Hydro Tech

Thrust Bearing Cavitation

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Abstract

A multiple unit generating station is currently experiencing thrust bearing failures due to cavitation pitting on the thrust shoes. This cavitation exists on, and around, the high pressure oil lift outlets. The bearing is currently a spring type babbitt bearing with a four-segment loose runner plate (i.e. segments are not keyed and bolted together).

The thrust bearing cavitation did not become evident until after the turbines were upgraded by 30%. An increase in thrust load has been associated with each of the new turbine runners; the increase in thrust load produced higher pressure on the thrust bearings. Prior to the turbine upgrade, each thrust bearing operated without incident. We believe this was due to lower average pressures on the bearing which reduced the pressure drop experienced by the bearing pads during the passing of each runner plate segment split. With the increased thrust, the oil film between the babbitt pads and thrust runner plate has decreased, while the average pressure has increased. This has increased the pressure drop at the thrust runner plate split, as well as increasing its subsequent effect on the babbitt (due to close proximity). **Hydro Tech Inc.** has developed and offered a solution by redesigning the thrust runner plate and improving the thrust bearing pads.

Not only did cavitation result from the turbine upgrade, but a temperature rise also occurred in all the bearing pads. The effect of this extra loading has resulted in the bearing overheating and operating at a temperature much greater than the safe temperature for a babbitted bearing. Several different modifications have been previously attempted, with varying degrees of success, to improve this bearing's performance. However, the bearing is still operating above normal temperature and cavitation is still forming around the oil lift system and is lightly evident over surfaces of the bearing.

Background

The thrust bearing is an eighteen segmented tilting pad, spring-supported babbitt bearing. The runner plate is divided into four segments that are loosely supported. Each segment is supported by the thrust block and held in place by radial keys. The runner plate's segments **are not** bolted together. They have a radius at the leading and trailing edge of each segment, as well as a space between each segment ranging from 0.7mm to 3.2mm.

The first time any cavitation appeared on the thrust bearing was in 1990. The generator was disassembled for maintenance providing opportunity to further inspect the bearing. This inspection was completed prior to the turbine runner being upgraded. On one pad, a small amount of cavitation appeared, approximately the size of a 10 cent piece. At the time this was dismissed as a defect in the babbitt. The bearing shoes were reinstalled and operated properly until the turbine runners were upgraded years later. Cavitation was occurring throughout this time; however, the timeline during which significant damage would occur was actually much longer. Thrust bearing cavitation was not significant until after the turbines were upgraded from 135 MW to 170 MW (Photo 1).

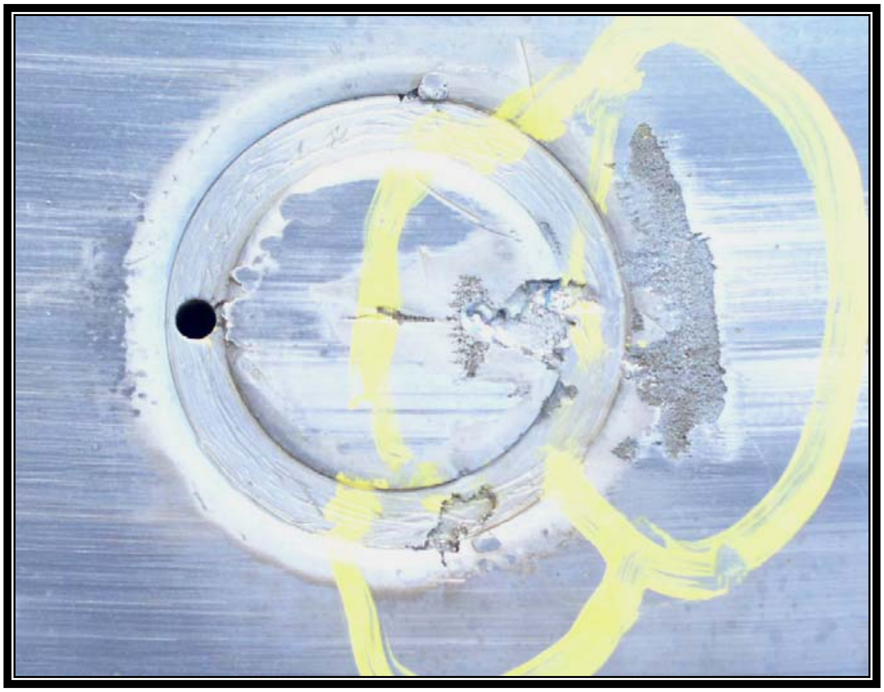

Photo 1
High Pressure Lift Port Cavitation

Of further concern, due to increased load on the thrust bearing, the bearing now operates much closer to its ultimate load limits. Photo 1 shows that, in addition to the cavitation, signs of metal-to-metal contact are visible in the presence of slight wiping indications. Small wiping and grooving is evident at the left side of the high pressure oil lift (HPOL) port circle; this indicates that the bearing is overloaded. Prior to the bearing redesign, the generator had to be operated at reduced loading during the warmest time of the year to prevent the bearing from overheating and “wiping”.

