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Bearing Root Cause Failure Analysis

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Premature bearing failures …

16% Poor fitting

36% Poor lubrication

14% Contamination

34% Fatigue

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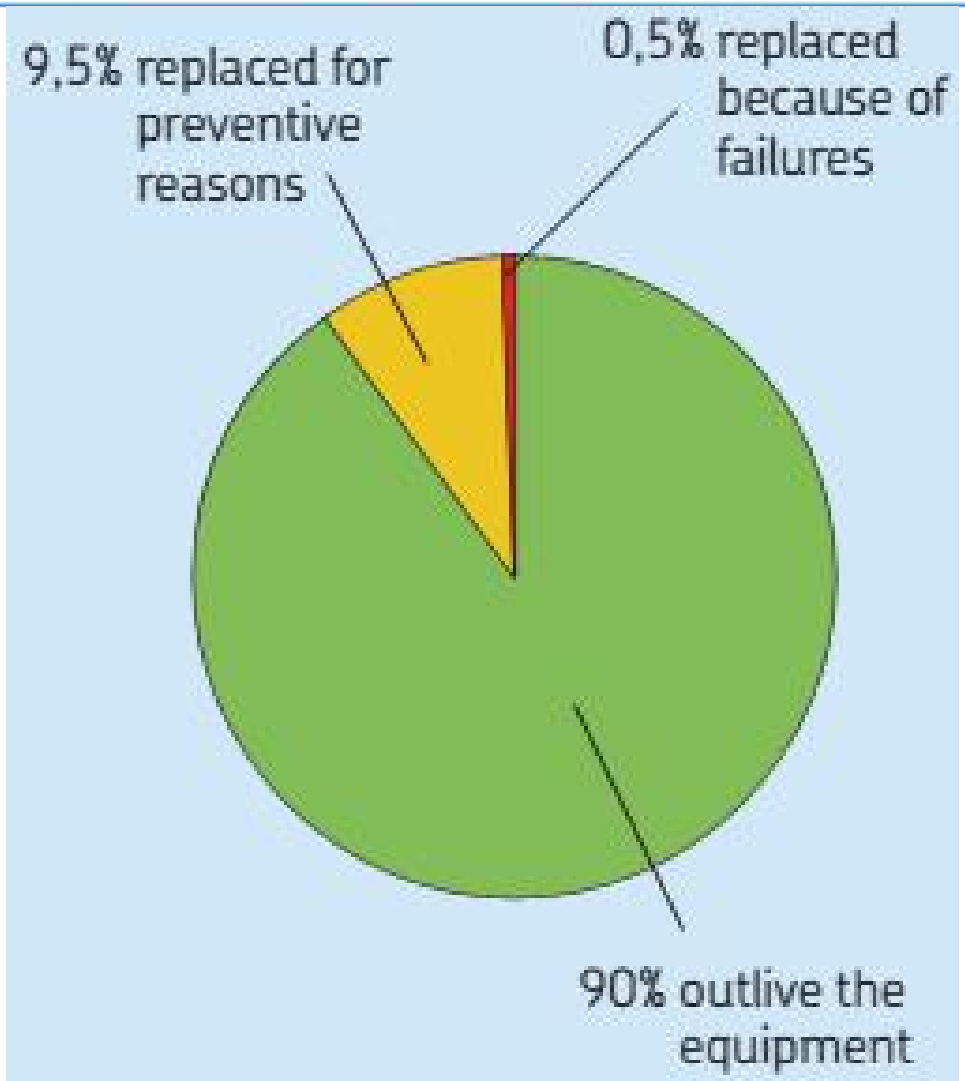
Bearing life and failure



