Bearings & their Failures (Part III)

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Abstract

Bearings are among the most important components in the vast majority of machines and exacting demands are made upon their carrying capacity and reliability. Therefore it is quite natural that rolling bearings should have come to play such a prominent part in textile machinery. In this paper it is studied that why the bearings failures are occurring and the reasons and remedies for the failures. Once the reason for the failure is found out it is easy to find out the remedial steps for the same. When the cause of failure is detected the prediction of the bearing life is also very easy.

Click here to read Part I

Indentations

Raceways and rolling elements may become dented if the mounting pressure is applied to the wrong ring, so that it passes through the rolling elements, or if the bearing is subjected to abnormal loading while not running. Foreign particles in the bearing also cause indentations.

Washer of a thrust ball bearing subjected to overloading while not running.

Improper handling of a roller in a double row cylindrical roller bearing

i) Indentations Caused by Faulty Mounting or Overloading

The distance between the dents is the same as the rolling element spacing. Ball bearings are prone to indentations if the pressure is applied in such a way that it passes through the balls during the mounting or dismounting operations.

Self-aligning ball bearings are particularly susceptible to damage in such circumstances. In spherical roller bearings the damage originates as smearing and subsequently, if the pressure increases, develops into a dent. The same conditions apply in taper roller bearings that are unduly preloaded without being rotated. Bearings that are mounted with excessively heavy interference fits, and bearings with tapered bore that are driven too far up the shaft seating or sleeve, also become dented.

Indentations, caused by dirt, in of the receways of a roller bearing

ii) Indentations Caused by Foreign Particles

Foreign particles, such as swarf and burrs, which have gained entry into the bearing cause indentations when rolled into the raceways by the rolling elements. The particles producing the indentations need not even be hard. Thin pieces of paper and thread from cotton waste and cloth used for drying may be mentioned as instances of this. Indentations caused by these particles are in most cases small and distributed all over the raceways.

Smearing

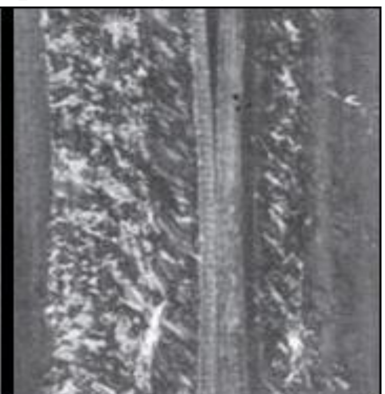
When two inadequately lubricated surfaces slide against each other under load, material is transferred from one surface to the other. This is known as smearing and the surfaces concerned become scored, with a "torn" appearance. When smearing occurs, the material is generally heated to such temperatures that rehardening takes place. This produces localized stress concentrations that may cause cracking or flaking. In rolling bearings, sliding primarily occurs at the roller end-guide flange interfaces. Smearing may also arise when the rollers are subjected to severe acceleration on their entry into the load zone. If the bearing rings rotate relative to the shaft or housing, this may also cause smearing in the bore and on the outside surface and ring faces. In thrust ball bearings, smearing may occur if the load is too light in relation to the speed of rotation.

i) Smearing of roller ends and guide flanges

In cylindrical and taper roller bearings, and in spherical roller bearings with guide flanges, smearing may occur on the guiding faces of the flanges and the ends of the rollers. This smearing is attributable to insufficient lubricant between flanges and rollers. It occurs when a heavy axial load acts in one direction over a long period, for instance when taper roller bearings are subject to excessive preloading.

