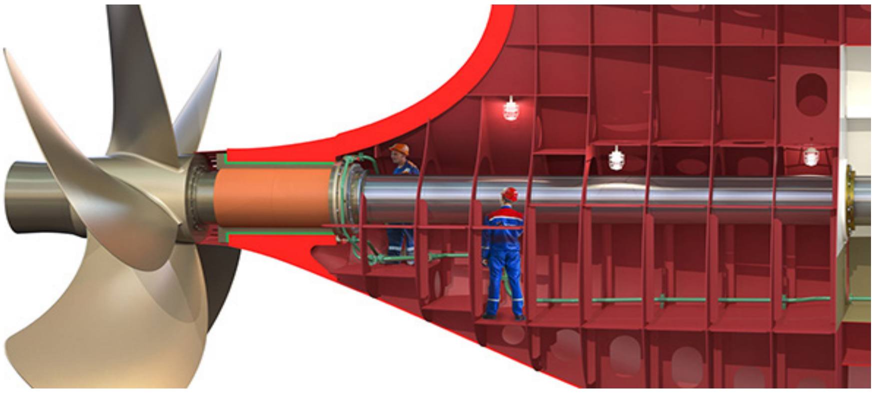
CASE STUDY:
STERNTUBELESS DESIGN

OVERVIEW



The vast majority of ocean-going ships operate with oil-lubricated stern tube bearings and use lubricating oils in applications for both on-deck and in-water machinery.

Progress by the shipping industry to reduce loss of oil cargoes – and the focus on air emissions – has meant that there has been less focus on oil leakages through the aft stern tube seal. The introduction of biodegradable, environmentally acceptable lubricants in stern tube bearings has not eliminated the oil pollution problem and such leakages are still regarded as a regulatory violation.

These challenges suggest that a new approach is needed to the stern propeller shaft area design to permit easier maintenance, reduce oil pollution and increase vessel efficiency. In response, ABS, Shanghai Merchant Ship Design And Research Institute (SDARI), Thordon Bearings and the National Technical University of Athens have collaborated to bring forward new approaches.

CHALLENGES

The impacts from the ocean, bad weather and vessel behavior affect stern tube aftmost seals causing an inherent propensity to leakage; by some estimates, ships with oil lubricated bearings can lose six liters of oil a day. This issue, once considered as part of the normal operational consumption of oil, has become a greater concern and is now considered to be pollution, with associated legal consequences. A rough calculation shows 45,000 vessels working at 330 days a year can release nearly 80 million liters of oil into the oceans annually.

The parallel development of new environmental regulations and related indices, such as the EEXI and CII, has created a requirement for improved vessel efficiency and increased cargo space – and as a by-product, it has affected the imposition of engine power limitations (EPLs) to enable the ships to achieve ratings that are attractive to charterers.

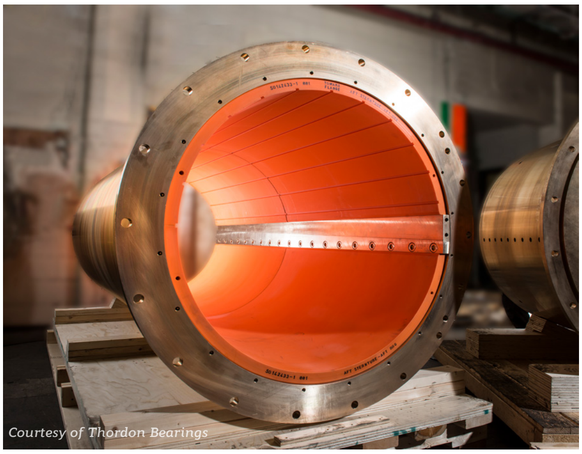
The traditional arrangement of a vessel's power train means that the existing stern tube bearing area is all but completely inaccessible in case of failure or need for maintenance without drydocking the vessel.

SOLUTION

Recent innovations in materials science have enabled water lubricated bearing manufacturers to create solutions combining wear-resistant materials with improved designs, improved water conditioning technology and software that can optimize shaft alignment and prolong the operation life of the propeller shaft bearings. This enables ship designers to rethink the stern area layout, potentially eliminating the stern tube casting itself and instead using conditioned seawater for bearing lubrication.

