

## Harshwardhan Gupta's Design Tips-6

### Rolling Bearing Failure

In India, we often let a damaged rolling bearing run till the whole machine or equipment comes to a standstill. This mentality actually does more damage to your own pocket than you realize!

Usually there are Evidences much before the catastrophe. They are: Uneven running; Vibration; Reduced working accuracy – as in machine tools; Unhealthy running noise – high-pitched whine or low-pitched rumbling; Gradually increasing bearing noise or machine noise. Increased bearing heating,

There are mechanics and fitters, who will just wash the bearing in kerosene, completely pack it with grease, and manage to reduce the noise. They have simply masked the Evidences, just as paracetamol reduces fever, but does not cure its cause.

Bearings, just like hearts, normally fail under life-long fatigue. However, abnormal conditions like wrong mounting, wrong mating part tolerances, wrong lubrication, wrong sealing, wrong alignments, all contribute to premature failures.

When a rolling bearing shows signs of distress, or fails completely, dismantle it carefully, as if it is a piece of evidence, which it is. Take care that it does not get contaminated by outside dirt. DO NOT wash, clean or wipe the bearing. Bring it onto a clean surface under bright light, scoop out as much lubricant as possible and keep it separately for study. Now wash the bearing thoroughly but with a light hand, study it and make notes, then break open the cage and separate all the elements, clean again, and investigate it as follows:

#### Evidences, causes and remedies:

1. Evidence: **Localized flaking (relatively deep pitting), with undamaged areas of the**

**raceway appearing quite normal.** Classical fatigue can be recognized by pitting in the raceway of a deep groove ball bearing inner ring. The bright, slightly shining track is an indication of an otherwise normal bearing. Subsequent damage propagation results in material flaking occurring over the entire raceway. Cause: Normal compression fatigue damage, with cracks starting at the surfaces of the components in rolling contact either due to overload or damage due to foreign particles, in case of substandard bearings, inclusions in the bearing steel. In cases of advanced damage, the evidence may no longer be recognizable. Remedy: Replace the bearing, or this will lead to ruin. This is where reputed bearings score over substandard ones. Microscopic sand or slag inclusions in cheap steels leads to early fatigue failure. Misalignment and overloads, often due to rigidly constrained thermal expansions, also lead to early fatigue failure.

2. Evidence: **Blackening of the entire bearing.** Cause: overheating. Can be due to several reasons: Insufficient clearance under operating conditions, over-pre-loading, over-lubrication (too much churning at high speeds), under-lubrication, heat from external sources. Remedy: Check for tight running (bearing making gravelly noises), and reduce preload and reduce the grease.
3. Evidence: **Indentations corresponding to the rolling element pitch** in the raceways of non-separable bearings. Cause: Mounting forces were applied through the rolling elements. Remedy: Mount the tight fitted ring first. In the case of tight fits for both rings mount them simultaneously with the aid of a suitable disc.
4. Evidence: **Score marks corresponding to rolling element pitch** parallel to the axis in raceways of separable bearings. Cause: The ring was forced cross into the rolling element set. Remedy: Prevent misalignment during mounting of separable bearings. Assemble parts at the same time turning them relative to each other. Use a mounting sleeve, if necessary.

5. Evidence: **Random indentations**: Shallow indentations with very low raised edges (caused by soft particles like mild steel chips); Deep indentations with higher raised edges (caused by hard particles like carbide chips); Many small indentations with high raised edges (caused by brittle particles). Cause: Dirty mounting conditions, penetration of contaminants (defective sealing), contaminated lubricant. Remedy: Obviously, cleanliness during mounting and maintenance of the rolling bearings, use of proper seals, replacement of defective seals, periodic replacement of lubricant with washing-out of the bearings.
6. Evidence: **Brownish discoloration of the complete bearing surface**, consequential wear and premature fatigue, originating from the rust pits. Cause: unsuitable storage in more than 60% humidity; moisture condensation in storage; seal failure leading to dirt and water getting in; unsuitable lubricant. Remedy: Sensible storage conditions to comply with the specifications of the rolling bearing manufacturer, better sealing, lubricant with corrosion inhibitors.
7. Evidence: **Black etched pits**. Cause: corrosion due to ingress of acid fumes, chlorine, etc. Unsuitable storage (aggressive chemicals stored in the same room), Seal failure, Unsuitable lubricant. Remedy is obvious. Remember, most seals cannot withstand any pressure difference across them.
8. Evidence: **Marks like brinelling at roller pitch, but with no raised edges**. Cause: stationary vibrations often due to long truck rides (minute movements) of stationary machines, causing wear. Remedy: Isolate the bearings from such vibrations. Unloading the pre-load during long transportation also helps.
9. Evidence: **Corrosion in the bore of the inner race or on outer surface of outer race**. Cause: Fretting corrosion due to a loose fit, Remedy is obvious. You will have to rebuild or make the shaft / housing again.
10. Evidence: **Craters, or many craters in a row**. Cause: passage of electric current either due to bad earthing, careless welding or faulty design. Remedy: Avoid electrical current, even a low current flowing through the rolling elements.
11. Evidence: **Regularly spaced brownish fluting (fine knurling-like marks)**. Cause: continuous passage of electric current. Remedy: Same as above. Avoid electrical current, even a low current flowing through the rolling elements.
12. Evidence: **Damaged cage (retainer)**. Cause: Misalignment, excessive vibrations or impacts in addition to the normal cage loads, e.g. in vibration machinery or vehicles. Remedy: Align bearings properly, or use self-aligning bearings. Use bearings with solid cages (metal or polyamide) instead of sheet metal cages. Remember, excessive vibration may lead to cage rivet fracture.
13. Evidence: **Roughening of the contact areas between rolling elements and raceways**, metal abrasion, increased bearing clearance or reduced preload. Cause: wear promoted by foreign particles and abrasion, inadequate, aged or contaminated lubricant. Remedy: Higher viscosity lubricants, EP additives, shorter re-lubricating intervals, improved sealing.
14. Evidence: **Localized welding of the components in rolling contact**, (unfortunately quite common in India) (metal particles are torn away and applied to the opposite surface), overload and seizure. Bearings with a high proportion of sliding contact friction (tapered roller bearings, spherical roller thrust bearings) are particularly susceptible. Cause: lubricant starvation under high load and speed; excessive pre-load, detrimental preload due to heat expansion, skewing of rollers due to raceway wear. Remedy: Improvement of the lubrication (lubricant, EP additives, lubricant quantity) Reduction of the preload or increase of the axial clearance. Design Change.
15. Evidence: **Roughening of raceways and rolling elements**. Very common too. Cause: Rolling element sliding on the raceway under very low bearing loads with insufficient

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lubrication. Remedy: Slight preloading of the bearings, e.g. with springs.

In short, these are the culprits:

1. Open bearings,
2. Dust, dirt, humidity, aggressive chemicals,
3. Wrong mounting methods or tools,
4. Moisture ingress,
5. Too tight fit,
6. Too loose fit,
7. Too high preload,
8. Too low preload,
9. Tilted (misaligned) mounting, often in fabricated equipment,
10. Overload,
11. Too little load on a big high-speed bearing, so it bounces around
12. External vibrations.
13. External heat,
14. Excessive speeds,
15. Passage of electric current,
16. Improper (often cheap or recycled or fake) lubricant,
17. Dry bearing,
18. Over-greasing,
19. And last but not the least, counterfeit or recycled or sub-standard bearings made from cheap steel, leading to early fatigue-failure.

*Chalti Ka Naam Gaadi?* Think again. Damaged bearings means damaged pockets.

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### **Next Month: Pneumatic Systems**

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