OPERATING *in a Material World*

BY PATRIK WHEATER, PR DIRECTOR, SEABORNE COMMUNICATIONS, THORDON BEARINGS

Understanding how bearing selection can help to solve common wicket gate regulation issues in hydropower plants that will save operators time and money.

Wicket gate bearings in hydro power plants can often cause problems for operators. Ryan Edmonds, Business Development Manager of Canadian bearing and seal specialist Thordon Bearings, has seen many of these problems and estimates that typically around 35% of all hydro power plants will experience wicket gate issues at some time or another.

According to Edmonds, all too often users will treat the symptoms, not the cause. "There is a lot of misunderstanding in the marketplace relating to the role and importance of bearing design and material selection within the turbine regulation mechanism."

One of the most common problems observed in the field is broken shear pins.

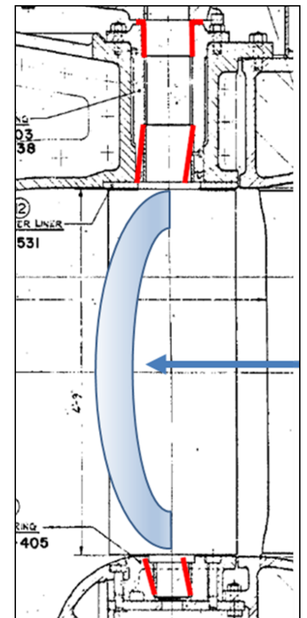
"Shear pins in the wicket gate connecting links are deliberately designed to be the first failure point in order to protect the rest of the mechanical system," says Edmonds, "but failure of the shear pin can indicate an underlying problem that needs to be investigated."

Many issues can affect wicket gate bearings: a) Excessive end loads – thrust on surfaces that were not designed to take thrust; b) lack of proper lubrication; or c) edge loading resulting from alignment issues are typical problems. Often these go together; wear of some bearing surfaces leads to greater misalignment, which then creates edge contact in other bearings, and in turn increases the loading on the entire system – often resulting in shear pin failure.

"A more forgiving bearing material reduces the effect of alignment issues," says Edmonds. "If the bearing material cannot accommodate the resultant edge loading, wear accelerates."

Wicket gate deflection, caused by the pressure of the water flow to the turbine through the distributor, is another common cause of increased bearing edge loading.

"For a 3ft (0.9m) high gate, even an angular deflection of the gate stem just past 0.05 degrees can create sufficient extra edge load to cause problems with a rigid metallic or layered bearing," says Edmonds. "Additionally, the normal limited range of motion of the gate levers can cause uneven wear on the axial thrust surfaces, which further exacerbates the misalignment. Understanding the bearing design intent and material selection definitely helps to correctly diagnose these issues."



An angular deflection of the gate stem just past 0.05° can cause edge loading

Thrust face wear is common with both the phenolic and metallic bearings that are commonly used as thrust washers to support the wicket gate assembly. Phenolic laminate bearings are made with layers of material, and sometimes only have adequate self-lubricating characteristics on a thin surface layer, so once the self-lubricated layer has worn off, the bearing wear rate will accelerate and friction will increase. Rigid metallic materials may support a higher ultimate load, but are less able to accommodate misalignment resulting from any uneven wearing of the thrust surfaces.

Bearing problems can also cause the wicket gates to become stuck in place, which can quickly lead to servo overload or reaching the servo capacity limit. When this happens, the turbine governing system is unable to regulate the wicket gate opening and closing properly, potentially leading to loss of unit control.

A range of issues can appear once the gates become stuck. "Turbine regulation is difficult if gates are hard to move because of bearing problems," says Edmonds. "Increasing servo hydraulic pressure to overcome the sticky bearings can result in overshoot during gate movement, (meaning that gates open or close further than intended). In the worst case, the force required exceeds the capacity of the servos, so without adding some external force it will be impossible to make the gates move."

Another common cause of gates sticking is that the lip seals can be worn or cracked from age, in either the servo motor or the gates themselves and this also increases the friction within the system. Worn bearings can have a similar effect, as can 'stick slip' behaviour of the bearing materials.

"Stick slip behaviour (resulting from large differences between static and dynamic friction) is a characteristic of the bearing and sealing materials, and often made worse when a mechanical system sits for a long time without moving," says Edmonds. "Some materials can exhibit problematic levels of stick-slip even when new. Low friction bearing layers can wear away, and the resultant increase in static friction increases the likelihood of stick slip. Overcoming the stick slip requires a higher starting force that can overload the servo or break a shear-pin."

It is important to remember that every single moving interface in the entire turbine operating mechanism contributes to the total system friction, including upper, lower and intermediate bearings, lip seals, thrust bearings, servo rod end bearings, servo linear guide bearings, and linkage bearings. As well as wearing away of the friction layer of layered phenolic bearings, there may be alignment issues – exacerbated through wear – and end loadings in bearings not intended to deal with thrust forces. Excessive friction is frequently caused by a combination of these issues.

For successful operation, the choice of the correct bearing material and understanding of the entire mechanical system is crucial. The properties of common bearing materials, and their use in wicket gate bearing applications, are not always correctly understood.

Unfortunately, there are few standards for friction measurement that are consistently used in documentation that can be directly correlated with the loads and motion typical of wicket gate applications. In many cases, bearing material product documentation will exaggerate or present misleading friction characteristics that appear quite good on paper, but may not have been tested at realistic loads relevant to the application, or proven in service. When very thin layers of low friction material are applied to rigid substrates, they may show an excellent testing result in a laboratory, but in service the thin low friction layer can be quickly worn away by abrasives, or may even be honed away if in-place machining is carried out to correct alignment problems between bottom ring and head cover at time of installation.

This misunderstanding of real-life vs. theoretical friction and wear performance of different bearing materials, together with increasing competitive price-pressure during new or refurbish turbine work, often leads to selection of a low-cost material. This, of course is false economy, as the bearing may survive the initial warranty period, but ultimately leads to costly problems for the plant operator if bearing problems show up before the next planned major overhaul.

Advice from an experienced bearing and seal specialist, such as Thordon Bearings or its approved distributors, can bring about longer-term savings by diagnosing the cause instead of the symptoms. A Thordon representative can advise which parts might need replacing, and what they should be replaced with. A complete unit overhaul may not be necessary – just attention to the weak points of the system. Fitting a bigger shear pin, or adding grease to a bearing that should be "grease-free", may solve an immediate issue in the short term, but doesn't treat the root cause of the problem.

"Choosing a self-lubricated elastomeric polymer material such as ThorPlas-Blue provides the necessary reassurance. It is homogenous, with consistent mechanical properties throughout the bearing. Unlike many other metallic or phenolic laminate bearings, ThorPlas-Blue is proven to provide stable and predictable friction, excellent resistance to edge loading, and offers an industry leading 15-year bearing wearlife guarantee," concludes Edmonds.

Thordon Bearings designs and manufactures a complete range of journal bearing and seal systems for marine, clean power generation, pump and other industrial markets. These products are built using Thordon proprietary non-metallic polymer materials that are lubricated with water eliminating oil or grease usage, meaning ZERO risk of oil pollution to rivers, lakes and oceans.

For further information, please contact:

Ryan Edmonds, Business Development Manager, Thordon Bearings Inc.

Email: ryane@thordonbearings.com

Tel: (905) 537-8524

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