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Vibration Analysis To Evaluate The Working Status Of The Roller Bearing

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ABSTRACT
Roller bearings are types of bearing in important mechanical drive structures. During the work of the drive systems, the bearings become reduce reliable over time. Sudden bearing failures can lead to severe damage to production lines. Evaluation of their working status should be done periodically and regularly. In this paper, I came up with the solution of working vibration analysis to evaluate the condition of the bearings. Analyzing the signal spectrum of vibrations and parameters of different types of bearings we can determine the fundamental problems of the bearings.
Keyword: Ball bearing, Roller bearing, Vibration analysis.

I. INTRODUCTION

The roller bearing is a form of shaft bearings, this is a mechanical structure that minimizes friction by shifting the sliding friction of two parts in contact with each other when moving into rolling friction between rollers or ball bearings was fixed in an annular frame.

Structure of bearings include an Inner ring, an outer ring, a separator ring and a roller. The inner and outer rings are usually grooved to guide the rollers and to reduce stress. The inner ring is fitted with a spindle shaft, the outer ring is fitted with a shaft bearing (machine chassis, machine body). Usually the inner ring rotates with the shaft, while the outer ring stays still, but sometimes the outer ring rotates with the bearing and the inner ring stays still with the shaft.

Figure 1. Roller bearing structure

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The roller bearings are commonly used in many types of machines: metal cutters, electric machines, cars, airplanes, tractors, agricultural machines, cranes, construction machines, mines, in reduction gear boxes, in mechanical structure, etc. Some typical roller bearings are shown in Figure 2 and Figure 3.

1.1. Types of roller bearings commonly used

- Ball bearing one row (Figure. 2a): Mainly for bearing radial force, but can also bear axial force equal to 70% of the unused radial force (unused radial force is the difference between radial force for allowed with the actual radial force). The ball bearing one row can work normally when the shaft is tilted at a slight angle, not exceeding 15'- 20'.

