Case Study

Another Perspective: False Brinelling and Fretting Corrosion

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Douglas Godfrey's December 2003 TLT article [1] on false brinelling and fretting corrosion provided an excellent discussion of both wear mechanisms. This article presents observations and conclusions regarding fretting wear derived from investigations of gearbox failures.

Figure 1.

False brinelling in a high-speed pinion from a modern wind turbine.

WIND TURBINES

As pointed out by Godfrey, a wind turbine gearbox is susceptible to fretting wear. Figure 1 shows the high-speed pinion from a modern wind turbine. With the high-speed pinion stopped by the brake, and the rotor buffeted by the wind, the mating gear rocks back and forth through small amplitude motion.

The four faint lines in Figure 1 are false brinelling that occurred when the wind turbine was parked for a short time under light winds. The three prominent red lines are fretting corrosion that occurred when the wind turbine was parked for an extended period under heavy winds.

Figure 2 shows the outer raceway of a rolling-element bearing, also from a wind turbine, which suffered false brinelling and fretting corrosion when the wind turbine was parked.

Fretting corrosion also can occur when a wind turbine is rotating. It occurs on components such as splines or blade pitch bearings that are subjected to small-amplitude, vibratory motion. Splines are especially vulnerable to fretting corrosion because, unlike gears, whose rotation entrains lubricant between mating gear teeth, splines have small sliding motion with essentially no motion to entrain lubricant between mating spline teeth. Blade pitch bearings are susceptible to fretting wear if the blades remain at one pitch angle for too long, and the lubricant is not replenished by movement of the rolling elements.

HYDROELECTRIC GEARBOX EXAMPLE

A gearbox from a hydroelectric power plant was removed from service and shipped by truck from the power plant in Idaho to a repair shop in Pennsylvania. This was a large planetary gearbox with a 0.5-m diameter sun pinion, three 0.8-m diameter planet gears and a 2.1-m diameter annulus gear. The sun pinion floats and is supported by the three planet gears. Each planet meshes with the pinion and the annulus gear.

During gearbox disassembly, false brinelling and fretting corrosion of varying degrees was found on all teeth that were in contact during shipping. Each planet gear had areas that supported the mass of the sun pinion. Loads from the sun pinion created torque on the planet gears causing them to rotate slightly and load the annulus gear teeth.

Consequently, many teeth were in contact and subjected to different loads, depending on the positions of the planet gears. Fretting wear varied from mild false brinelling to severe fretting corrosion due to different load intensity and vibration due to transport.

Figure 3 shows an area on the planet gear teeth with false brinelling. The contact area is surrounded by black debris assumed to be magnetite as described by Godfrey [1]. When magnetite powder mixes with oil in the meniscus around the contact, it forms a black mixture with the consistency of grease.

In some contacts with magnetite debris, the damage was limited to false brinelling. In other contacts with relatively large amounts of magnetite debris, the area of false brinelling had small patches of fretting corrosion at the center of the false brinelling scar as shown in Figure 3. Apparently, the magnetite debris formed a dam around the contact, which prevented oil from entering, and the contact eventually

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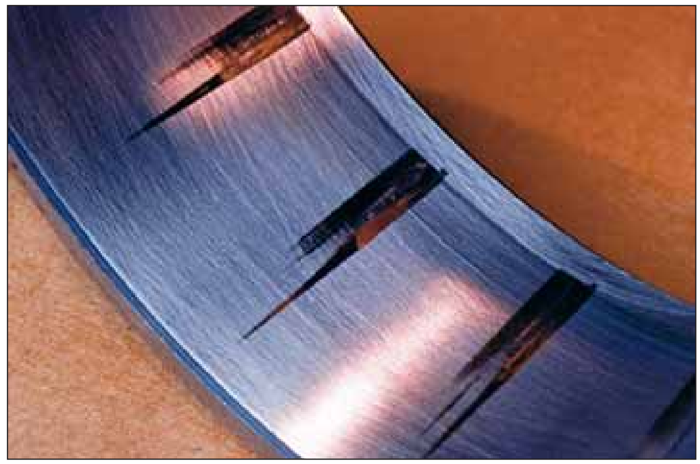
Figure 2.



False brinelling and fretting corrosion in the outer raceway of a rolling-element bearing.

Figure 3.

False brinelling on planet gear teeth.

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Fretting corrosion occurs under unlubricated conditions.

became unlubricated. Without lubrication, the damage escalated into fretting corrosion. This result corroborates Godfrey's [1] assertion that fretting corrosion occurs in unlubricated contacts.

CONCLUSIONS

The following conclusions were derived from empirical observations made during many failure investigations:

False brinelling occurs under boundary lubrication. The wear mechanism is mild adhesion that is confined to the natural oxide layer. On steel, the wear debris is magnetite.

Fretting corrosion occurs under unlubricated conditions. The wear mechanism is severe adhesion that breaks through the natural oxide layer and forms strong welds with parent material. On steel, the wear debris is hematite.

Fretting wear can start as false brinelling and escalate into fretting corrosion when magnetite wear debris dams the oil causing the contact to become unlubricated. <<

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REFERENCES

1) Godfrey D. (2003), "Fretting Corrosion or False Brinelling?" *Tribology & Lubrication Technology*, 59, 12, pp. 28-30.