Transmission & Bearing Corp.
A Division of Turbo Research Inc.

Technical Notes by Dr. Mel

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Solving Ring-Oiled Bearing Problems

In recent years, TRI has encountered and resolved a number of problems with ring-oiled bearings for fans, motors, and pumps. Oiling rings damage the journal surfaces and a lack of good lubrication can lead to excessive wear and eventually complete bearing failure. Many cost effective improvements can be implemented for this class of bearings given the technology that is available today.

Maintenance and repair of ring-oiled bearings have also benefited from new technologies. On-site machining has improved so that shafts can be restored with straight and concentric journals. Pressurized lubrication systems can be added to assure proper lubrication at all times and monitoring systems can be added to give operators a warning before a failure occurs.

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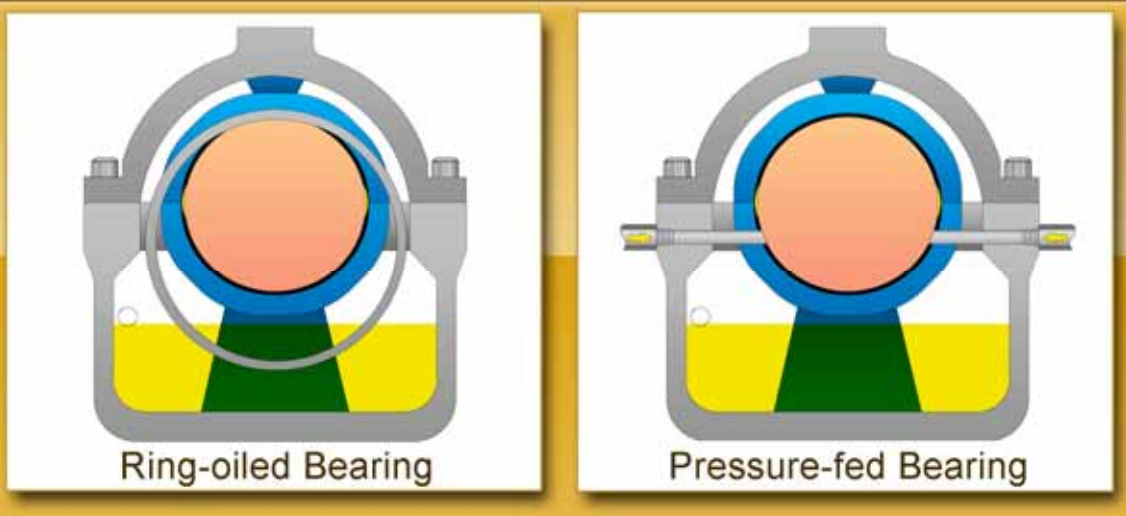


Dry Start

A typical problem with bearings that are only ring oiled is that they start dry. Oil is not properly distributed until the shaft rotates for some time. A lack of lubrication at startup leads to Babbitt wipes.

To counter this known problem, many procedures call for manual lubrication before startup. The inspection port is opened and a small amount of oil is poured onto the journal surface. This procedure helps but opening the inspection port can also lead to particulate matter entering the bearing, causing damage to the Babbitt.

Solution: Add a small external oil conditioning system comprising a reservoir, pump, filter and an oil to air heat exchanger. This system greatly reduces that chance for contamination and continually filters the oil while maintaining the proper supply temperature.

Journal Surface Grooves

During operation, oil rings rub against the top of the journal. Although the rings are usually made from a soft copper alloy, wear of both the journal and ring occurs. Wear causes a groove in the journal. The groove provides a leak-off path for the high pressure oil film causing the film thickness to decrease. The steel and copper alloy wear particles can be embedded in the bearing Babbitt.

The oil film in a heavily loaded bearing can be as little as 0.0015 inches thick. A groove that is 0.001 inches deep and 0.5 inches wide can provide an effective leak-off path for the high pressured oil, particularly when the shaft is starting or stopping. A reduced oil film thickness will increase the bearing temperature and can lead to contact between the journal and the bearing while rotating. Such contact between these two surfaces damages the bearings.

Wear grooves can usually be seen by eye but often are not deep enough to be measured with a flat end micrometer. Many times this condition can be considered OK when in fact it is not.

Partial Solution: A quick fix for journal wear can be achieved by machining and honing the journal to make it round and concentric with a minimal taper. The bearing is re-Babbitted and machined to match the undersized journal.

Complete Solution: If no changes are made to the rings or lubrication system, the problem will reoccur. A more complete solution eliminates the ring which causes the wear. A pressure-fed lubrication system with AC main oil pumps and a DC emergency pump is added to assure continuous lubrication, temperature control, and constant filtering of the oil.