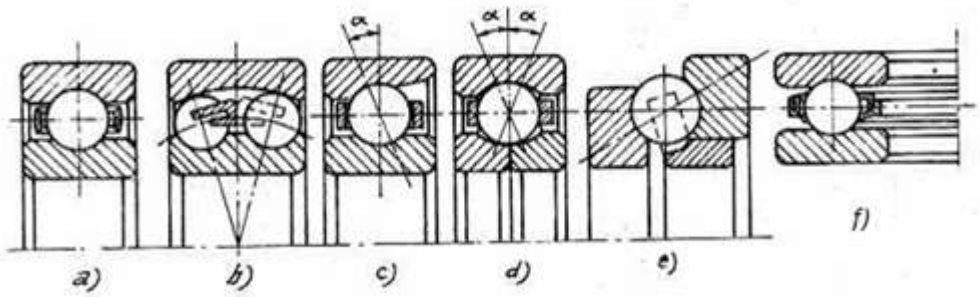

Figure 2. Types of ball bearings

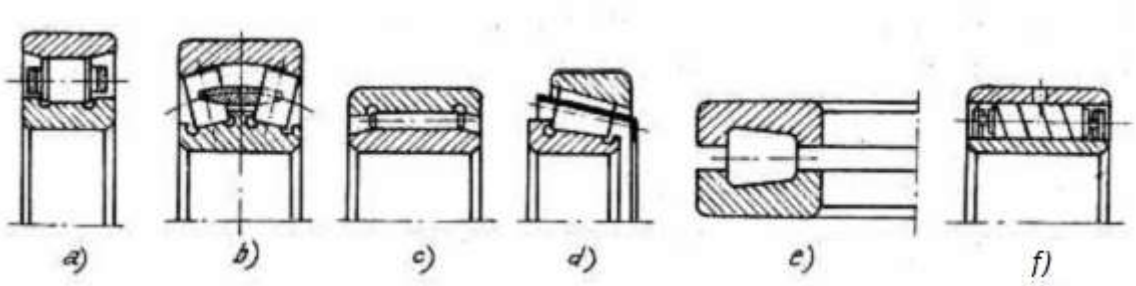

Figure 3. Types of roller bearings

- Double row spherical roller bearings (Figure 2b): Mainly subjected to radial loads, but can also bear additional axial loads equal to 20% of the unused radial bearing capacity. The Double row spherical roller bearings can work normally when the shaft is inclined at an angle of up to 2' - 30'.
- The block one row ball bearing (Figure 2c): Withstand both radial and axial forces. The bearing capacity of this bearing is larger than the bearing one row about 30 ÷ 40%. Bearing capacity along the axis depends on the contact angle between the ball and the outer ring - the greater the contact angle, the greater the bearing capacity.
- The short cylindrical roller bearing fixed one row (Figure 3a): Mainly for bearing radial forces. Compared with the one row ball bearing of the same size, this bearing has a radial force of about 70% and has a better impact resistance. However, some types of short cylindrical roller bearings cannot withstand axial forces (Figure 3a) and do not allow tilting of the shaft.
- Double row spherical roller bearings (Figure 3b): Mainly subjected to radial forces, the bearing capacity of this type is twice that of a double row spherical roller bearing of the same size and can withstand force axial with 20% of the unused radial force.
- Needle bearing (Figure 3c): A bearing in which the rollers are small long cylindrical chopsticks - called needle bearing. The number of needles is higher than the number of chopsticks in the conventional roller bearings. Needle bearings are often used where the size of the direction of the needle is limited.
- Taper roller bearing (Figure 3d): Can bear both radial and axial forces. The taper roller bearings

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bear radial 170% compared to bearings of the same size. This type is used in machine construction because of simple assembly, gap adjustment and convenient wear compensation.

- Helical roller bearing (Figure 3e): A bearing where the roller is a hollow cylinder, rolled up by thin steel tape (called a cylindrical roller bearing), this bearing does not withstand axial forces. Due to the high elasticity of the cylindrical roller, the bearing withstands good impact load, can work normally when the shaft is tilted to 30'.

1.2. Operating parameters of bearings

According to [1] the main operating parameters of bearings are noise, temperature, vibration and lubricant condition.

- Noise of bearings: During operation, use an audio monitoring device to measure the volume and characteristics of noise as the bearings rotate. The failure of the bearing can be distinguished as the flaking as based on the unusual characteristics of the noise.
- Bearing temperature: The bearing temperature can be estimated from the temperature measured from the outside of the bearing housing and can be measured directly from the bearing outer ring with a probe passes through an oil hole on the pillow housing. Usually the bearing temperature rises slowly after starting the machine until it runs smoothly after about 2-3 hours. The bearing temperature when running stably depends on the load, the rotation speed and the heat transfer characteristics of the machine. Insufficient lubrication or improper assembly can cause the bearing temperature to rise quickly. Such cases should temporarily stop the device and take corrective measures.
- Vibration on bearing: Abnormalities of bearings can be analyzed by measuring the vibration of a running machine. A spectrum chart analyzer is used to measure the magnitude of the vibration and the distribution of frequencies. The test results can identify the cause of the bearings' abnormalities. The measurement data is changed according to the operating conditions of the bearing and the vibration measuring position. Therefore, the evaluation criteria for each measuring device should be determined. Monitoring of vibration abnormalities from bearings during operation is very helpful in maintenance.
- Effect of lubrication: The main purpose of lubrication is to reduce friction and reduce wear inside the bearings to avoid premature bearing damage. Lubricant helps prevent direct contact of metal parts such as bearings, inner rings, outer rings and separators; Reduces heat generation due to friction and cooling effects, seals and prevents rust, extending bearing life.
- Choice of lubricants: There are two main methods for lubricating bearings are grease lubrication and oil lubrication. Depending on the condition and purpose of using choose the appropriate lubrication method to achieve the best performance of the bearing.

II. FAILURE STATUS AND CAUSES OF THE ROLLER BEARING FAILURE

When the roller bearings are used under ideal conditions, the types of bearing failures that arise are fatigue types. Usually the rollers bearing life is expressed by working time or the total number of revolutions before fatigue occurs on the inner ring, outer ring, on the roller, fatigue arises due to changing stresses in cyclical.

Roller bearings may appear cracks earlier than normal, causes of this type of failure include:

- Using the bearing is incorrectly.
- Installing is wrong drive or the installing process is not correctly.
- The lubricant is broken, the lubrication method is not correct or not covered.
- Speed and temperature work are not properly.
- Dirty lubricant is generated during install.
- Use a heavy load (overload).

