Innovation in Motion

MIBA INDUSTRIAL BEARINGS

Eliminating Oil Leaks

by optimizing Bearing Case Oil Labyrinths

www.miba.com

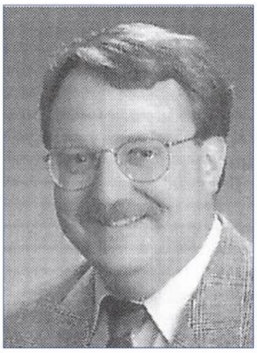
ELIMINATING OIL LEAKS

by optimizing Bearing Case Oil Labyrinths

by John K. Whalen, PE, who was Manager of Engineering for TCE (now Miba Industrial Bearings)
Miba Industrial Bearings, Houston, Texas

Skip Krieser, Maintenance Superintendent
Farmland Industries, Enid, Oklahoma

Presented and published in the proceedings of the 27th Turbomachinery Symposium, September 22-24, 1998, Turbomachinery labratories, Mechanical Engineering Department, Texas A&M University, College Station, Texas



John K. Whalen was the Engineering Manager and Vice President of TCE (now Miba Industrial Bearings), in Houston, Texas. He spent seven years at Turbodyne Steam Turbines (Dresser-Rand) as a Product Engineer in the Large Turbine Engineering Department and as an Analytical Engineer in the Rotordynamics Group of the Advanced Engineering and Development Department. In 1988, Mr. Whalen accepted a position with Centritech, as the Assistant Chief Engineer. In 1989, he was promoted to Manager of Engineering. In 1991, he left Centritech to help start TCE. At TCE, he was responsible for the engineering department and engineering for the product lines, which include babbitted journal and thrust bearings, Labyrinth seals, and related engineering services.

Mr. Whalen received his B.S. (Mechanical Engineering) degree from the Rochester Institute of Technology (1981).

Skip Krieser is the Maintenance Superintendent at Farmland Industries, Enid Nitrogen Plant, in Enid, Oklahoma. He began his career in rotating equipment in 1978, with Phillips Petroleum as an equipment mechanic at the Beatrice, Nebraska, nitrogen plant. Farmland purchased the facility in 1988 and Mr. Krieser was transferred to Enid in 1991, as the plant's rotating equipment specialist. In February 1998, he was promoted to Maintenance Superintendent. Farmland is one of the nation's largest manufacturers of nitrogen-based fertilizers and Enid is the largest facility in the Farmland system. Throughout his career, Mr. Krieser has received training in vibration, oil analysis, infrared thermography, and other reliability-based maintenance techniques, which are an integral part of the maintenance program at Enid. He is a charter member of the Oklahoma Predictive Maintenance Users Group (OPMUG), a user forum for predictive related maintenance issues, technology, and techniques.

ABSTRACT

Many pieces of rotating equipment experience oil leaks. Any piece of equipment with oil fed bearings, such as turbines, motors, gearboxes, and compressors, are susceptible to oil leaks from the bearing case seals. Usually these seals are of the labyrinth type and their designs have remained unchanged for years. Examination of this seal, the bearing case design, and the lube system can point to possible causes for leaks. Once it has been determined that

INTRODUCTION

In these days of high-tech aerodynamics, state-of-the-art rotordynamics capabilities, and modern polymer seal internal labyrinths, it can be amazingly frustrating for the rotating equipment engineer to still be faced with the task of combating oil leaks. Of course, these leaks need to be dealt with due to the very real fire hazard potential, along with the danger of oil coated surf aces and the time and money spent cleaning up this wasted oil, which then needs to be replenished. Also, the environmental impact of waste oil containment and disposal is always a consideration when dealing with machinery oil leaks. Quite often the cause of the leak is simple, but elusive. Items such as scraping too much clearance into the seals at installation, overzealous use of sealing compounds on splitlines, plugged vents, etc., can be hard to pinpoint once the machine is up and running.

The following discussion will address these concerns and the fact that on the larger rotating equipment with babbitted bearings, the problem is usually keeping the oil in the bearing case and not keeping the elements out of the bearing case, contaminating the oil. Cary (1991) discusses how water leaking into the bearing case can be a very real and serious problem. The most common machine experiencing this problem is the single stage steam turbine with carbon ring packing. Coleman (1988) goes into great detail on solving the water contamination problem, and Morris, et al. (1993), discuss eliminating carbon rings and replacing them with dry gas seal technology. While this is a serious problem, it has been treated very well already, and is beyond the scope of the present paper.

The authors will attempt to use the experience of a user and an engineered parts supplier to walk through the steps of dealing with an oil leak. This will include trying to determine the cause of the leak, trying intermediate fixes to stop the leak, and then bringing in the engineered parts supplier to custom design the oil seal for maximum sealing capability, while staying with conventional labyrinth technology.

THE OIL LEAK SCENARIO

The compressor train is all coupled up and has been turned over to operations. The unit is brought up, and the turbine and compressor run smooth and make rate easily; but... there is an oil leak on the thrust end bearing case of the high pressure steam turbine. Oil is soaking the insulation, and that hot steam is just waiting for enough oil to accumulate for it to ignite.