Poor Alignment

In many cases, bearings sit in a cylindrical seated bearing housing with no method of aligning the bearing to the journal.

Solution: In most cases, it is possible to design and manufacture a replacement two-part bearing with a spherical fit between them. The outer bearing ring, with an insulated OD if necessary, and with a spherical bore at the ID, is installed in the existing cylindrical fit of the end bell or pedestal, and the inner Babbitted bearing with mating spherical OD is installed. Then align the bearing so that there is no tilt and no twist between the journal and bearing. DO NOT scrape the bearing to increase contact area to the journal. Close the end bells so that there is a very slight pinch on the outer bearing rings, limiting vibration.

Oil Leaks

Oil leaks are one of the biggest problems for ring-oiled bearings. These bearings function by rotating rings pulling oil to the top of the journal. There is some splashing of oil so oil transfers to the inside of the housing. In addition, thrust faces on the shaft act like slinger rings throwing oil to the inside surface of the bearing housing. Oil then drips onto the shaft at the ends of the housing and migrates to the oil deflectors.

Bearings with cylindrical fits are particularly difficult to seal at the shaft. The labyrinth seals attached to the bearing housing can not be properly aligned to the shaft because the bearing can not be properly aligned to the shaft. It is rare to find a bearing with a cylindrical fit that has proper seal to shaft clearances.

Solution: Self-aligning bearings with a spherical fit are the best solution. The seals are attached to the bearing and will be aligned to the shaft and have proper clearances when the bearing is aligned. Having good oil drain capabilities within the sealed bearing housing is very important. For the best solution, a pressure fed oil supply keeps the oil flow path within the inner bearing housing. In this case, oil cannot readily escape the inner housing. This prevents oil dripping to the shaft and migrating out to the outer oil deflectors.

Excessive Bearing Metal Temperatures

Every Babbitted bearing depends on a properly formed oil wedge to develop. The oil wedge lifts the journal off the Babbitt bearing bore. When a bearing is scraped or wiped, the diameter of the Babbitt bore takes the same diameter as the journal. This leads to a very thin oil film, hence, to high temperature. Proper maintenance procedures for turbine or generator bearings prohibit scraping of bearings, and scraping should not be permitted for motor, fan or pump bearings either.

Other sources of excessive temperature should be examined:

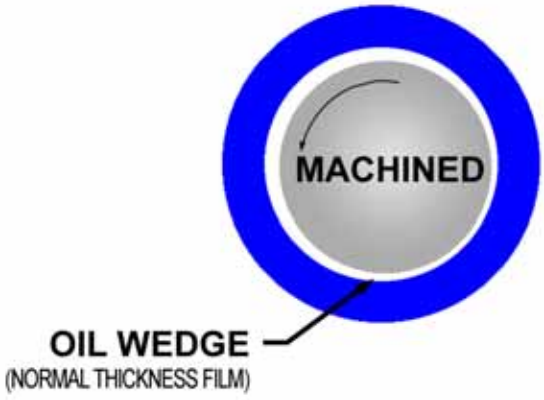
Heat generated in the film increases as the film thickness decreases. Excessive temperatures can be caused by misalignment. A bearing that is misaligned has high localized film pressures and localized thin films.

Bearings that start dry can easily develop a wear pattern in the lower half of the bearing. The bearing bore takes on the shape of the journal similar to the geometry of a scraped bearing with a similar result of running hot.

A non-uniform wear pattern in the bearing due to grooves worn in the journal can lead to very thin oil films. The temperature will elevate whenever reduced film thicknesses occur.

Excessive particulate matter that has embedded into the Babbitt will cause the Babbitt to extrude and conform to the journal diameter. This will inhibit the proper formation of an oil wedge again causing thin films and high temperatures.

Dovetails grooves in the bearing backing can lead to ridges in the surface of the Babbitt when the bearing heats up. The coefficient of expansion for Babbitt is about twice that of steel or iron. The Babbitt is much thicker in the area of the dovetail groove. When the bearing heats in normal operating conditions, the thicker Babbitt in the dovetail groove will rise into a localized ridge. When this happens, the journal contacts the tops of the ridges and wipes the Babbitt. Significant wiping heats the Babbitt



more, softening it so that it reforms and takes the journal diameter. Again, this causes thin oil films and elevated temperatures.

Excessive loading will aggravate any of the problems described above.