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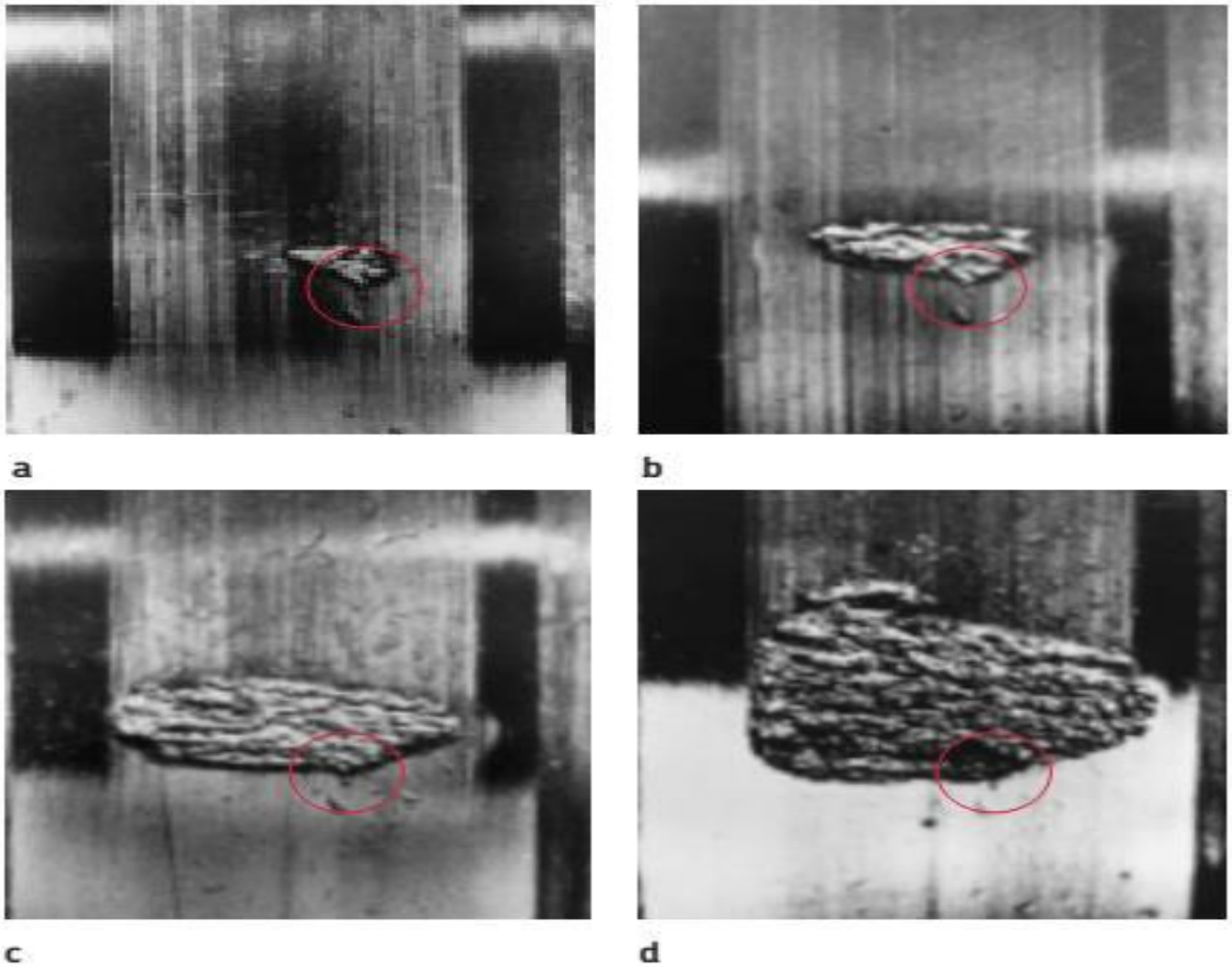

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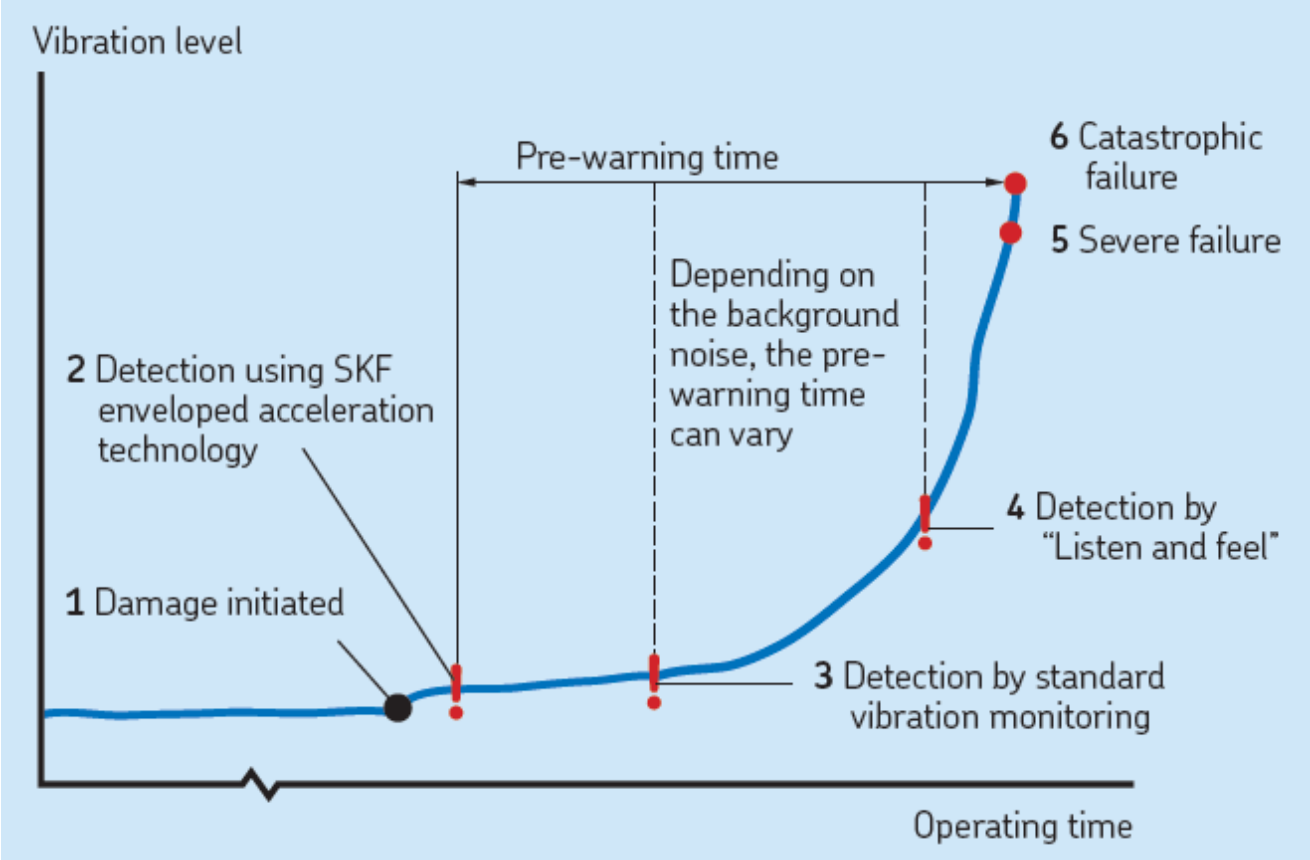
The advantage of advanced condition monitoring