You hoped that this time the changes you made would fix the leak. You modified the seal and case to accept a nitrogen purge, made sure the seal clearance was not scraped oversized during installation, used a very light coat of thin sealer on the laby splitline, but it still leaked. No matter how much nitrogen you put to it, the leakage rate was unchanged. The other fixes did help cut down on the oil leak, but it was still unacceptable. It is time to look at this problem from the beginning.

Oil Supply

Consider the problem from the source. Did a bearing change initiate the leak? Did it make it better or worse? With sleeve bearings (***FIGURE 1***), a point to look at is the chamfers or v-notches often found at the ends of the axial oil distribution grooves. As shown in ***FIGURE 2***, these notches are required, with force lubed bearings, to keep the groove flushed and to ensure an adequate supply of cool oil to the bearing. But, are they too big now so that more oil than needed is being supplied to the bearing, thereby overburdening the drain? Or is it set so that the pressurized oil squirting out is sneaking past the oil seal? If a sleeve bearing change initiated or changed the problem, it is an area that should be looked into a little deeper.

As a side note, it is never a good idea to add bleed-off grooves at the ends of the pressure dams in pressure dam bearings. This eliminates the effectiveness of the pressure dam bearing by not allowing the complete buildup of pressure in this pocket region. It is also best to avoid the use of chamfers in oil ring fed bearings, since these bearings essentially run "starved" and all the oil available needs to be directed to the load region of the bearing.

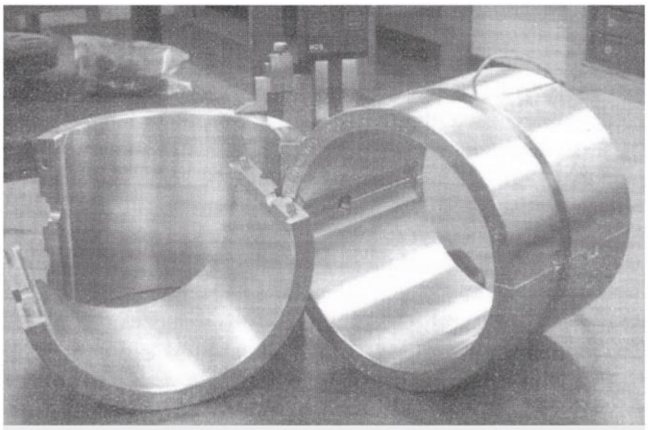


***FIGURE 1** – Photograph qf Two Sleeve Bearings, Showing the Axial Oil Distribution Groove and the V-Notch Bleed-Off*

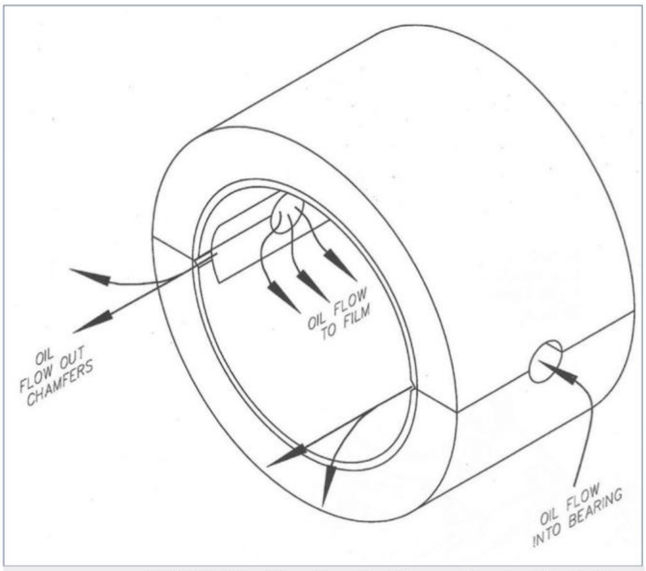


***FIGURE 2** – Drawing of a Sleeve Bearing Illustrating Oil Flow Paths.*

Tilting Pad Journal Bearings

Tilt pad journal bearings could also contribute to the problem. Is the bearing orificed or is the oil supply line supposed to have the orifice? The oil supply methodology of the bearing is an area that should be investigated. It is also good to know the oil pressures and orifice sizes in order to have complete records on the machine. Tilt pad bearings also usually have end seals to help control bearing oil flow through the bearing. They act as an orifice in series with the supply orifice, much the same way the v-notch works with the sleeve bearing. But they also capture the oil as it exits the bearing, directing it down toward the bearing case drain. Does the bearing have a sound design for this end seal? A two-toothed labyrinth design (***FIGURE 3***) is good, in that the oil is encouraged to collect in the trough between the lands and drain to the bottom of the seal, which has drain holes allowing the oil to drain down to the sump. Also, floating end seals combined with outer shells that drain out the top into a channel that

FIGURE 3 *– Photograph of a Tilting Pad Journal Bearing Illustrating the Use of Labyrinth Type End Seals*

directs the oil to the drain area are components of another good design (***FIGURE 4***).