The installation of aft bearings using seawater as lubricant is not new; many naval and commercial vessels have already successfully installed seawater lubricated bearings using seawater as the lubricant.

However, the proposed design is novel in that it involves removing the stern tube casing itself altogether, substantially decreasing the shaft line length, adding a torsional vibration damper to eliminate the barred speed range, and most importantly, the creation of an irregularly shaped chamber behind the bulkhead of the engine room. This chamber provides several benefits to the inspection of the shaft line and bearings throughout the operational life of the vessel.



The traditional arrangement of a vessel's power train means that the existing stern tube bearing area is all but completely inaccessible in the case of a bearing failure, shaft inspection for damage and/or need for maintenance. To inspect, replace or repair a damaged or worn-out bearing, a multi-step process usually takes place: the vessel has to go to dry dock; its shaftline and propeller disassembled and removed; its bearing inspected, removed and replaced; its centerline laser measured and its shaftline and propeller re-assembled and re-measured for shaft alignment verification and compliance. The process lasts about two weeks and it is not always free of the so-called "maintenance-induced damages".

The consortium's approach aims to change all this. It enables engineering staff or class surveyors to access the tailshaft area through the irregularly shaped chamber from within the engine room from the aft bulkhead, inspect the shaft, the aftmost bearing and stern seal, and observe the structural condition of local steel plate and stiffening members.

Ultimately, it becomes possible to replace a worn-out water lubricated bearing from inside the vessel for the first time using a tapered key design to release the upper and lower cylindrical bearing parts that slide along the shaft and enabling bearing replacement from inside the vessel, without a visit to dry dock, shaftline disassembly or propeller removal. By some estimates the off-hire time required would shrink from two weeks in dry dock at an average cost of $100,000 to one day of repairs while afloat.

The project partners built 3D models to test the impact of the changes on the ship structure as well as on vibration and shaft alignment. Testing in extreme scenarios demonstrated that shear and reaction forces on the shaft line would still be within the manufacturer and classification approval limits. The installation of a torsional damper could, as an add-on benefit, eliminate the undesirable barred speed range present in the vast majority of direct-drive diesel engine vessels.

RESULTS

A sensitivity analysis considering maximum wear-down on the aftmost bearing found no issues, with condition monitoring requirements similar to using a traditional oil-lubricated shaft bearing, with tail shaft survey requirements maintained at the 15-year interval if the ABS TCM-W Notation is adopted.

This novel design proposal complies with all classification society rules and regulations, such as those governing torsio-axial vibration, shaft alignment and structural integrity, including basic SOLAS requirements.

To create the model, the consortium revisited an existing container vessel design from SDARI and made a number of design interventions. In June 2022, ABS awarded Approval in Principle to SDARI for the novel design.

> "*Besides the benefits for operators, the new concept also gives more possibilities and flexibility for designers to optimize the engine room arrangement. Consequently, for the shipbuilding, the initial cost including the construction materials and labor cost may be reduced accordingly. It will contribute a series of benefits to all parts involved in the vessel,"* said Mr. Wang Gangyi, Chief Engineer, SDARI.

> "*Our technical discussions have led to a revolutionary propeller shaft bearing system design that offers easy monitoring and maintenance of bearing and seal condition without shaft withdrawal, lower operational expenses and elimination of oil emissions forever,"* said Anthony Hamilton, Technical Director, Thordon Bearings, Canada.

> "*The concept of using seawater as a lubricant is well-established and the proposed design takes this further by removing the stern tube casting, decreasing the shaft line length, reducing the engine room space and increasing the cargo space. The elimination of the barred speed range and the creation of an aft chamber to enable in-water inspection, enable significant efficiencies and cost savings for operators,"* said Dr. Chris Leontopoulos, Director of Global Ship Systems Center, ABS Athens.

ABS

WORLD HEADQUARTERS
1701 City Plaza Dr. I Spring, TX 77389 USA
1-281-877-6000 | ABS-WorldHQ@eagle.org
www.eagle.org

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