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ISO classification of bearing damage and failure modes

The ISO 15243 standard is based primarily on features that are visible on the rolling elements, raceways and other functional surfaces.

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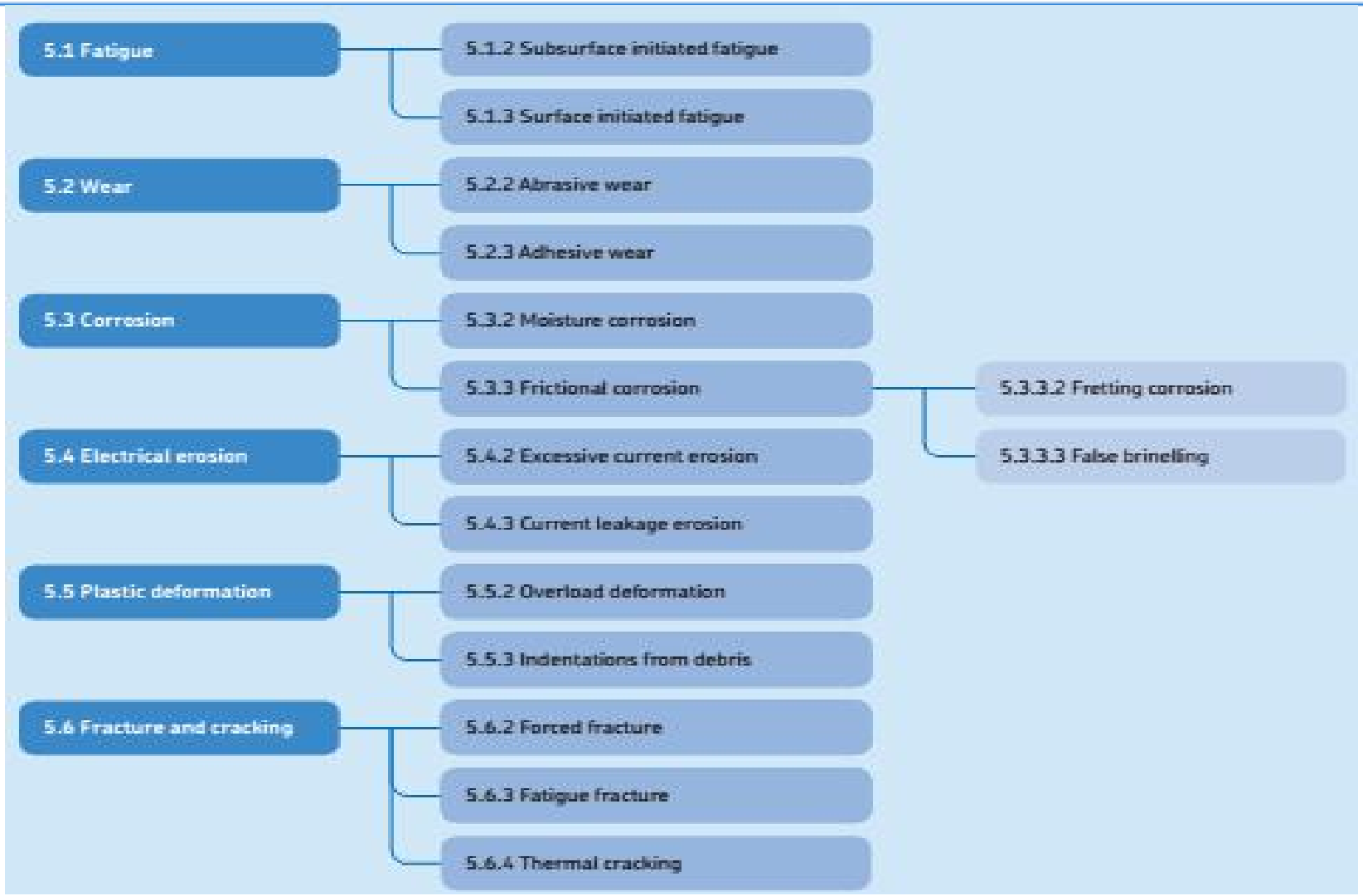