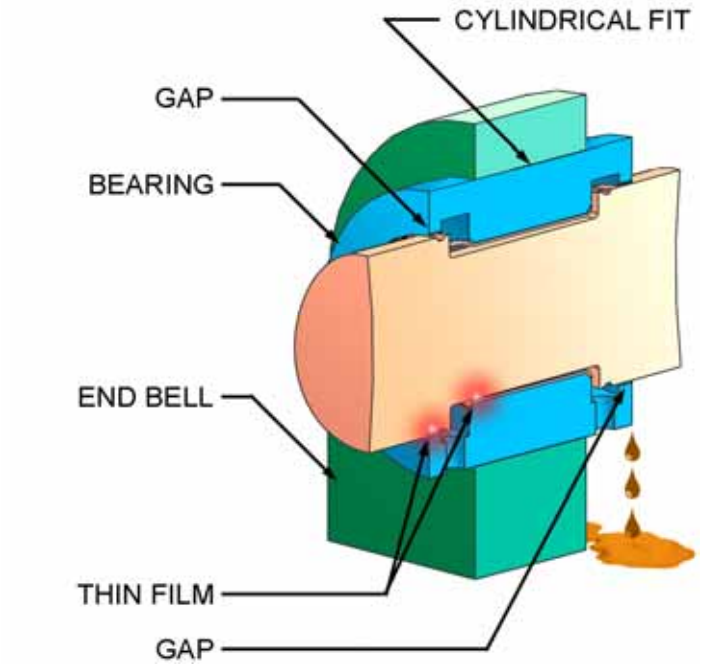
A proper "wedge film"

The bore in a Babbitt bearing must be slightly larger than the journal to develop a properly shaped wedge film. This is critical to the successful operation of any bearing. The wedge film under the journal lifts the journal off the Babbitt.

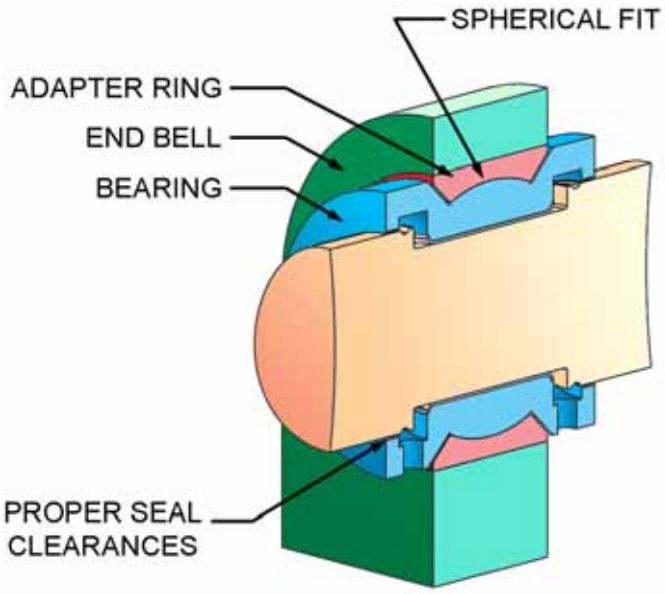
Bearings with a cylindrical fit to the housing can not be properly aligned to a shaft. A bearing that is not properly aligned will not form a properly shaped wedge film.

Solution: The best solution is to replace the cylindrical fit bearing with a spherical fit bearing or to have the bearing modified with a spherical fit adapter ring. When a misaligned cylindrical fit bearing must be used until a new spherical bearing can be obtained, scraping may be necessary. For best results when scraping such a bearing, a minimal amount should be removed from the lower half of the bearing. The axial contact pattern of a scraped bearing should be no more that 1/2 inch wide for bearing bore diameters under 7 inches and up to 1 inch for bearing bore diameters up to 12 inches. It should be noted that scraping is not the preferred solution. Scraping should maintain the original diameter of the bearing. The goal is to achieve the minimal amount of support required for starting and stopping the journal.

