February/March 2012

the journal of ships' engineering systems

marine propulsion
& auxiliary machinery

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Water-lubricated sterntube bearings combat oil loss

Manufacturers and suppliers of sterntube lubricating and bearing systems are offering increasingly smart technology driven solutions to address issues including pollution. Rudder and pump bearings are benefitting from these developments

By Dick Amos

Although not an obvious source of major marine pollution, one leading seal manufacturer estimates that global oil losses account for more than 10 million litres per annum. This is without considering the higher losses arising from excessive wear or seal damage.

It is clear that maintenance plays an important part in keeping this problem to a minimum but the nature of sterntube installations can present maintenance problems or, at best, requirements for expensive drydock work. Another aspect which poses potential problems is the basic design of oil-lubricated systems where, by definition, the oil pressure must exceed the seawater pressure. Leakage can therefore only be outwards from the sterntube. Regular replacement of wear components is required to minimise leakage but, with commercial vessels operating high annual hours, windows for this work are limited.

Hydrex, headquartered in Antwerp, Belgium, markets solutions that enable this work to be carried out without having to drydock. In one recent example, a sterntube oil leak had developed on a cargo vessel located in Mobile, Alabama, and permission to sail to a different location was denied until a permanent repair had been carried out. A Hydrex diver team was deployed to perform an underwater repair. First, the team set up a diving station at the ship's position. The Hydrex flexible 'mobdock' was then installed to create a dry underwater environment, enabling work to be carried out on the leaking stern tube. The damaged sterntube's seals were replaced successfully in a minimum timescale and the vessel was released to its next charter with no further leakage problems.

The original mobdock principle was first developed in 2002 and, since this time, the system has been progressively improved and adapted for a range of underwater repair activities. The principle of the system is the creation of a localised dry working environment, using a flexible structure installed around the area requiring work. The replacement of sterntube seals is a prime application but the system is also suitable for in-situ repairs of bow or azimuth thrusters.

For newbuild vessels, there has been considerable pressure to adopt shaft and seal systems which are designed to entirely eliminate oil loss to the environment. The Thordon Compac bearing system uses sea water for lubrication in place of lubricating oil, eliminating oil loss problems. To facilitate this, the propeller shaft bearings are non-metallic and the seawater feed is fully treated to remove any suspended particles which could cause abrasive damage to the bearings.

Under installation at Sembawang Shipyard, Singapore, this Compac bearing will provide zero sterntube oil leakage on a 141,000 dwt tanker

Water is taken directly from the sea, and suspended solids with a specific gravity of 1.2 or higher, and greater than 80 microns, are removed. It is then pumped through the propeller shaft bearings and returned to the sea. As the loss of sea water is of no environmental consequence, the need for an aft sterntube seal is eliminated. The full system provided by Thordon includes shaft liners, a water quality package, a forward seal and bearings. The bearings are manufactured from an elastomeric polymer alloy with the lower area of the bearing being smooth and the upper area incorporating groove features for flow of the water lubricant/coolant, promoting the formation of a hydrodynamic film between the shaft and bearing.

To minimise corrosion and wear, Thordon has developed a shaft coating system which provides 10-year corrosion protection against seawater damage. This is a two-part epoxy coating which Thordon says is significantly more flexible than existing equivalent shaft coating products.

Another selling point is that it takes away the need for the storage, sampling and disposal of oil. Thordon also offers a 15-year bearing wear life guarantee on the Compac shaft bearing system, which is already installed on 600 vessels worldwide. The system is also available as a retrofit, to replace standard oil-lubricated metal-bearing-based designs.

Icon Polymer Group, based in Retford, England and owned by Wyatt International, specialises in the supply of materials for water-lubricated bearings. Working with chemists at Aston University, has resulted in the development of a compound combining standard nitrile rubber with PTFE polymer – two materials that were previously incompatible. The new material provides both a low coefficient of friction and reduced stiction – the generalised term for the initial friction effect which has to be overcome in order to start the shaft turning. These characteristics enable pumps, for example, to be operated dry for a short priming period. The low stiction also allows the use of smaller motors for turning propeller shafts in drydock, saving significantly on equipment costs. The latest water-lubricated bearings can also be offered in a specially formulated nitrile compound that offers minimum and increased life in high-silt water conditions.

Many global companies manufacture both oil-lubricated and water-lubricated bearings and associated seal systems. Suppliers such as Kemel, renamed in 2010 and continuing the business of Kobelco-Eagle, Japan, offers water-lubricated sterntube bearings and other sterntube associated equipment, plus a biodegradable oil for users of oil-lubricated systems wishing to reduce their environmental impact. Other industry developments include the acquisition, in 2011, of Cedervall of Sweden by the Wärtsilä Corp of Finland. Cedervall has built a strong reputation as a supplier of water and oil-lubricated sterntubes and sterntube bearings.