5.1 Fatigue
5.1.2 Subsurface initiated fatigue
5.1.3 Surface initiated fatigue
5.2 Wear
5.2.2 Abrasive wear
5.2.3 Adhesive wear
5.3 Corrosion
5.3.2 Moisture corrosion
5.3.3 Frictional corrosion
5.3.3.2 Fretting corrosion
5.3.3.3 False brinelling
5.4 Electrical erosion
5.4.2 Excessive current erosion
5.4.3 Current leakage erosion
5.5 Plastic deformation
5.5.2 Overload deformation
5.5.3 Indentations from debris
5.6 Fracture and cracking
5.6.2 Forced fracture
5.6.3 Fatigue fracture
5.6.4 Thermal cracking

Causes of pre-operational damage:

- Incorrect shaft and housing fits
- Defective bearing seats on shafts and in housings
- Static misalignment
- Faulty mounting practices
- Passage of electric current through the bearing (excessive voltage)
- Transportation, handling and storage

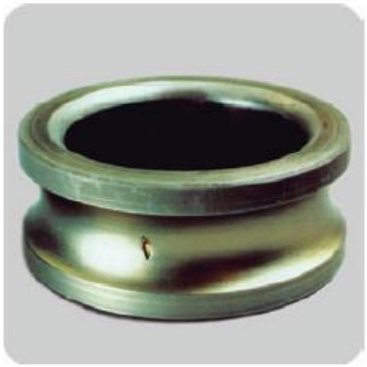
Causes of operational damage:

- Material fatigue
- Ineffective lubrication
- Ineffective sealing
- Vibration (false brinelling)
- Operational misalignment
- Passage of electric current through the bearing (current leakage)

Fatigue

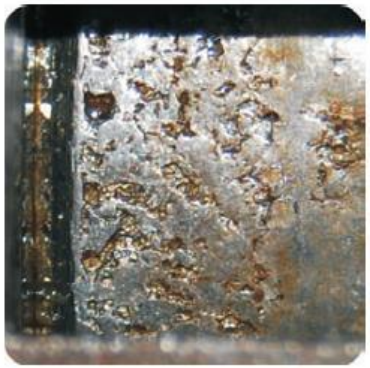
Subsurface initiated fatigue

Spalling of particles as a result of microcracks below the raceway surface



Surface initiated fatigue

Distress of the surface. Failure of the rolling contact metal surface asperities due to inadequate lubrication



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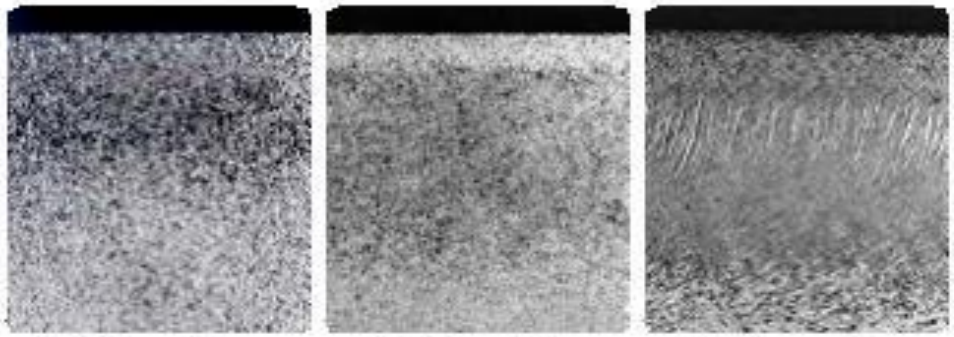
Sub-Surface Initiated Fatigue

