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IMPROVEMENTS TO SLIDING BEARINGS OF THE PROPELLER SHAFTS OF THE MOTORS FOR SHIPS USED ON INLAND WATERWAYS

Renato de Oliveira
Estação Naval do Rio Negro BR 316, Km 4,5 - Distrito Industrial s/n. CEP 69075-510 - Manaus / AM, Brazil.
renatocaxeta@yahoo.com.br

Ángel Silvio Machado Rodríguez
Universidade do Estado do Amazonas, UEA. Escola Superior de Tecnologia (EST). Av. Darcy Vargas 1200, Parque 10 de Novembro, 69050-020, Manaus, AM, Brazil.
asilviomr@gmail.com

Eduardo Rafael Barreda Del Campo
Universidade do Estado do Amazonas, UEA. Escola Superior de Tecnologia (EST). Av. Darcy Vargas 1200, Parque 10 de Novembro, 69050-020, Manaus, AM, Brazil.
eduardoserapio@yahoo.com.br

Abstract. *The continuous operation of the propeller shaft of a ship in water with high pH and many dispersed particles cause excessive wear on the sliding bearings that support the shaft. This wear causes a clearance of up to 6 mm in radius on the shaft. The problem is the wear of the polymer coating of bronze bushings, which in contact with the circular shaft and sleeve due to stress, produce premature wear of the joint. This creates serious problems in the operation of the transmission of the ship. This problem is very specific to this type of inland waterways in the Amazon region. Therefore it is necessary to find a solution that can be generalized to other boats operating in this environment. At work several ways to approach and troubleshoot the problem to prevent premature wear on the joints of ship propulsion are discussed.*

Keywords: *Propeller shaft, Wear, Polymer, Ship, Inland waterways.*

1. INTRODUCTION

Self-propelled ships are becoming more common, for that reason become more relevant the studies of their propulsion systems. The problems that occur in these systems are common, the mechanical systems have specific characteristics and they work in an aggressive environment. One of the most common problems in these systems is misalignment of the shaft line due to multiple reasons. In "Fig. 1" we can see an overview of the propulsion system of a ship. (Latorre, et al., 1981; Latorre and Dünow, 1981).

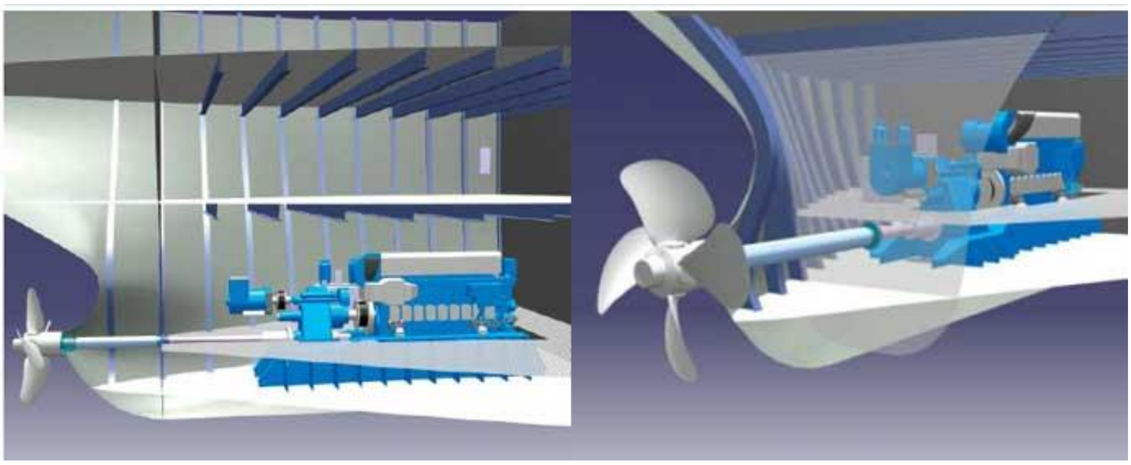

Figure 1. Propulsion system

Any propeller shaft, besides being the power transmission element between the motor and propeller, has own weight, causing that the bearings support all the efforts of the transmission. The shaft must support all loads originated by these efforts. First, originating from the weight of the propeller shaft and the second due to its own weight thereby behaves as a supported and loaded beam, if a horizontal force is applied; the support will remain fixed and reacts with the same intensity in opposite directions preventing the horizontal displacement (Latorre, et al., 1981; Latorre and Dünow, 1981). If there is misalignment of the shaft line, the system will work outside the projected conditions and carrying various problems such as:

- Big radial and axial forces on the bearings, reducing their life;
- Produce dynamic instability of the propeller shaft;
- Increase wear in the coupling components;
- Increased possibility of shaft failure by cyclic fatigue;
- Increase shaft deflection in power transmission points, maximizing power loss;
- Wear in bushings supports;
- Considerable increase of vibration.

2. PROPELLER SYSTEM

All these problems directly affect the propulsion system, if there is an unexpected failure; it is required to do a corrective maintenance, which involves considerable economic losses due to high costs of the repair (Cowper, et al., 2006; Latorre, et al., 1981). This paper will focus on one of the most common problems of inland navigation in the Amazon region, which is the bushing wear of the supports of the propeller shaft. Excessive wear on the bushings of the supports, is due to several factors that are related to multiple variables. To increase the life of these elements will be carried out analysis and testing, with new materials for better performance and high resistance that are proposed to be used in these supports.

Characteristics of the analyzed system

Types of propeller shafts systems

There are various projects of propeller shafts systems; however there are two projects that are most commonly used. The system of water-cooled propeller shaft, and propeller shaft system cooled by lubricating oils (Cowper, et al., 2006; Ken and Craig, 2010). The most used in the Amazon region to the present day is the water cooling system of major importance for its positive impact on the environment. This work will aim this system.

Water-cooled propeller shaft

The propeller water-cooled shaft works with slide bearings, where the joint is composed of a bronze sleeve, high wear resistance, placed at the point of support with a bronze bushing coated internally with Thordon SXL, type of polymer used to guarantee high wear resistance and capable of support the loads that are acting, while also ensuring proper alignment of the shaft (Cowper, et al., 2006; Ren and Muschta, 2011; Ken and Craig, 2010; Thordon Newsworks, 2006; Thordon Bearings Inc., 2014). “Fig. 2” and “Fig. 3”.

Figure 2. Supports of the propeller shaft

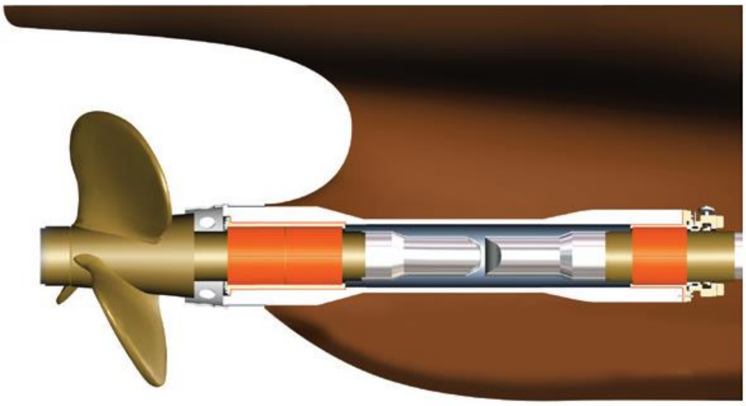

Figure 3. Propeller shaft water-cooled

Propeller shafts. Characteristics

In this work was analyzed a boat that has propeller shafts sustained by a support, close to the propeller and a telescopic tube with two supports in their ends, supporting the propeller shaft in the middle and close to the gearbox, located in the engine room. This propeller shaft system has the following characteristics:

Shaft Material: Steel SAE 1020; diameter 89 mm;
Shaft length: 4600 mm;
Power: 560 HP;
Angular rotation speed: 0 to 900 rpm;

Characteristics and number of existing supports in the propeller shaft analyzed

The propeller shaft is supported by three main supports and an anchored support.