The Trelleborg Group's Orkot marine bearing range includes many types of fabric-reinforced composite bearings which are used in stern tube, rudder and hatch slide pads applications, as well as in on-deck machinery.

Orkot bearings, made in Rotherham, England, were selected for the rudders fitted to *Mozah*, the world's largest LNG carrier, built by Samsung Heavy Industries in South Korea. Capable of carrying 266,000m^3 of LNG, which its class society Lloyd's Register says is almost 80 per cent more cargo than conventional ships, the 345m ship is fitted with a twin rudder system. The choice of Orkot TXMM material for the rudder stock and TLMM material on the pintle enables these rudders to operate without lubrication.

The TXMM material is an advanced synthetic composite which provides both long service life and a low unlubricated friction co-efficient. The material incorporates solid lubricants, and Trelleborg claims it has exceptional wear resistance, with virtually no swell in water and high-dimensional stability. Both bearing materials can also be used in conjunction with water and grease lubrication.

Trelleborg also offers long service life water-lubricated designs for pollution-free propeller shaft bearings. "Service life of water-lubricated tail shaft bearings is influenced by bearing and liner wear and is extremely important on naval and merchant vessels where unscheduled docking times are costly and affect fleet programmes," says Barry Davies, general manager, Trelleborg Sealing Solutions.

The vast majority of bearings used for sterntubes are still lubricated with oil and rely on the effectiveness of the sealing system to prevent oil leakage into the sea. Orkot TXMM bearing material offers a significant solution to this problem, particularly as the material has been developed to operate with unfiltered sea water. The Orkot TXMM segmented bearing system was also designed with a patented, removable locking system to allow easy removal of the bearing segments with the shaft and housing remaining in place in the vessel. This system is used on the UK Royal Navy Type 45 destroyer, the Queen Elizabeth class aircraft carriers and the Khareef class corvettes for the Royal Navy of Oman.

The Orkot TXMM bearing uses two composite materials to give the required stiffness and self-lubricity for the low speed operation required on new generation vessels using direct electric drives. In these low shaft speed conditions, the normal hydrodynamic water film generated by shaft rotation is absent and trouble-free operation relies on the wear resistance and low friction factor of the bearing materials. While most bearings will generate a hydrodynamic film at higher speeds, the critical period for wear risk is when the water film is absent.

Independent testing showed that the wear rate for Naval Bronze and Inconel 625, both used on naval and other vessels, was extremely low when operating in sea water containing silica flour, as specified by the Royal Navy. A further important factor for wear is the alignment of the shaft and bearing, which may vary with shaft speeds due to propeller lift and other factors. This will affect the contact area and, therefore, the contact pressure on the bearing. Trelleborg Sealing Solutions developed a programme to assess the bearing pressure at static (cold) and running (warm) conditions and then modified the bearing by machining

The Hydrex 'mobdock' system enables sterntube seals to be replaced without drydocking

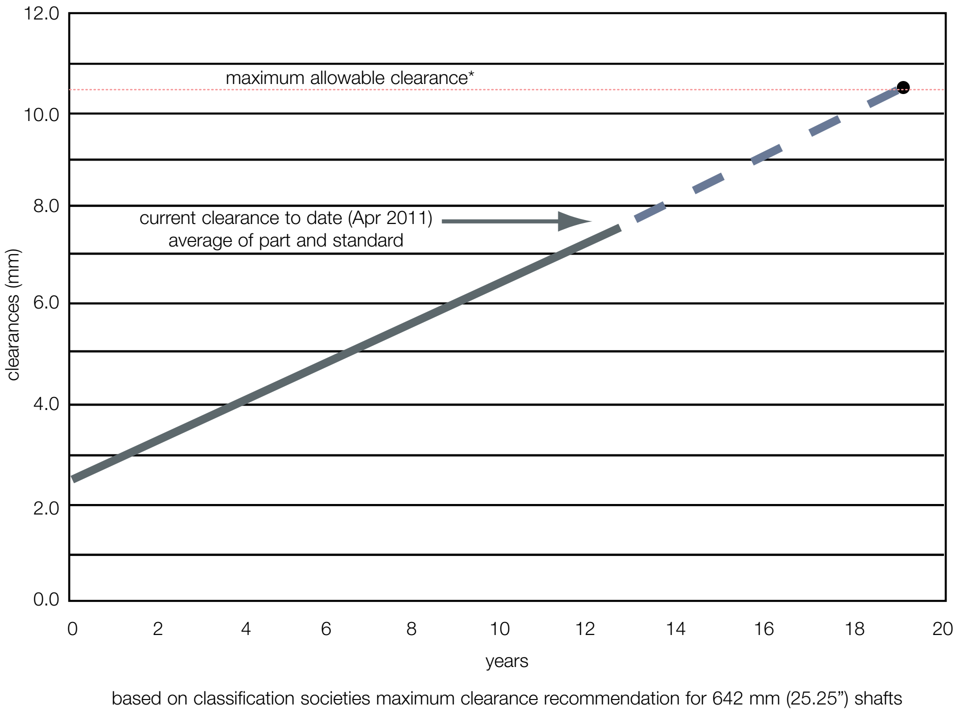
An Orkot TXMM Mainshaft Bearing is made from machinable composite material a slight taper. This allows elastic deformation of the bearing and a resultant increase in contact area.