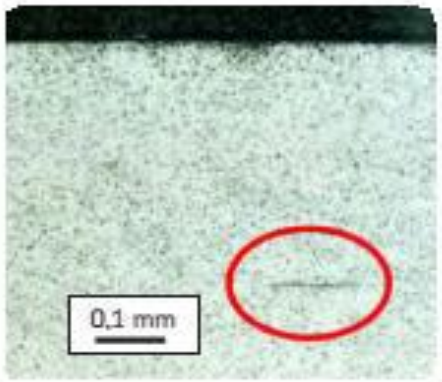
Changes in structure beneath the raceway surface over time (highly stressed, well lubricated small deep groove ball bearing)

Fig. 2



Crack development beneath the raceway surface (~ 0,3 mm)

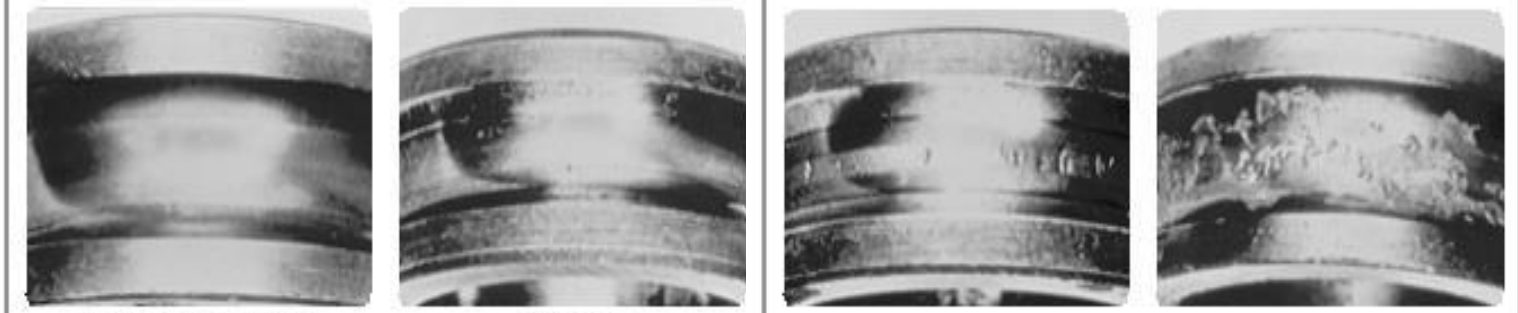
Fig. 3



Surface Initiated Fatigue

Progress of surface initiated fatigue on the inner ring of a deep groove ball bearing

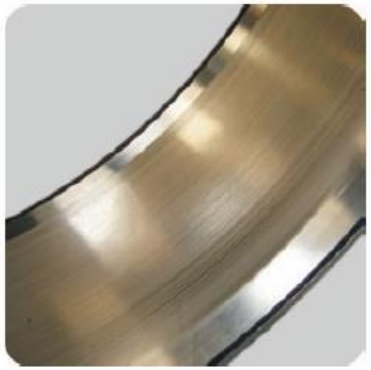
Fig. 10



Wear

Abrasive wear

The result of inadequate lubrication or the ingress of contaminants



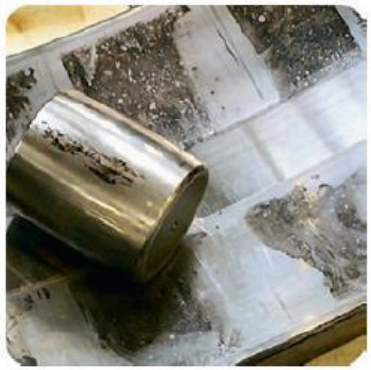
Adhesive wear

Material transfer from one surface to another as a result of frictional heat

Corrosion

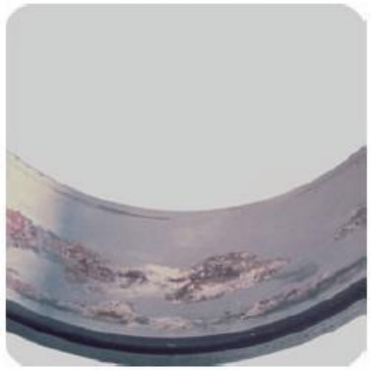
Moisture corrosion

Oxidation of the surfaces in the presence of moisture



Fretting corrosion

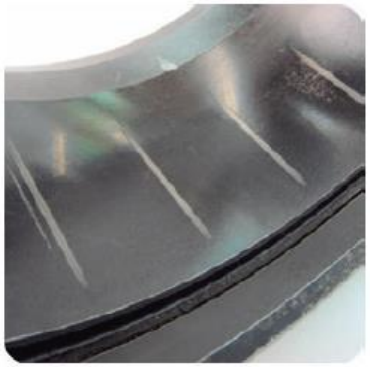
The oxidation and wear of surface asperities under oscillating micromovement between mating surfaces