Smearing on the surface of a roller from a spherical roller bearing

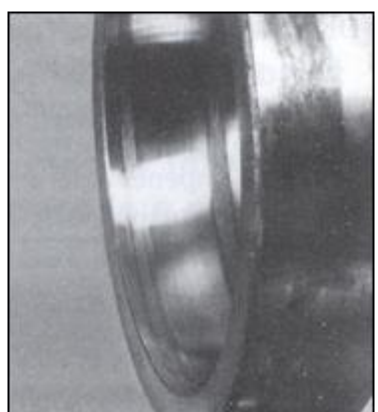
A cylindrical roller with end smearing caused by heavy axial loading and improper lubrication



Guide flange smearing attributable to the same causes as the smearing

ii) Smearing of rollers and raceways

In certain circumstances, smearing may occur on the surface of rollers and in raceways of spherical and cylindrical roller bearings. This is caused by roller rotation being retarded in the unloaded zone, where the rollers are not driven by the rings. Consequently their speed of rotation is lower than when they are in the loaded zone. The rollers are therefore subjected to rapid acceleration and the resultant sliding is so severe that in may produce smearing.



Skid smearing in both raceways of a spherical roller bearing outer ring

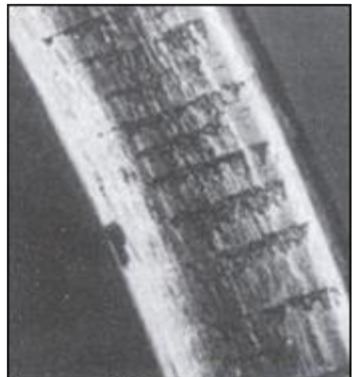
iii) Raceway smearing at intervals corresponding to the roller spacing

When cylindrical roller bearings are being mounted, the ring with the roller and cage assembly is entered askew, without being rotated. The rollers then scratch the raceway of the other ring, causing smearing in the form of long, transverse streaks. The rollers may be smeared too. This type of damage can be avoided if the bearing is well lubricated and one of the rings is rotated.

A cylindrical roller with smear streaks in the inner ring raceway and on the roller

iv) Smearing of external surfaces

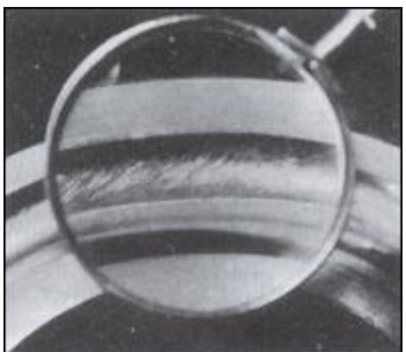
Smearing may occur on the external surfaces of heavily loaded bearings. Here, the smearing is the result of movement of the bearing ring relative to its shaft or housing. Smearing of the inner ring bore, outer ring outside surface and ring faces can only be avoided if the fits are tight enough to prevent movement of the ring concerned in relation to its seating. Increasing the axial compression does not result in any improvement.



Smeared face of a cylindrical roller bearing inner ring

v) Smearing In Thrust Ball Bearings

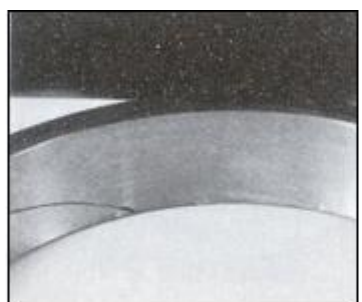
Smearing may occur in the raceways of thrust ball bearings if the rotational speed is too high in relation to the loading. The centrifugal force then impels the balls to the outer part of the shallow raceways. There the balls do not roll satisfactorily and a great deal of sliding occurs at the ball-to- raceway contacts. This leads to the formation of diagonal smear streaks in the outer part of the raceway. In the case of thrust ball bearings operating under light loads and at high speeds, such damage can be prevented by subjecting the bearings to extra loading, for instance by applying springs.



