28-31 tlt pract appl 12-03 11/7/03 9:31 AM Page 28

Fretting Corrosion or False Brinelling?

Contrary to popular opinion, these two wear mechanisms are not the same.

By Douglas Godfrey
(Fellow, STLE)

Two wear mechanisms, fretting corrosion and false brinelling, are both caused by small relative motions, usually due to vibration while the components of a machine are stationary or not rotating. An example of vibrating components is the gears and rolling element bearings in the turbine of an electrical generating windmill that is rotating but which is being vibrated by breezes. Another example is the rolling element bearings of a machine being shipped by truck or railway. Some publications (1, 2, 3) state that the two mechanisms are the same and that the terms are synonymous. The author proposes that they are two different wear mechanisms.

Fretting corrosion. Fretting is the damage to contacting surfaces experiencing slight relative reciprocating sliding motion of low amplitude.

Fretting corrosion is the fretting damage to unlubricated contacting surfaces accompanied by corrosion, mostly oxidation that occurs if the fretting occurs in air. Fretting corrosion of steel in air produces the iron oxide hematite. Hematite, the ore of iron, also jeweler's rouge, is alpha Fe_2O_3, ferric oxide, a dark red or cocoa-colored material (4). Red films or reddish debris are a symptom of the absence of lubricant.

Figure 1 shows a schematic and micrographs of fretting corrosion between steel specimens. After removal of the oxide crust, sliding marks can be seen in the damaged spot by scanning electron microscopy (bottom micrograph). Their length corresponds to the amplitude of vibration.

Brinell metal hardness test. The brinell hardness test uses a 10-mm diameter hard ball to make an impression or dent in a metal specimen. The load and dent size determine the brinell hardness. Original grinding marks are visible microscopically in the dent. The brinell hardness number is the load in kilograms divided by the area of the indentation in square millimeters (1).

True brinelling of a rolling element bearing. True brinelling of a rolling element bearing occurs when it is not rotating and is subjected to a force, impact or shock load great enough to cause the rolling elements to plastically deform and indent the raceway (2, 4, 5). The dents in the raceway correspond to the position of the rolling elements. The original grinding marks are still visible microscopically in the indentation, as seen in Figure 2.

False brinelling of a rolling element bearing. False brinelling is the formation of a worn depression on the raceway of a lubricated rolling element bearing due to the slight rocking of the rolling elements, maybe only a fraction of a degree (4, 5, 6, 7). Conditions prevent the formation of an elastohydrodynamic oil film and impose boundary lubrication.

The worn depressions replicate the shape and the position of the rolling elements. There is no shoulder around the depression such as occurs with true brinelling. The original grinding marks in the depression are worn off. No sliding or skidding marks have been found in false brinelling depressions.

The oil meniscus or adjacent grease around the contacts contains wear fragments, which, for steel on steel, is usually the black oxide Fe_3O_4, magnetite. Magnetite is a common wear fragment of steel contacts under moderate boundary lubrication conditions. The dents occur due to the wearing off of the pre-existing and continually reforming oxide film on steel.

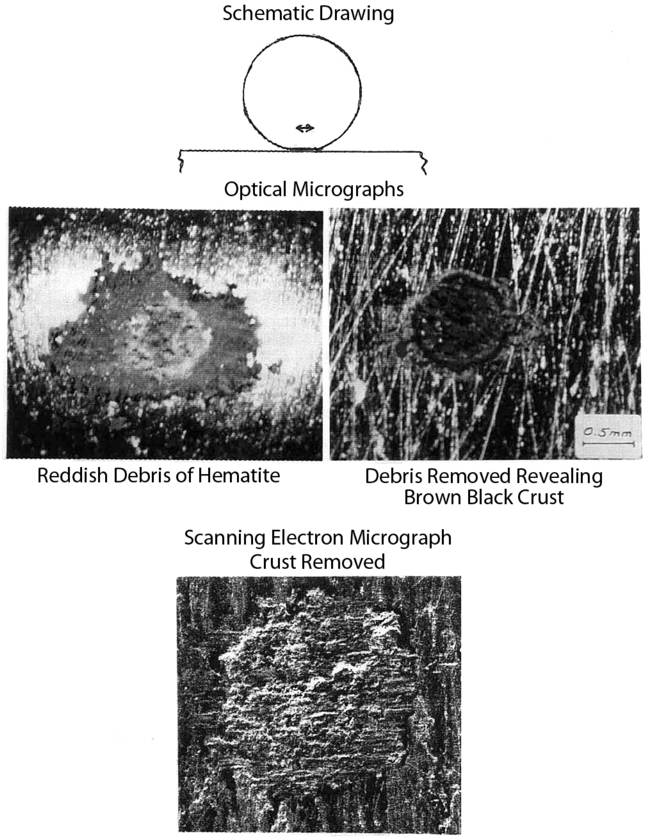
Figure 3 shows a schematic and a photograph of typical false brinelling of a tapered rolling element bearing raceway. False brinelling causes noisy and, in some cases, inhibiting performance. It can also reduce rolling element bearing life by creating stress raisers leading to fatigue failure.