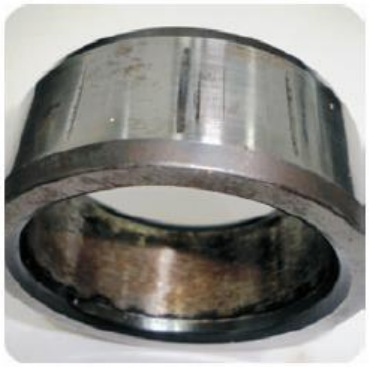


False brinelling

False brinelling

Shallow depressions in raceway/rolling element contact caused by cyclic vibrations on a non rotating bearing

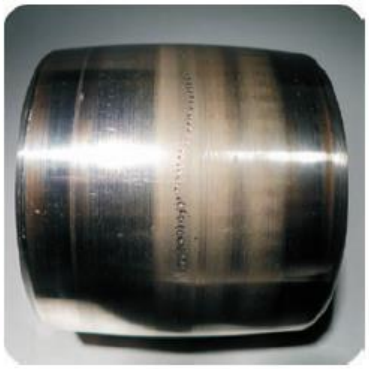




Electrical erosion

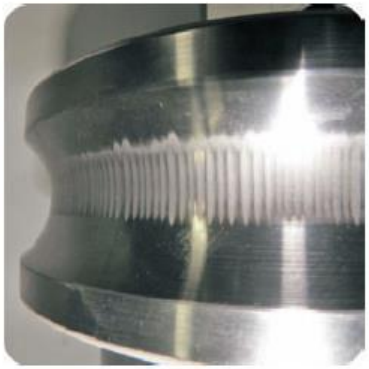
Excessive voltage

Sparking and localized heating from current passage in the contact area because of ineffective insulation



Current leakage

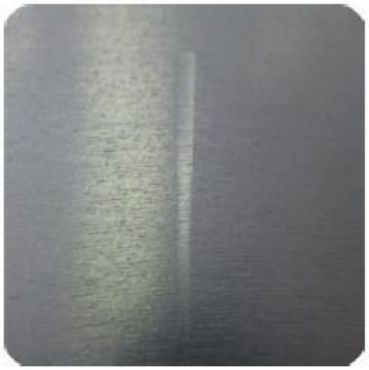
The generation of shallow craters from (low) current passage. They develop over time into flutes



Plastic deformation

Overload

Permanent deformation caused by static or shock overloads (true brinelling)



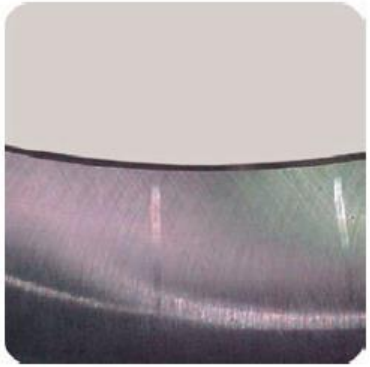
Indentation from debris

Dents as a result of particles that are over-rolled in the raceway/rolling element contact areas

Overload

Indentation from handling

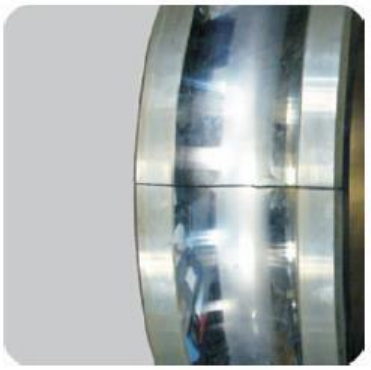
Bearing surfaces that are dented or gouged by hard, sharp objects

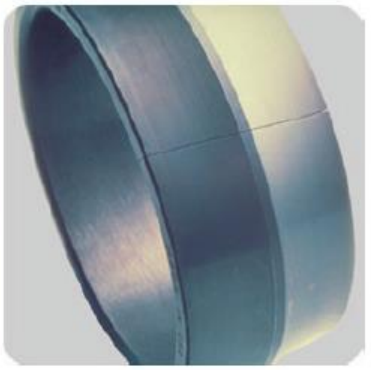


Fracture

Forced fracture

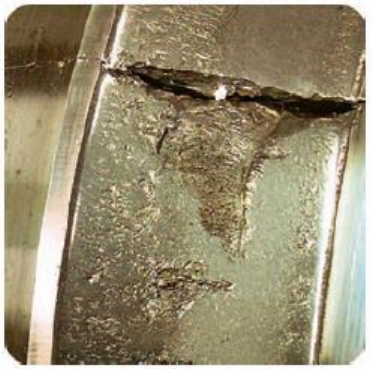
A fracture resulting from a stress concentration in excess of the material's tensile strength





