The textbook cases of distress modes are especially useful in diagnosing problems prior to the damage that occurs when a bearing can no longer support an oil film. Through the prudent use of temperature and vibration monitoring equipment, routine oil analysis, lubrication system evaluations and machine operational performance reviews, bearing distress may be identified and evaluated before catastrophic failure occurs.

Bearing health is commonly monitored through the use of temperature measurements. Temperature sensors may be mounted in a wide variety of locations, with a corresponding variation in temperature. The specific location and type of sensor must be known for the measured temperature data to have any real value.

Being able to properly identify the damage resulting from pitting (from arcing), fatigue, erosion and corrosion is key to diagnosing bearing problems.

**Voids**

**Electrical Pitting**

Electrical pitting appears as rounded pits in the bearing lining. The pits may appear frosted (Figure 1), or they may be blackened due to oil deposits. It is not unusual for them to be small and difficult to observe with the unaided eye. A clearly defined boundary exists between the pitted and unpitted regions, with the pitting usually occurring where the oil film is thinnest.

As pitting progresses, the individual pits lose their characteristic appearance as they begin to overlap. Pits located near the boundary should still be intact. The debris that enters the oil begins abrasion damage. Once the bearing surface becomes incapable of supporting an oil film, the bearing will wipe. The bearing may recover an oil film and continue to operate, and pitting will begin again. This process may occur several times before the inevitable catastrophic bearing failure.

Electrical pitting damage is caused by intermittent arcing between the stationary and rotating machine components. Because of the small film thicknesses relative to other machine clearances, the arcing commonly occurs through the bearings. Although the rotating and other stationary members can also be affected, the most severe pitting occurs in the soft babbitt.
Electrical pitting can be electrostatic or electromagnetic in origin. Although both sources result in pitting damage, they differ in origin and destructive capabilities.

Electrostatic shaft current (direct current) is the milder of the two. Damage progresses slowly, and it always occurs at the location with the lowest resistance to ground. It can be attributed to charged lubricant, charged drive belts or impinging particles.

This type of shaft current can be eliminated with grounding brushes or straps. Bearing isolation is also recommended.

Electromagnetic shaft current (alternating current) is stronger and more severe than electrostatic current. It is produced by the magnetization of rotating and/or stationary components.

This type of current will not always occur at the location of lowest resistance. Because the current is stronger, bearing damage is often accompanied by journal, collar or runner damage.

Electromagnetic currents are best eliminated by demagnetizing the affected component. Grounding brushes or straps may or may not be helpful. The bearings should also be isolated.

The lubricating oil must be filtered or replaced. Pitting damage often blackens the oil and fills it with debris. In addition to filtering or replacing the oil, the entire bearing assembly, oil reservoir and piping should be flushed and cleaned. The original bearing finish should also be restored. Journal shoes typically must be replaced, but if the correction leaves the bearing within design tolerance, the bearing may be reused. The condition of the rotating journal, collar or runner surfaces must also be evaluated. It must be restored to original condition, either by lapping, hand stoning or replacement.

**Fatigue**
Fatigue damage may represent itself as intergranular or hairline cracks in the babbitt. The cracks may appear to open in the direction of rotation. Pieces of babbitt may spall out or appear to be pulled away in the direction of rotation. The cracks extend toward the babbitt bond line, and may reveal the shoe backing (Figures 2, 3, 4).
A combination of causes contributes to fatigue damage, but concentrated cyclic loading is usually involved. The fatigue mechanism involves repeated bending or flexing of the bearing, and damage occurs more rapidly with poor bonding.
It is important to note that fatigue damage will occur without poor bonding. Fatigue can occur when conditions produce concentrated cyclic loads, such as:

- Misalignment
- Journal eccentricity
- Imbalance
- Bent shaft
- Thermal cycling
- Vibration

Performance data should be reviewed to determine if a vibration increase occurred. The leveling plate wings should be examined for signs of excessive wear, indicating the rotating collar or runner is not perpendicular to the shaft axis.

High bearing temperature may also be considered as a contributing factor to fatigue damage. As temperatures increase, the fatigue strength of bearing materials decreases.

The lubricating oil must be filtered or replaced. In addition to filtering or replacing the oil, the entire bearing assembly, oil reservoir and piping should be flushed and cleaned. Depending on the damage, voids in the babbitt can be puddle-repaired. The original bearing finish must be restored. Journal shoes may also be puddle-repaired and refinished. If this cannot be done, the shoes must be replaced.

Although the babbitted surface is usually damaged more severely, the rotating collar or journal surface must also be evaluated. This surface must be restored to original condition, either by tapping or hand stoning.

**Figure 5. Cavitation Damage on**
Cavitation damage appears as discreet irregularly shaped babbitt voids which may or may not extend to the bond line. It may also appear as localized babbitt erosion. The location of the damage is important in determining the trouble source (Figures 5, 6, 7).