CONTINUED ON PAGE 30

False brinelling causes noisy and, in some cases, inhibiting performance.

Figure 1

FRETTING CORROSION OF UNLUBRICATED STEEL



Shows Short Sliding Marks

CONTINUED FROM PAGE 29

PREVENTION

For both fretting corrosion and false brinelling the basic prevention method is to stop the vibration to cease the sliding or rocking motion. This may be done by using vibration isolators and, in some cases, by tightening contacts to increase friction with greater loads.

Fretting corrosion is prevented by keeping the metal surfaces apart by antiwear films, surface treatments, solid lubricants or a rubber or plastic gasket. Lubricating the contacts with oil containing an antiwear additive, or grease made with a base oil containing a soluble antiwear additive is beneficial. Another approach is to alter the surface finish providing microchannels so that the oil can reach the areas of real contact.

False brinelling is prevented mechanically by not allowing a rolling element to rock in the same place a long time. This is accomplished by continuously or at least occasionally rotating the bearing. Rotation distributes the wear uniformly around the raceway. Since boundary lubrication is in effect, antiwear additives in the oil are beneficial in reducing the rate of wear and, thus, the depth of the depressions. **<<**

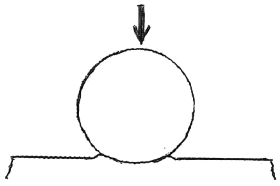
False brinelling is prevented mechanically by not allowing a rolling element to rock in the same place a long time.

Douglas Godfrey heads his own consulting company, Wear Analysis in San Rafael, Calif. You can contact him at **douggodfr@aol.com**.

Figure 2

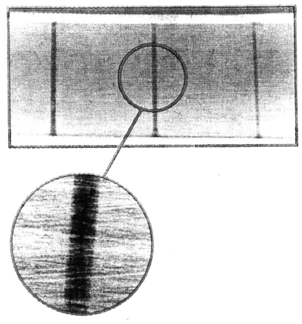
TRUE BRINELLING

Schematic Drawing



True Brinelling of Tapered Roller Bearing

Courtesy of The Timken Company (Ref. 7)

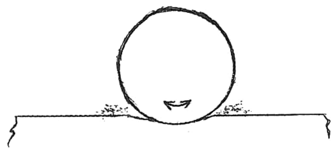


Shows Original Grinding Marks in Dent

Figure 3

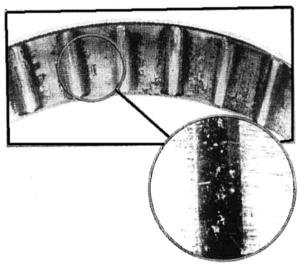
FALSE BRINELLING

Schematic Drawing



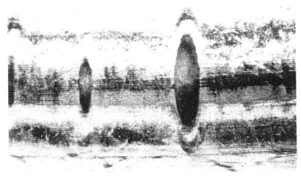
False Brinelling of Lubricated Tapered Roller Bearing

Courtesy of The Timken Company (Ref. 7)



Shows Wear Debris (Probably Black Magnetite) Adjacent to Worn Dents

False Brinelling of Ball Bearing Raceway



Shows Smooth Indentations, After Debris Removed

REFERENCES

1. Metals Handbook, Desk Addition, American Society for Metals, (1985). Glossary of Definitions, pp 1-6, and 1-16.
2. Eschmann, Hasbargen and Weigand (1985), Ball and Roller Bearings, John Wiley and Sons, New York, pp 970.
3. Faultersack, M. (1982), "Analysis of Bearing Damage," SAE Paper 820626.
4. Harris, T. E. (1991), "*Rolling Bearing Analysis, 3rd Edition*," John Wiley and Sons, pp. 965-986 (Failure Investigation and Analysis).
5. The Barden Corp. "*Bearing Failure: Causes and Cures*". Bulleting WAV 10M 4/99.
6. Wilcock, D.F., Booser, E. R. (1957), "Bearing Design and Application", McGraw Hill, New York, pp. 160-162.
7. The Timken Co., "Tapered Roller Bearing Damage Analysis," Bulletin 35M -11-95 Order No. 6347.