Fatigue fracture

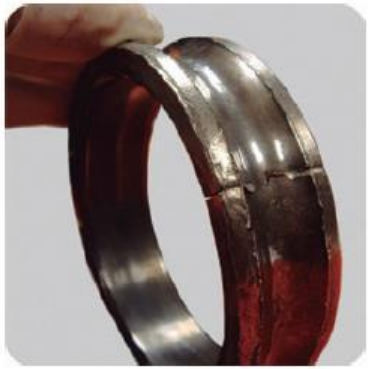
A fracture resulting from frequently exceeding the fatigue strength limit of the material

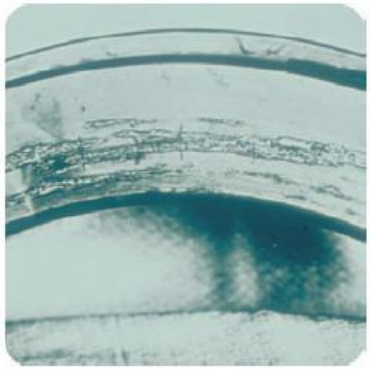


Thermal cracking

Thermal cracking

Cracks that are generated by high frictional heating. They usually occur perpendicular to the direction of the sliding motion.



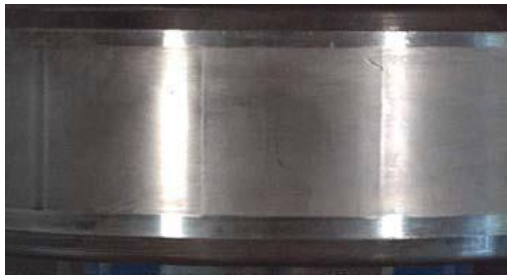


Case study: Variable speed electric motor

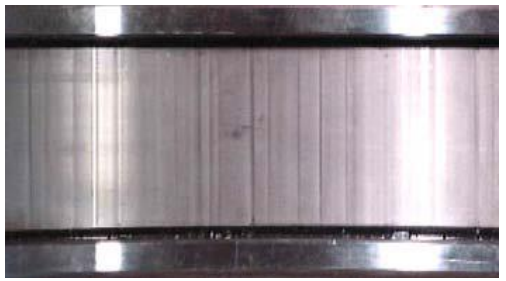
Application: Variable speed electric motor in the reel section of a tissue paper machine, 400 VAC with frequency converter

After only one month of operation there was severe damage to the cylindrical roller bearing.

Inner ring: There was heavy wear on the raceway. The wear was irregular; some flats were observed. The raceway was dull and grey in colour.



Outer ring: There was heavy wear on the raceway (load zone). The wear was irregular. Marks similar to those caused by vibration (washboarding) were visible. The raceway was dull and grey in colour. The insulation coating on the outside surfaces was intact.



Case study: Variable speed electric motor

The raceway surface showed microcraters that were the result of a damaging electrical current passing through the bearing (current leakage). This led to washboarding. After that (and continuously) a large amount of material had worn off, and had led to the strange pattern on the raceways of the inner and outer rings.

Conclusions

The failure mode is clearly current leakage erosion.

Corrective actions

The inspection showed that during one of the motor repairs, the grounding (earth) cable was disconnected and not reconnected. Once the grounding cable was reconnected and another set of insulated bearings was installed, no further problems were reported.

Case study: Clay mill

Application: Clay mill in a brick factory

Loads: Unknown, but relatively heavy, with shock loads

Speed: Below 100 r/min

Problem: Premature bearing failure. 1.5 years service life

Observations
After washing and before disassembly, radial internal clearance of the bearing was measured at 0,900 mm. A new bearing measures between 0,250 and 0,320 mm. When the inner ring was swiveled, rollers fell out from the cage pockets.