When bearing failure phenomena begins to appear, this stage is important to focus on the study of the cause of the bearing failure. At this time, not only the roller bearings but also the shaft, bearing cover and lubricant have been used should also be considered at the same time with the determination of the bearing status.

1.3. Abnormal activities, causes and remedies

The causes and remedies of abnormal operation of the bearings [1] - [3] are shown in Table 1.

Table 1. The causes and remedies of abnormal operation of the bearings

Abnormal operation	Causes	Remedies
The temperature rises abnormally	The internal slot is over allowed limit	Replace the new bearing

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		Deformation on bearings	Replace the new bearings carefully
		Due to overload	Adjust the bearing properly
		Error in assembly	Adjust the concentricity of the shaft with the pillow hole and the assembly accuracy
		Defect of bearings	Replace the new bearing
		Not enough lubricant	Add the right type of lubricantoil
		Incorrect type of lubricant	Replace the right type of lubricating oil
		Lubrication method is not correct	Replace lubrication method by adjusting or replacing new parts
		Lubricating oil: Lubricating excessively, lacking lubricant or Improper lubrication	Reduce the amount of lubricant and choose a harder type of grease. Add more lubricant. Use the right type of lubrication and proper lubrication method
		Unusual contact with hidden cushions and other parts	Reasonable sealing, mounting mode and reasonable mounting method
Strange noise	Loud noise of metal	Abnormal load	Mounting mode, internal slot, pre-load, position of body and shoulder are not reasonable
		Wrong assembly	Machining accuracy and axial concentricity with bearing holes and assembly accuracy are not reasonable
		Insufficient or incorrect lubrication	Add lubricant or choose another lubricant
		Rubbing of rotating parts	Change the design the round of the hidden corners
	Loud noise at regular intervals	There are cracks, corrosion or scratches in the groove	Replace or clean the bearings carefully, improve sealing and use clean lubricants
		There is a dimples	Replace the new bearings carefully
		There is flaking on the groove	Replace the new bearing
	Loud noise at irregular intervals	The slot is over allowed limit	Change install mode, slot and preload
		There is intrusion from the outside element	Replace or clean bearings carefully, improve cover and use clean lubricants
		There are cracks or scabs on the balls	Replace the new bearing
Excessive vibration		There is a dimples	Replace the new bearings carefully
		There are scabs	Replace the new bearing
		Wrong assembly	Ensure the perpendicularity between the shaft and the shoulder hole pillow
		Intrusion from external factors	Replace or clean bearings carefully, improve cover and use clean lubricants

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Leakage or color change of lubricant	Too much lubricant. Penetration of outer particles or abrasive particles	Reduce the amount of lubricant and choose a harder type of grease. Replace bearings or lubricants. Clean pillow chamber and internal parts

1.4. The most common failure types of roller bearing

In the course of working, usually there are some main types of damage on roller work surfaces [3]:

1.4.1. Exfoliating, pitting due to fatigue of the work surface

Pitting and flaking are often encountered on the work surface of details such as Inner ring, Outer ring, Ball. The cause of this phenomenon is due to severe wear, contact stress exceeds the permissible limit. This type of failure is usually located at some points on the sliding surface, the consequence of which is that when the growths and pits develop on a large area, it will lead to the sudden damage to working parts and stalling the operation of the entire device as shown in Figure 4. Therefore, the early diagnosis and detection of this type of failure plays a very important role in ensuring equipment operation.