Often called cavitation erosion, cavitation damage is caused by the formation and implosion of vapor bubbles in areas of rapid pressure change. Damage often occurs at the outside diameter of thrust bearings due to the existence of higher velocities. This type of damage can also affect stationary machine components in close proximity to the rotor. Based on its source, cavitation can be eliminated in a number of ways. These include the following:

- Radius/chamfer sharp steps
- Modify bearing grooves
- Reduce bearing clearance
- Reduce bearing arc
- Eliminate flow restrictions (downstream)
- Increase lubricant flow
- Increase oil viscosity
- Lower the bearing temperature
- Change oil feed pressure
- Use harder bearing materials

The lubricating oil must be filtered or replaced. In addition to filtering or replacing the oil, the entire bearing assembly, oil reservoir and piping should be flushed and cleaned.

Depending on the extent of damage, voids in the babbitt can be puddle-repaired. The original bearing finish must be restored. Journal shoes may also be puddle-repaired and refinished. If this cannot be done, the shoes must be replaced.

Although the babbitted surface is usually damaged more severely, the rotating collar, runner or journal surface must also be evaluated. This surface must also be restored to original condition, either by lapping or hand stoning.
Erosion
Erosion damage may appear as localized babbitt voids with smooth edges, particularly in the direction of rotation. Damage is more likely to occur in stationary members.

As a rule of thumb, if the babbitt has been affected, the cause was cavitation damage, not erosion. Because erosion is caused by sudden obstructions in oil flow, it is more likely to occur in other areas, because the babbitt is under high pressure. Once damaged, however, babbitt erosion may occur.

Corrective action is similar to that employed in eliminating cavitation damage, with the emphasis on streamlining oil flow through the bearing.

Corrosion
Corrosion damage is characterized by the widespread removal of the bearing lining by chemical attack. This attack produces a latticework appearance. The damage may be uniform with the affected elements being washed away, leaving the corrosion-resistant
elements behind. Corrosion may also affect the rotating collar, runner or journal, appearing as random, widespread rust or pitting. The pits are easily distinguished from electrical pitting, because they are not as uniform or smooth-bottomed.

Corrosive materials may appear in the lubricating oil through:

- Decomposition of oil additives
- Acidic oxidation products formed in service
- Water or coolant in lube oil
- Direct corrosive contamination

Bearing housing seals, oil additive packages, and oil reservoir operating temperatures should be evaluated as an initial step in eliminating corrosion. The integrity of cooling coils should also be examined.

The cause of corrosion is best detected by knowledge of the babbitt composition and an oil analysis. Corrosion can be eliminated by replacing the lubricating oil. In addition, the entire bearing assembly, oil reservoir and piping should be flushed and cleaned. If the original bearing finish cannot be restored, the bearing must be replaced.

The rotating collar, runner or journal surface must also be evaluated and restored to original condition, either by lapping or hand stoning.

**Collar/ Runner/ Journal Surface**

The most commonly overlooked bearing component is the collar. It is the single most important part of the bearing. Collar rotation draws oil into the region between the collar and shoe surfaces. Oil adheres to the collar and is pulled into pressurized oil wedges. This occurs due to the collar surface finish. If the collar finish is too smooth (better than 12 root mean square (RMS)), it will not move an adequate supply of oil; too rough, and the bearing shoes will be damaged. Ideally the finish should be between 12 to 16 RMS.

Each time a bearing is inspected, the collar should be inspected and worked as necessary. Glossy areas on the collar can easily be removed by hand-scrubbing with a soft 600-grit oilstone. Collars with significant operating time may have lost their original surface flatness. This flatness, as well as the surface finish, should be restored.
If a split runner is used, it should be separated into halves and evaluated. Relative motion between the halves will result in fretting damage to the runner, as well as potential cavitation-like damage to the bearing surfaces.

It is important that the collar faces be parallel, and perpendicular to the centerline of the shaft. If the collar is not within tolerance, the resultant wobble will force the shoes and leveling plates to constantly equalize, causing rapid leveling plate wear (Figure 8).

**Oil Analysis**
A quick visual examination of the oil or oil filter may be all that is required to determine that a problem exists and that further investigation is necessary. Cloudy or discolored oil indicates a problem.

A thorough oil analysis can provide useful data to assist in diagnosing bearing or machine distress. The usefulness of the analysis is directly related to the information requested. As a minimum, the following should be supplied:

- Particulate density
- Particulate breakdown
- Viscosity
- Water contamination
- Chemical breakdown

The amount of particulate, as well as its content, can identify potential trouble spots. Oil viscosity will decrease in time, and whether or not distress is suspected, it should be periodically evaluated. Water contamination is extremely unwanted, because it can cause rust and oil foaming, and if it is drawn into the oil film, bearing failure. A chemical breakdown of the oil will help to determine the integrity of the additive packages and the presence of unwanted contaminants.

**Operational Data**
Another important source of diagnostic information is unit operational data. Identifying periods of load or speed changes, recent maintenance, or the performance of related machinery may help determine the root cause of distress.

Vibration data or an analysis may help uncover existing problems, as well as examine the remaining bearings in a troubled unit.

In a perfect world, hydrodynamic bearings theoretically have an infinite life. Equipment operators know that their world is far from perfect. By taking a forensic approach to plain bearing failures, the operator can uncover and correct system-related problems and ultimately increase machine availability and output.
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