Root Cause:

An increase in thrust load has been associated with each of the new turbine runners; this increase produced a higher average pressure and created higher operating temperatures on the bearing. Given the approximate average load on the thrust bearing of 3.8 Mpa (551psi), which includes an overload of approximately 30 to 35 percent, the bearing is still operating at this level of loading; however, the chance of failure is higher.

The runner plate segments have a gap between them ranging from 0.7mm to 3.2mm. This creates a void in which oil pressure between the stationary bearing pads and the rotating runner plate can disappear. Prior to the turbine upgrade, the thrust bearing operated without incident due to lower average pressures on the bearing. With the increased thrust, the oil film between the babbitt thrust pads and thrust runner plate has decreased, while the average pressure has increased. Because of increasing the pressure drop at the thrust runner plate split, as well as increasing its subsequent effect on the babbitt due to close proximity, the bearing began showing signs of thrust shoe cavitation pitting. This pitting first became evident in the area of the HPOL outlet (Photo1).

Cavitation results from pressure drops, usually in an unloaded (low pressure) area where pressure can change to slightly below atmospheric pressure. In this particular case, the average pressure is 3.8 Mpa; however, some areas are more loaded than others. Generally, a higher load area is located in the middle of the bearing pad surface toward the trailing edge, close to where the HPOL ports are. The HPOL port is where the most significant pressure drop occurs due to a change in oil film thickness (step in the babbitted surface).

As the runner plate passes over the babbitted stationary surface, particularly the HPOL ports, pressure drops dramatically. This creates turbulence causing oil film breaks that disperse dissolved gases and, possibly, oil vapours. Thus, cavitation begins.

Repairing the Thrust Bearing:

It has been suggested that a substitution of high capacity PTFE (PolyTetraFluoroEthylene) thrust bearing pads for traditional babbitt shoes would provide a solution to this problem because of their superior load-carrying capacity, and by eliminating the need for a high pressure oil lift or injection system. The PTFE bearing's design criteria of 6.5 MPa, as opposed to the 2.9 MPa of babbitt, can clearly withstand the higher thrust loads present in this unit. While babbitt bearings have been known to operate successfully for long periods of time at loads higher than 2.9 Mpa and beyond their recommended design loads, the actual pressure in this unit (3.8 MPa) surpasses the safe working limits of babbitt.

Since cavitation is not a phenomenon that occurs over a short duration, the babbitt bearing loading is not the only problem to be addressed. While extremely durable, the PTFE bearing is not cavitation resistant. Therefore, even though the PTFE bearing pads are capable of supporting more than double the thrust load of babbitt (with no HPOL system being required), it is likely that after several years cavitation may exist on the new surfaces as well.

The most viable option for addressing the cavitation and overloaded condition of this thrust bearing assembly requires two steps: (1) A new segmented runner plate correctly manufactured, then bolted and keyed together making one complete ring after installation, This would create an improved running surface for the bearing, eliminating spaces for oil pressure to vacate from the bearing surface. (2) Changing the babbitted bearing pads to high capacity PTFE bearing pads able to provide additional thrust support.

Conclusion:

Due to overloading of the thrust bearing, cavitation began to appear on the babbitted surface of the bearing pads. Also, slight wiping was present on the surface of the bearing which suggested the bearing was operating at close-to-failure limits for its particular design and the given operating conditions.

The thrust bearing needed to be re-designed. A new segmented runner plate had to be designed and installed to prevent any rapid oil pressure drops on the bearing pad surfaces. Also, the bearing required more capacity, enabling it to operate at full load throughout the year.

A new bolted and keyed runner plate was designed to prevent cavitation from forming on the bearing pads. PTFE bearing pads were supplied to replace the babbitted bearing pads, thereby providing double the thrust load carrying capabilities.

References:

The Manual of Bearing Failures and Repair in Power Plant Rotating Equipment was prepared by Mechanical Technology, Inc. for the Electric Power Research Institute (EPRI) in July 1991.

Author:

Mike Dupuis has been the President and CEO of Hydro Tech Inc. since 2001. Mr. Dupuis has extensive experience in overhauling and upgrading hydro generator/turbines, alignments, maintenance, and hydro electric generator operations. He has been working exclusively in the hydro electric field for the past fifteen years.