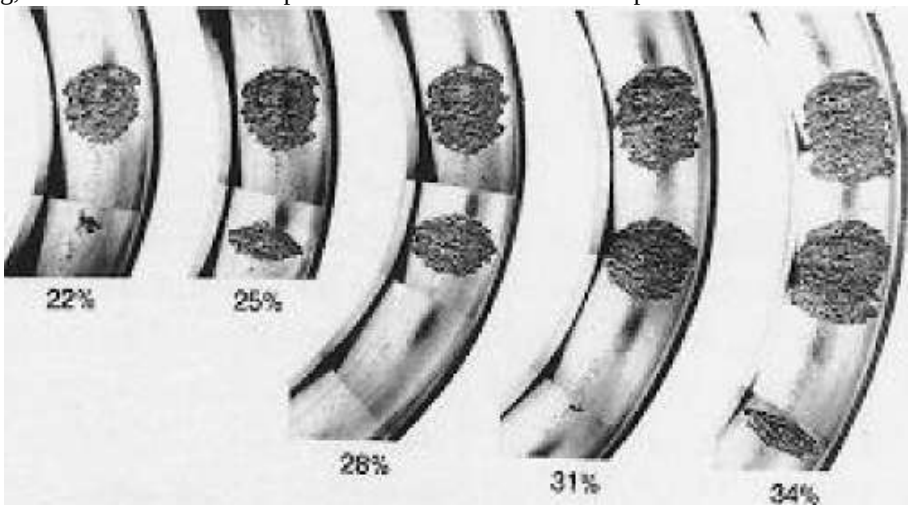
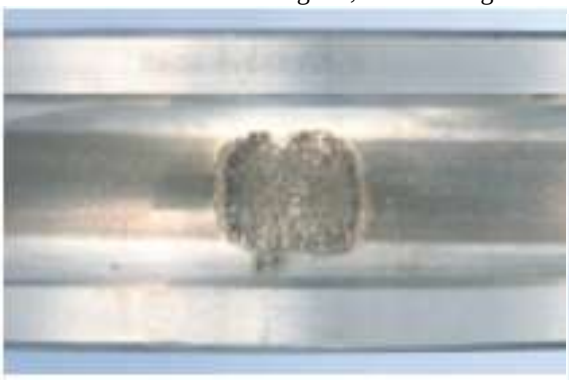


Figure 4. Pitting and flaking in roller bearings

Sloughing, pitting occurs early in the working time of the bearing under conditions such as during work, the internal tolerance of the bearing becomes narrower than the original, the bearings are tilted due to incorrect installation, cracks appear during installation, rust appears on the roller groove surface or on the roller, the shape of the shaft, the inner ring of the drive is incorrect.



a. Pitting on the inner rings in ball bearings

b. Pitting on the inner rings in cylindrical ball bearings

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c.Pitting on the outer ring 2-row cylindrical roller bearings d. Pitting on the ring in a taper roller bearings

e. Pitting on the inner rings in two-row self-arranged ball bearings

Figure 5. Some pitting pictures bearings

1.4.2. Attrition on bearings and rollers

Wearing occurs due to friction of the sliding surface (the top of the rollers with the side, the surface of the ring is separated from the roller surface). The main reason here is due to an inadequate and proper lubrication, under the influence of external factors. The wear increases in proportion to the operating time. The consequence of this type of failure is to increase the drive's radial clearance and make the premise for the next type of failure more dangerous. Wearing can be reduced by improving lubrication and increasing the quality of contact surfaces of parts during machining.

a. Wear between the roller bearing and the cylindrical roller bearing surface

b. Wear the outer ring's face of the 2-row roller bearings

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c. Wear due to friction with the ring hole in tapered roller bearings

d. Wear by friction with the outer ring of the roller bearings

e. Wear by friction with the inner ring of the roller bearings

Figure 6. Some pictures of wear of the bearings

III. VIBRATION MONITORING AND ANALYSIS

Vibration monitoring and analysis techniques are a very important part of equipment health monitoring techniques. Vibrations are contagious to other parts of the system. We can say that "This vibration is the cause of the other vibration". Therefore, detecting and preventing vibrations is a very important task and has great significance in the work of diagnosing and preventing damage.

All moving machines and assemblies cause repetitive vibrations in a certain frequency range.These oscillation frequencies can be determined from the geometry of the machine parts and plotted to describe the magnitude of the oscillation at each particular frequency value. These plots are called the frequency spectrum of the oscillation. The frequency spectrum of the oscillation allows us to distinguish vibrations caused by coupling inaccuracies, gearing, bearing failures, and many other phenomena.

Usually, the vibration of a part or a mechanical part is progressive. Therefore, it is possible to monitor the progression of vibrations if we have the right equipment and follow the correct methods.

Applying the vibration monitoring technique helps us to determine quite accurately the time of failure, or in other words, the time when a part or equipment is incapable of working. Accordingly, we will avoid accidental, unintended damages. Because normally this type of damage will incur a huge cost, especially for the parts and assemblies that are important to production.

In addition, the vibration monitoring technique will help prolong the life of the equipment such as bearings, rotors, roller, ... and other rotating parts.