DO NOT scrape to achieve a large contact area



Improper Alignment



Proper Alignment

Ring-oil bearings with pressure-fed lubrication

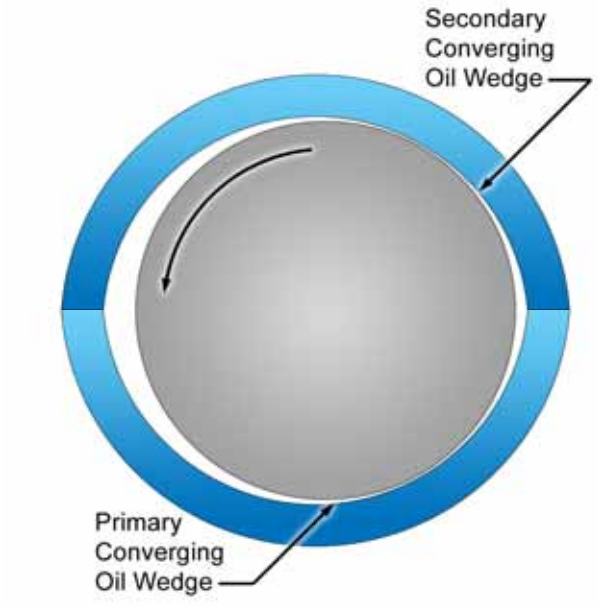
Not all ring-oiled bearings start dry. Some bearings have been equipped with pressure-fed lubrications systems. Although the addition of pressurized lubrication is an improvement, they are not without problems. Grooves worn into

the journal by slinger rings are still a problem.

Solution: If the lubrication system consists of one or two AC powered pumps and either a DC powered emergency oil pump or a shaft driven positive displacement pump, then the lubrication system should supply adequate oil during all phases of operations including the startup and run down. The oiling ring should be removed, if at all possible. The leak-off paths created by the grooves can be removed by machining and honing the journal. Today's on-site machining technology make this process an affordable solution.

The journal will be slightly undersized after the wear grooves are removed. The bearing should be re-Babbitted with a machined bored. If the bearing does not already have a spherical seat for alignment, then a modification using a spherical adapter ring should be implemented.

Without the oil ring, the bearing can be modified with fully enclosed oil feed grooves at the horizontal joint and shaft seals. This will control the oil flow so that it is directed to the drain and away from the oil deflectors where the shaft penetrates the housing. In most cases, oil flow through the bearing can be increased without shaft seal leakage. An increased pressure-fed oil flow usually will reduce the maximum bearing metal temperature.



Excess Vibration

A bearing bore that conforms to the journal has little chance of controlling temperature or vibration.

Many of the solutions discussed earlier will go a long way toward solving most of the temperature and vibration problems. In addition, modifying the bearing with an elliptical bore will help to produce an effective secondary wedge film above the journal. This modification will help to restrain the vibratory motion of the journal.

Thrust Bearing Failure

Some ring-oiled bearings have thrust bearings that can resist a limited axial load. They are designed to be used for fans, pumps and similar equipment with double flow in a back-to back arrangement so there is no significant constant axial load. If one end of the equipment settles so that the assembly goes downhill axially, the rotor will be restrained by one thrust bearing face. If the axial load is large enough, it can lead to a failure of the thrust bearing. Then the oil flow out that bearing end will be restricted by the wiped Babbitt. Eventually, half of the journal bearing melts away and the bearing fails.

Solutions: A thermocouple in the bearing metal is the best detector of such an impending failure or of an actual failure in process.

There is a lot of rotating equipment in service that is unmonitored. Prior to 1980, much of the instrumentation for equipment monitoring was unreliable. Older equipment can be enhanced with today's instrumentation systems. Cost and reliability of instrumentation systems has improved to the point that no significant piece of rotating equipment should operate without a monitoring system. The cost of downtime is now so high that such instrumentation is easy to justify.

TRI Transmission & Bearing Corp.

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TRI Transmission & Bearing Corporation has the capabilities to repair equipment and solve problems with ring-oiled bearings for motors, fans and pumps. We are available for:

- Consulting engineering activities on site to identify all aspects of the problems including "root cause", with all components of the train, e.g., fan/pump/compressor, gear box, fluid drive, motor.
- Remachine journals and shaft by subcontract to a reputable on-site machining company, so that TRI provides a "single-source" repair job for a machine.
- Vibration monitoring and balancing.
- Evaluation of foundations and supporting structures.
- Technical Direction on site for all facets of the solution, including: oil system modifications, bearing installation, and alignment of the equipment train.
- Design and manufacture new bearings to suit the application, using high strength Babbitt. This includes making new bearings for equipment made by any US or foreign manufacturer.
- Convert bearing support from cylindrical (with no tilt/twist alignment) to full spherical seat with easy tilt/twist alignment.
- Manufacture bearings with improved oil seal arrangements to minimize/eliminate oil leaks out of the bearing housings.
- Repair / re-Babbitt existing bearings and to provide improved bore design, including elliptical geometry.
- Provide upgraded oil system arrangements and components.
- Provide other components required to complete the rebuild or new construction package.
- Manufacture new shafts for fans and other equipment, now up to 13 ft long.
- Modify or manufacture new bearing housings.
- Modify or manufacture new stiff (very stiff !) supporting pedestals for bearings.
- Design, purchase, and install vibration sensors and/or the mounts for them.

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