Thrust ball bearing raceway with smear streaks due to rotational speed of too high in relation to the load

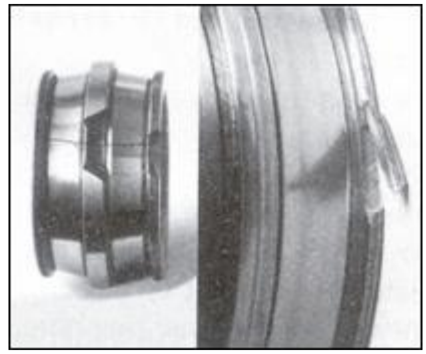
Cracks

Cracks may form in bearing rings for various reasons. The most common cause is rough treatment when the bearings are being mounted or dismounted. Hammer blows, applied direct against the ring or via a hardened chisel, may cause fine cracks to form, with the result that pieces of the ring break off when the bearing is put into service. Excessive drive up on a tapered seating or sleeve is another cause of ring cracking. The tensile stresses, arising in the rings as a result of the excessive drive-up, produce cracks when the bearing is put into operation. The smearing described in an earlier section may also produce cracks at right angles to the direction of slide. Cracks of



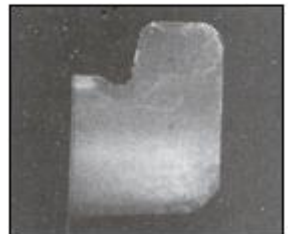
Fractured outer ring of a Self-aligning ball bearing

this kind produce fractures right across the rings. As in the fig. the indentations visible at the bottom edge of the ring were caused by rough treatment and the crack originated at one of these indentations.



i) Cracks caused by rough treatment

It is a cracked inner ring of a spherical roller bearing. One roller has been removed to allow the raceway of the left-hand of the photograph to be examined. The roller has then been hammered back in place, causing part of the centre flange to break away. The impacts have been transmitted via a roller in the other row and part of the outer flange has broken off too. At the same time the ring has cracked right through Inner ring of a spherical roller bearing with outer flange fracture produced by direct hammering.



ii) Cracks caused by excessive drive-up

It is the section of the inner ring of a spherical roller bearing. The ring has cracked because of excessive drive up. The fracture originated at the dark area by the bore chamfer.

iii) Cracks caused by smearing

It is the spherical roller bearing inner ring that has cracked right across following smearing of one face. The ring has been mounted to abut a spacer that has not had a sufficiently tight fit on the shaft. Consequently the spacer has rotated relative to the shaft and the bearing ring

iv) Cracks caused by fretting corrosion.

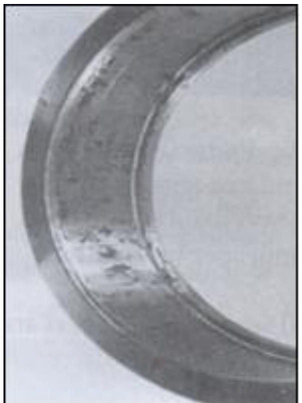
Spherical roller bearing inner ring with fretting corrosion and a transverse crack right through the ring. The fretting corrosion has caused the cracking

Longitudinal crack in a deep groove ball bearing outer ring with fretting corrosion

Surface distress

If the lubricant film between raceways and rolling elements becomes too thin, the peaks of the surface asperities will momentarily come into contact with each other. A small crack then form in the surfaces and this is known as surface distress. These cracks must not be confused with the fatigue cracks that originate beneath the surface and lead to flaking. The surface distress cracks are microscopically small and increase very gradually to such a size that they interfere with the smooth running of the bearing. If the lubricant film does not become too thin because of lubricant starvation or viscosity changes induced by the rising temperature or on account of excessive loading, there is no risk of surface distress.