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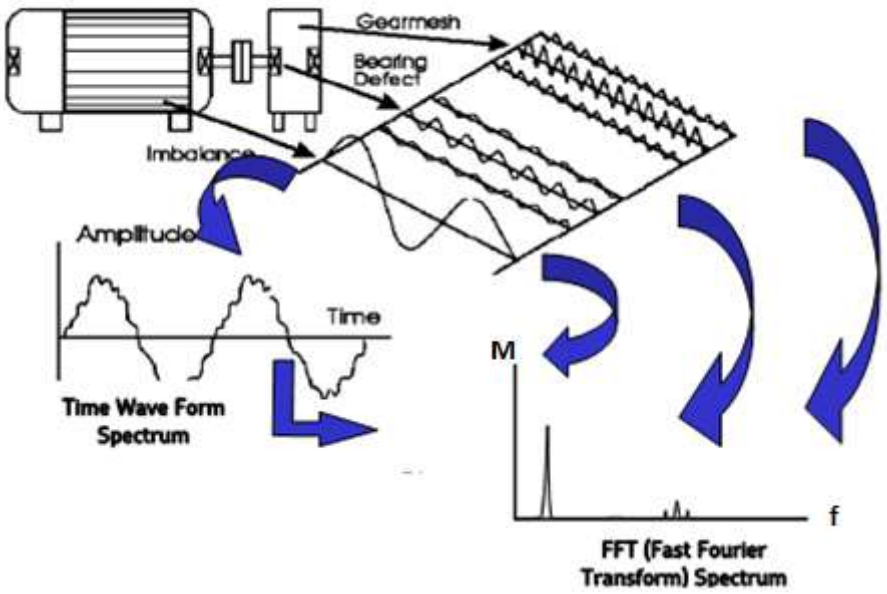

Figure 7. Monitor the status working of some devices through infrared thermal imaging

Vibration analysis is a measurement method used to have determined, predict, and prevent damage to rotating machinery. To Implement machine vibration analysis improves machine reliability and leads to higher machine efficiency and minimizes electrical or mechanical damage. Vibration analysis programs are used around the world in the industrial sector to detect faults in machines, plan machine repairs, and keep machines running properly, without failures for long periods of a long time.

Vibration monitoring is work performed while operating conditions are not changed, and when vibrations increase, impending failures are indicated. Vibration increases the failure also increases. When the mass and elastic mechanism is vibrated, force is appear. This force can be generated by the component acting directly on the structure; it can be either deployed by jet or transmitted to the device from the rotor via a bearing. The centrifugal force can be transmitted from the rotation due to an imbalance or it can be thrust by coupling in the gear drive or by the impact of fluid in the impeller.The parameters such as the rotation speed of the shaft, the number of teeth of the gear, the number of impeller, ... can calculate its frequency when there is vibration. By comparing the values of these frequencies with that when the vibration is increased, it can determine the source of that increase.

If a change in vibration can be detected earlier and analyzed, then we can do maintenance and repair before a failure occurs. Besides, a shutdown can be scheduled at an appropriate time. Thus, continuous periodic vibration measurement and analysis can be fundamental to monitoring the condition of rotating machines (Figure 7). Hence, a vibration monitoring system should be provided:

- Measure the increase in vibration to indicate the urgent need for attention.
- Measure the frequency at any increments that occur and allow diagnosis of the problem.

Hence, vibration monitoring is a useful tool for detecting the presence of a machine problem at an earlier time. Different problems cause vibrations in different ways.

IV. CONCLUSION

Abnormal operations and common bearing failures have a great impact on the maximum performance of the equipment, sudden shutdowns, and repair costs. To ensure that the working condition of the roller wheel is always reliable, it is essential to monitor, diagnose and check the working status of the roller.Several methods of working condition monitoring to diagnose bearing failures have been listed and analyzed. In this paper, I recommend a method of monitoring roller bearing performance that is based on vibration. We can accurately determine the machine condition by the measured oscillation values by monitoring the change of the oscillation frequency spectrum.We can accurately determine the machine condition by the measured oscillation values by monitoring the

change of the oscillation frequency spectrum. Once the oscillations occurring on the machine have been monitored, it is possible to accurately identify the failures before repairing the equipment and based on the magnitude of the oscillators caused by specific failures, it is precisely the forecast. Exactly how long the damage will occur. Since then, take full initiative in building a necessary repair and maintenance schedule.

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