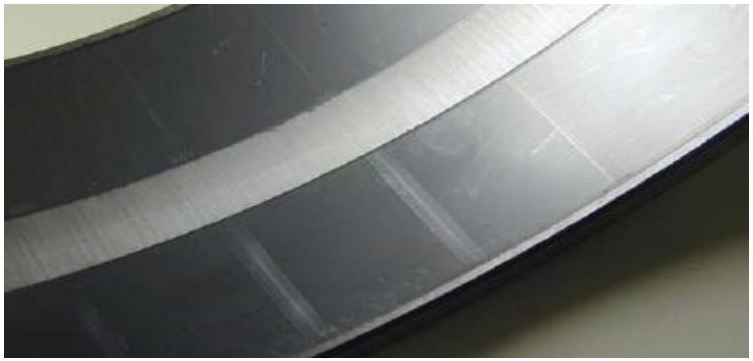
Case study: Clay mill

Inner ring

The bore showed no signs of fretting corrosion and the side faces were undamaged. The raceways showed severe abrasive wear. On both raceways, the cages had cut a groove at the edge of the raceway, indicating that the cages were making contact with the raceways. The raceways were dull and grey in colour.

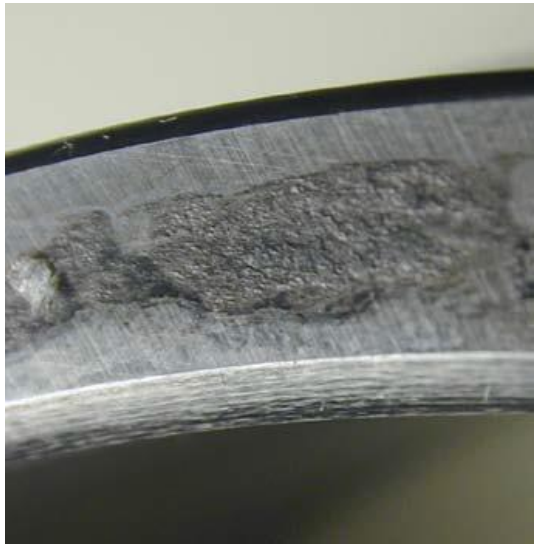
Outer ring

The raceways showed heavy abrasive wear, and were dull and grey in colour. There were also transverse smearing marks (at roller pitch) from dismounting. Severe fretting corrosion was visible on the outside surface, which was the result of ring creep movements under heavy load and uneven ring support.



Case study: Clay mill

Outer ring: Fretting corrosion on the outside surface



Outer ring: Fretting corrosion on the side face

Case study: Clay mill

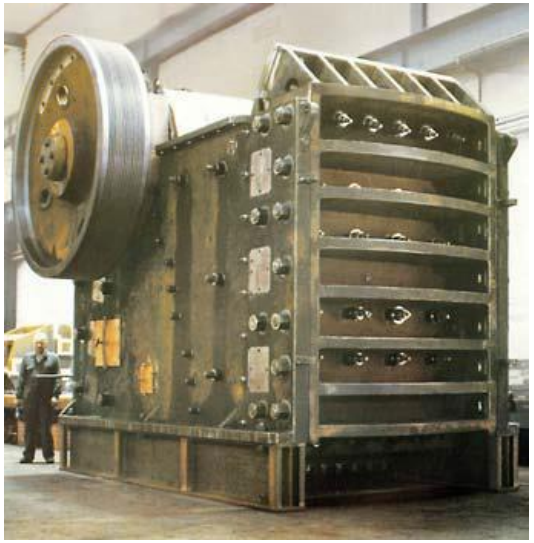
Failure analysis
There was a huge amount of abrasive wear in the bearing. The cage pocket clearance had increased substantially, making the cage drop and cut a groove at the edge of the raceway. Clearly, there was a problem with lubrication resulting from clay that entered the bearing cavity.

Conclusions
The failure mode is clearly abrasive wear.

Recommendations
Improve the sealing arrangement to protect the bearing. This can be done by:

- relubricating daily
- using sealed SKF Explorer spherical roller bearings
- using a labyrinth seal that has a relubrication feature
- replacing the current sealing solution with SKF taconite seals
- installing a continuous relubricator

Case study: Jaw crusher



Problem: Premature bearing failure (main shaft bearing, outboard)

The customer had been using only high quality bearings. The main shaft bearings were replaced every five years. After the last overhaul, the bearings failed within two years.

Observations

Inner ring: There was heavy abrasive wear on the raceways. No other marks were visible.

Case study: Jaw crusher

Outer ring

There was heavy spalling on the raceways in a small area of the load zone. There were heavy vibration marks over a large part of the load zone. There was heavy fretting corrosion on the outside surface corresponding to the load zone.

Cage

The cage pockets exhibited heavy and irregular wear.

Case study: Jaw crusher

Conclusion

The cause of the failure appeared to be the fretting corrosion from a damaged outer ring seat.

SKF Gulf

SKF offers an extensive 2-day training on '**Bearing Root Cause Failure Analysis'** in order to provide inspection procedures and instructions for analyzing failed bearings (due to mounting errors, heat, vibration, etc.) and their components.

Students will learn to determine the true root causes of bearing failures and its impact on service life.