:

(a) Healthy bearings (HB).

(b) Combined bearing defects (CBD).

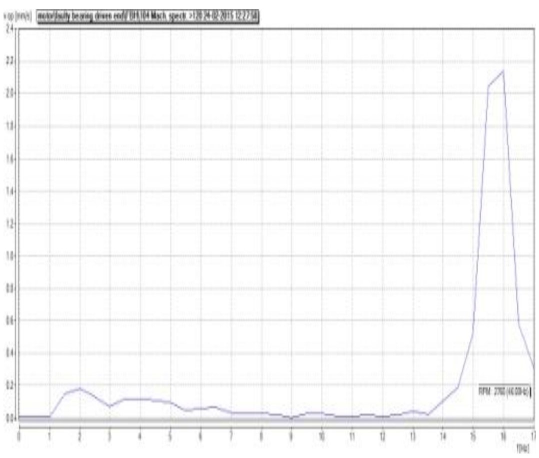
**Table 1 Parameters of Bearing used for experiment**

| Parameters | Value |
|---|---|
| Bearing Specification | 2205 |
| Outer race diameter | 52 mm |
| Inner race diameter | 25 mm |
| Width | 18 mm |
| Type | Self-Aligning Ball Bearing |

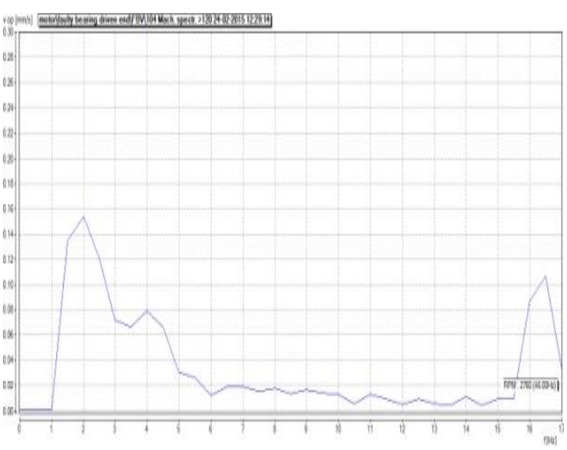
**Figure 2 Healthy Bearing 2205 And Faulty Bearing 2205**

Frequency responses are obtained at various speeds and with different conditions with considerations of all cases in a phased manner. The frequency responses at 1500 rpm at faulty bearing at driven end and healthy bearing at non-driven end is shown in Figure 3 respectively:

**(a) Faulty Bearing At Driven End**



**Horizontal Response**



**Vertical Response**

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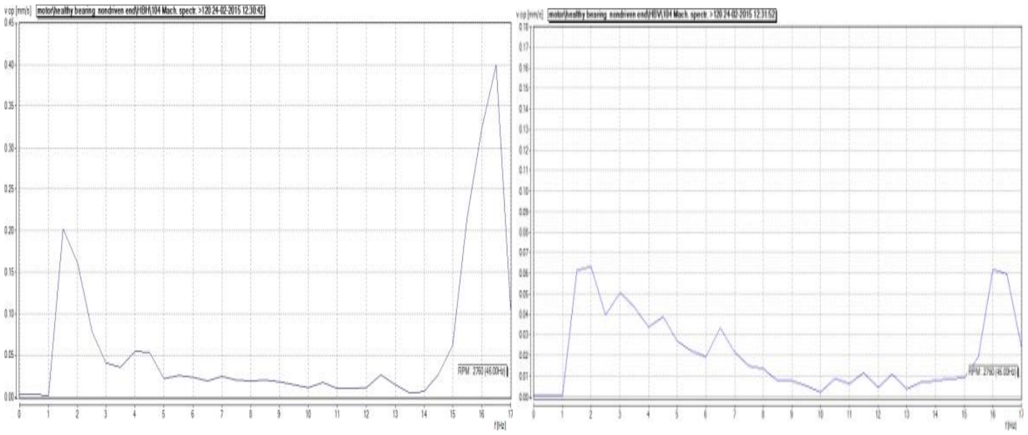
**(b) Healthy Bearing At Non-Driven End**



**Horizontal Response** **Vertical Response**

**Figure 3. Vibration Signal From Various Bearing Conditions At 1500 rpm With Condition**

## 4. RESULT

**Table 1: Showing the frequency and velocity variation when healthy bearing are used on both ends.**

| Types Of Bearing ⇨ | Healthy Bearing | | | | Healthy Bearing | | | |
|---|---|---|---|---|---|---|---|---|
| Response ⇨ | Horizontal | | Vertical | | Horizontal | | Vertical | |
| Parameter ⇨ / Loading ⇩ | Frequency | Velocity | Frequency | Velocity | Frequency | Velocity | Frequency | Velocity |
| No Load | 16.25 | 1.01 | 16.25 | 0.13 | 16.25 | 1.10 | 16.00 | 0.14 |

The following values are obtained when we have fixed the healthy bearing at the driven end and the same bearing is also used at the non-driven end the bearing used for the experiment is 2205 bearing. The experiment has been done on the various operating speed (RPM). The maximum speed obtained on which the highest mach ratio was obtained was 1000 RPM which is corresponding to the frequency equal to 16.25Hz.In the given table-1 the variation of the velocity at different range of frequencies has been shown. As we can see at the frequency 16.25 Hz the velocity at the driven end is 1.01 mm/s, when we are using the healthy bearing at the side of the rotor element. At the same frequency we are getting the velocity of 1.10 mm/s at the non-driven end, these observations are done when we are operating the system at horizontal boundary conditions. The set of the following values are also being calculated in the vertical operating conditions. The values obtained are – at 16.25 Hz the velocity is 0.13mm/s at the driven end and at 16.00Hz the obtained value of velocity is 0.14mm/s. we can conclude from the above data that the velocity in the horizontal conditions is increased at the non-driven end when we are operating at the same frequency i.e- 16.25Hz. Similarly working in the vertical operating conditions the velocity is increased by a small fraction as we are operating at the same frequency i.e- 16.00Hz.