With a non-floating end seal, the clearance needs to be sufficient to ensure the rotor will not contact the seal. It also needs to be tight enough to ensure the bearing runs flooded with oil. Thorough seal clearance calculations take into account the bearing set clearance, the effect of the rotor settling between pads (outside the clearance circle), an assumption on axial pad tilt (this can be a significant factor with long pad length bearings), and an additional safety factor of 1 to 2 mils. Basically, all of these factors can be evaluated

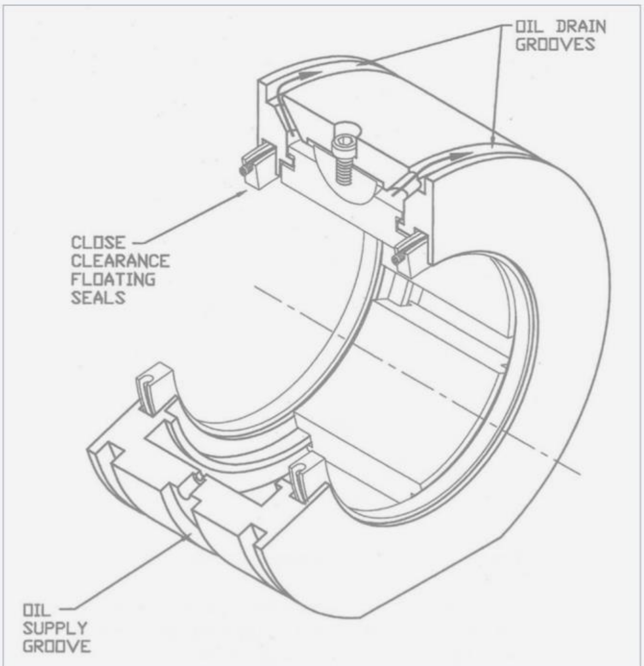


FIGURE 4 *– Drawing of a Tilting Pad Journal Bearing Utilizing the Floating Endseal Concept*

to determine a "minimum" seal clearance. Then the oil flow through the bearing is evaluated assuming orifices in series, and the resulting oil pressure in the bearing shell is calculated. Common design practice is to size the seals for 1 to 1.5 psi shell pressure to ensure the shell is flooded. Ultimately, the bore of the bearing shell can be used with the oil properties, to determine the shell pressure required to run flooded.

If the end seal clearance needs to be great enough so as to not allow a sufficient pressure buildup in the bearing shell, floating end seals can be used. Since these seals can float with the shaft, their clearance is not restricted by the mechanical concerns addressed above. These seals can be designed with clearances on the order of 1 mil per inch of shaft, but usually not less than 5 mils diametral. Care must be made not to overpressure the bearing shell, thereby causing a large delta P across these seals, which can result in high exit velocities contributing to oil leak problems. If floating end seals are used, a shell design such as that drawing in ***FIGURE 4*** is preferred.

Other Concerns

Can supply oil be getting to the bearing case from other sources? Is an oil supply (or drain) flange or fitting leaking? Is the bearing to case fit sound, so that all the oil is directed into the bearing for lubrication? Is the oil pressure higher than design, causing too much oil to be supplied? (Normally, if the machine is not leaking, too much oil is not a problem.) Keep in mind that for orifice flow, the flowrate is directly proportional to the square root of the pressure drop across the orifice, a few psi change · in oil pressure will have a small effect on oil flow. Are the thrust bearings isolated and away from the leaking seal, or should they be looked at closer? These are the types of effects that should be considered from the oil. supply standpoint.

Oil Drain

Some areas to consider with oil drains· were discussed previously. This section is more geared toward getting the oil out of the bearing case and to the reservoir. One of the most common causes of oil leaks is improper venting of the bearing cases. Tue case needs to be vented to allow a free flow of oil out of and back to the reservoir. Oil allowed to linger will tend to find its way out of the bearing case on its own, usually through the oil seal. Some equipment trains have their bearing case vents piped to the reservoir, and then the reservoir is vented. With this type of design, it is important that the pressure in the bearing case not get above atmospheric pressure, or the oil will try to leave the case through the seal instead of down the drain. Pressurization of the bearing case and drain system can be caused by restricted reservoir vents causing back pressure, possibly

1 | Miba Industrial Bearings Germany
Göttingen, Germany

2 | Miba Industrial Bearings Germany Osterode
Osterode, Germany

3 | Miba Industrial Bearings US
Grafton, WI, USA

4 | Miba Industrial Bearings US
Columbus, NE, USA

5 | Miba Industrial Bearings US (Houston)
Deer Park, TX, USA

6 | Miba Industrial Bearings Brasil
Cataguases, Brazil

Miba Industrial Bearings U.S. (Houston) LLC
1800 W 13th St, Deer Park, TX 77536, USA
Houston.Sales@miba.com

www.miba.com/en/product-areas/industrial-bearings/