Corrosion


Deep seated rust in the outer ring of a cylindrical roller bearing

Rust will form if water or corrosive agents reach the inside of the bearing in such quantities that the lubricant cannot provide protection for the steel surfaces. This process will soon lead to deep seated rust. Another type of corrosion is fretting corrosion.

i) Deep seated rust
A thin protective oxide film forms on clean steel surfaces Deep seated rust in the exposed to air. However, this film is not impenetrable and if water or corrosive elements make contact with the steel surfaces, patches of etching will form. This development soon leads to deep seated rust. Deep seated rust is a great danger to bearings since it can initiate flaking and cracks. Acid liquids corrode the steel quickly, while alkaline solutions are less dangerous. The salts that are present in fresh water constitute, together with the water, an electrolyte which causes galvanic corrosion, known as water etching. Salt water, such as sea water, is therefore highly dangerous to bearings.

ii) Fretting corrosion
If the thin oxide film is penetrated, oxidation will proceed deeper into the material. An instance of this is the corrosion that occurs when there is relative movement between bearing ring and shaft or housing, on account of the fit being too loose. This type of damage is called fretting corrosion and may be relatively deep in places. The relative movement may also cause small particles of material to become detached from the surface. These particles oxidize quickly when exposed to the oxygen in the atmosphere.


Fretting corrosion on the outer ring of a spherical roller bearing


Extensive fretting corrosion in the bore of a self-aligning ball bearing.

Cage Damage

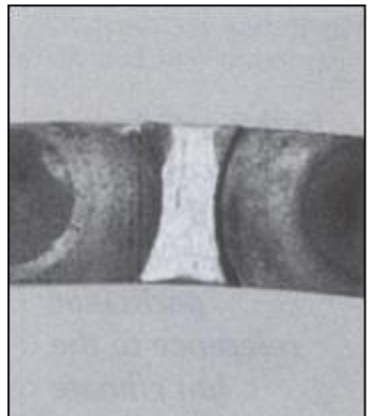
In many of the cases it is difficult to ascertain the cause. Usually other components of the bearing are damaged too and this makes it even more difficult to discover the reason for the trouble. However, there are certain main causes of cage failure, viz. vibration, excessive speed, wear and blockage.

a. Vibration: When a bearing is exposed to vibration, the forces of inertia may be so great as to cause fatigue cracks to form in the cage material after a time. Sooner or later these cracks lead to cage fracture.

b. Excessive speed: If the bearing is run at speeds in excess of that for which the cage is designed, the cage is subjected to heavy forces of inertia that may lead to fractures. Frequently, where very high speeds are involved, it is possible to select bearings with cages of special design.

c. Wear: Cage wear may be caused by inadequate lubrication or by abrasive particles. The idea with rolling bearings is of course to avoid sliding friction. However, where the cage is concerned, sliding cannot be eliminated in the contacts with the other components of the bearing. This explains why the cage is the first component to be affected when the lubrication becomes inadequate. The cage is always made of softer material than the other components of the bearing and consequently it wears comparatively quickly.

d. Blockage: Fragments of flaked material or other hard particles may become wedged between the cage and a rolling element, preventing the latter from rotating round its own axis. This leads to cage failure.



Fractured surface of the cage shwn in figure. The fatigue cracks are clearly visible

e. Other causes of cage damage

If the rings of a deep groove ball bearing are fitted out of alignment with each other, the path of the balls has an oval configuration. If the cage is centered on the balls, it has to change shape for every revolution it performs. Fatigue cracks then form in the material and sooner or later they lead to fractures. There is a similar case when a thrust ball bearing is fitted together with radial plain bearings. If clearance arises in the plain bearings, the washers of the thrust bearing become displaced in relation to each other. Then the balls do not follow their normal path and heavy stresses may arise in the cage.

Conclusions

1. From the above mentioned bearing failure causes it is become easy to improve the bearing run in life on the machine.
2. By considering the failure causes due to the passage of electric current some precautions can be taken to avoid bearing failures.
3. The bearing failures due to indentation, smearing, vibration, and crakes can be avoided by proper mounting and loading of the bearing.
4. Lubrication failures can be avoided by practicising adequate lubrication.
5. Failures like indentation and blockage can be avoided by preventing the chances of contamination.
6. Deep seating rust and fretting corrosion can be minimized by protecting the bearing from corrosion.

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