**Table 2: Showing the frequency and velocity variation when healthy and faulty bearing are used**

| Types Of Bearing ⇨ | Healthy Bearing | | | | Faulty Bearing | | | |
|---|---|---|---|---|---|---|---|---|
| Response ⇨ | Horizontal | | Vertical | | Horizontal | | Vertical | |
| Parameter ⇨ / Loading ⇩ | Frequency | Velocity | Frequency | Velocity | Frequency | Velocity | Frequency | Velocity |
| One Load | 12.00 | 1.51 | 16.00 | 0.26 | 16.00 | 8.38 | 16.00 | 0.77 |

In the given table-2 the variation of the velocity at different range of frequencies has been shown. As we can see at the frequency 12.00 Hz the velocity at the driven end is 1.51 mm/s, when we are using the healthy bearing at the side of the rotor element. At the 16.00Hz we are getting the velocity of 8.38 mm/s at the non-driven end, these observations are done when we are operating the system at horizontal boundary conditions. The set of the following values are also being calculated in the vertical operating conditions. The values obtained are – at 16.00 Hz the velocity is 0.26mm/s at the driven end and at 16.00Hz the obtained value of velocity is 0.77mm/s. We can conclude from the above data that the velocity in the horizontal conditions is increased drastically at the non-driven end when we are operating at the same frequency i.e- 16.00Hz. Similarly working in the vertical operating conditions the velocity is increased by a small fraction as we are operating at the same frequency i.e- 16.00Hz.

**Table 3: Showing the frequency and velocity variation when faulty bearing are used on both ends**

| Types Of Bearing ⇨ | Faulty Bearing | | | | Faulty Bearing | | | |
|---|---|---|---|---|---|---|---|---|
| Response ⇨ | Horizontal | | Vertical | | Horizontal | | Vertical | |
| Parameter ⇨ / Loading ⇩ | Frequency | Velocity | Frequency | Velocity | Frequency | Velocity | Frequency | Velocity |
| One Load | 16.50 | 3.36 | 16.50 | 0.35 | 16.50 | 6.80 | 16.50 | 0.40 |

In the given table-3 the variation of the velocity at different range of frequencies has been shown. As we can see at the frequency 16.50 Hz the velocity at the driven end is 3.36 mm/s, when we are using the healthy bearing at the side of the rotor element. At the same frequency we are getting the velocity of 6.80 mm/s at the non-driven end, these observations are done when we are operating the system at horizontal boundary conditions. The set of the following values are also being calculated in the vertical operating conditions. The values obtained are – at 16.50 Hz the velocity is 0.35mm/s at the driven end and at 16.50Hz the obtained value of velocity is 0.40mm/s at the non –driven end. We can conclude from the above data that the velocity in the horizontal conditions is increased at the non-driven end when we are operating at the same frequency i.e- 16.50Hz. Similarly working in the vertical operating conditions the velocity is increased by a small fraction as we are operating at the same frequency i.e- 16.50Hz.

**Table 4: Showing the frequency and velocity variation when healthy and faulty bearing are used**

| Types Of Bearing ⇨ | Faulty Bearing | | | | Healthy Bearing | | | |
|---|---|---|---|---|---|---|---|---|
| Response ⇨ | Horizontal | | Vertical | | Horizontal | | Vertical | |
| Parameter ⇨ / Loading ⇩ | Frequency | Velocity | Frequency | Velocity | Frequency | Velocity | Frequency | Velocity |
| One Load | 16.00 | 2.14 | 2.00 | 0.15 | 16.50 | 0.40 | 2.00 | 0.14 |

In the given table-4 the variation of the velocity at different range of frequencies has been shown. As we can see at the frequency 16.00 Hz the velocity at the driven end is 2.14 mm/s, when we are using the healthy bearing at the side of the rotor element. At 16.00Hz we are getting the velocity of 0.40 mm/s at the non-driven end, these observations are done when we are operating the system at horizontal boundary conditions. The set of the following values are also being calculated in the vertical operating conditions. The values obtained are – at 2.00 Hz the velocity is 0.15mm/s at the driven end and at 2.00Hz the obtained value of velocity is 0.06mm/s. We can conclude from the above data that the velocity in the horizontal conditions is decreased at the non-driven end when we are operating at the same frequency i.e- 16.50Hz. Similarly working in the vertical operating conditions the velocity is decreased by a small fraction as we are operating at the same frequency i.e- 2.00Hz.

## 5. 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 position of bearing show the severe vibration occur under the faulty bearing. When we need to rotate the faulty bearing mounted on the shaft we have to add load on the shaft.

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