The new bearing segments can be pre-machined at the Orkot factory and no additional machining is required at the shipyard. Segments are easily fitted using simple tools and may be removed and replaced, in an emergency, without docking the vessel and provided split composite rope guards are used. The bearing systems can be retrofitted into any existing plain bearing housing without modification. When sterntube and bracket bearings are not required to be removed with the shaft in place, semi-finished tubes can also be supplied for shipyard machining. These can be fitted into the bronze or composite housings by removing the existing rubber bearing from the housing, usually by machining. The new bearings can then be refitted by press or by shrink fitting.

Trelleborg Sealing Solutions has also developed composite shaft coupling protection covers for both hydraulic and flange couplings, to fully seal these from seawater ingress. Designed for the life of the vessel, these can be removed and replaced with no need for epoxy bandaging or paint protection. Originally produced for the Royal Navy, with the trial cover fitted to HMS *Cornwall* Type 22 frigate 11 years ago, these covers have now been retrofitted to all Type 22, 23 and 42 vessels and are fitted new on Type 45 Queen Elizabeth class and Royal Navy of Oman's Khareef corvettes. The system has proved successful in operation with a recent inspection showing no corrosion or water ingress when a cover was removed.

Manufactured from Orkot machineable composite material, the covers locate on either the shaft liners or on split location sleeves bonded to the shaft and sealed with O-rings and gaskets. To further protect the shaft coupling, the internal voids are filled with Orkot Envirogrease, which is specially formulated and biodegradable. *MP*

THORDON COMPAC SEAWATER LUBRICATED PROPELLER SHAFT BEARING CLEARANCES (for Grand Princess)



Based on recent inspection, the Compac bearing on M/V Grand Princess will achieve a service life of close to 20 years

Briefing: water-lubricated bearings

Water-lubricated bearings were first used around 150 years ago to provide underwater support for propellers on the earliest generations of steam-powered vessels.

The earliest water-lubricated bearings consisted of a tubular housing with longitudinal slots along the interior, into which were placed dense wooden staves, which reduced the running bore of the bearing. To control the lubricating water flow, Victorian design engineers optimised the gap between the staves and shaft surface, as well as the ratio of stave width and the 'flute', or gap, between the staves. Today's water-lubricated bearing designs have come a long way since these early examples but still apply the same principles of optimisation.

The limitations of early products were mostly due to the nature of the materials available at the time. Wooden staves, for example, were prone to rapid wear in service and needed regular replacement. This issue was not overcome until early in the twentieth century, when it was found that the wear characteristics of the rubber were far better, thus marking the end of the use of wooden staves. Nitrile rubber, installed in a stave-and-flute pattern inside metal tubes, then became the standard material in the design of water-lubricated bearings. The material was a logical choice as it exhibits minimum swell in water and is very hard wearing. It is still widely used in modern water-lubricated bearing products.

Water-lubricated bearings are now seen in a range of industries and, within the marine sector, they are applied in a variety of applications. This is particularly so where low noise signatures are required and, for at least the last half century, rubber-lined water-lubricated shaft bearings have been commonplace in many types of surface ship and submarine used by navies worldwide.

"It was thought for many years that shaft rotation in a water-lubricated bearing gave lift to raise the shaft above the bearing surface," said Mr Neave. "It was not until 2003 that sponsored work conducted by Liverpool John Moores University proved this to be incorrect." Practical in-service microscopic measurements of operating bearings, backed up with computational fluid dynamics analyses, demonstrated that, under the rotating shaft load, the flexibility of the rubber surface causes it to deflect. Although the effect is slight, this leaves a pocket a few microns in depth where water can support the shaft, although still just rubbing tangentially on either side of the pocket.

This research explained why the use of non-elastomeric materials such as wood, or composites, creates much greater wear and noise than rubber, as their lack of flexibility does not enable them to deflect under shaft loading. Results also emphasised the importance of understanding how rubber technology enhances the service life of the bearing, by ensuring the rubber is optimally cured and possesses optimal wear and compression set properties.

Acknowledgement: Icon Polymer Group