The supports are distributed along the propeller shaft, being located at the ends and in the center of it. These supports form a composite set of two parts, one inside and another outside:

- Internal part composed of a bronze sleeve lining the propeller shaft at all points of support. See “Fig. 2”
- Outside consists of a bronze bushing inside covered by the polymer Thordon SXL (Thordon Newsworks, 2006; Thordon Bearings Inc., 2014). See “Fig. 4”

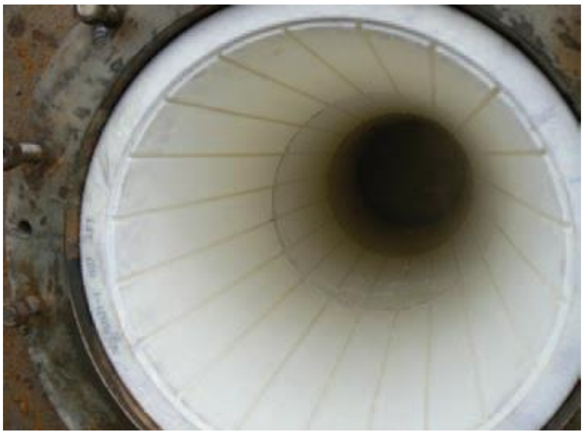

Figure 4. Bushing coated with Thordon SXL

Thordon SXL bearing

Thordon is a self-lubricating synthetic polymer alloy formulated to provide excellent performance, combining flexibility and stiffness of a material, high strength specially developed for the manufacture of bushings, bearings and sliding guides.

Depending on the application and the compound selected, Thordon can run dry, under pressure that can reach 70 MPa (10,000 psi), impact loads, submerged in extreme conditions of pollution and temperatures that can reach 110 ° C (Ren and Muschta, 2011; Thordon Newsworks, 2006; Thordon Bearings Inc., 2014).

The anchored support, is located in one end of the shaft in the engine room, its main function is to reduce the radial and axial forces.

Problems encountered and possible solutions

Approximately seven months after installation of the propulsion system in the boat, he began to show excessive clearance in the bearings. It was realized a visual inspection detecting a possible displacement of the protective sleeve on the shaft (Latorre and Dünow, 1981).

Later, it was verified that the bronze sleeve had not moved. When removing bronze sleeve the presence of excessive wear was verified, reaching the allowed limit that almost affecting the shaft surface. See “Fig. 5”

The inner lining of the bushings with polymeric material Thordon SXL (Thordon Newsworks, 2006; Thordon Bearings Inc., 2014), was not worn, but it was damaged by the incrustation of bronze particles due to intensive process of bronze sleeve wear that protects the shaft. See “Fig. 6”.

Figure 5. Bronze sleeve wear

Figure 6. Polymer lining damage

Results and studies carried out

The bushings presented misalignment up to 4 mm and eccentricity of up to 4.5 millimeters.

The bushing covered with the polymer Thordon SXL suffered no wear, but was damaged by incrustation of bronze particles due to heavy wear of bronze sleeve.

The bushing covered with Thordon SXL had bronze pieces embedded in its inner diameter.

It was confirmed that the bushing covered with the polymer Thordon SXL, has high resistance to abrasion, despite not being the best material Thordon to operate in conditions of rivers with high density of particles in the water and high pH, and can provide more than 2 years service life.

Due to high abrasion, the size of the slots of the bushing must be greater to guarantee a better flow of water and prevent the accumulation of potentially abrasive materials.

Bronze is not recommended as material to manufacture bushings for propeller shafts, which must work in regions with the aforementioned features for its low resistance to abrasion.

Proposed solution

After making a detailed study of the problem, together with specialists from several companies, and verify that the polymer Thordon SXL has a high resistance to wear in working conditions was studied and considered that it was necessary replace the bronze sleeve lining the shaft, for their problems to work in an environment where abrasive wear dominates, by a material with better performance, was proposed replacement of bronze sleeve by a sleeve of carbon steel Chromium Nickel Boron coating with a minimum thickness of 0.5 mm and a surface hardness of 55 to 60 HRC.

Due to the high water pollution in the region was requested to the firm Thordon Bearings Inc., that the thickness of the slots in the bushings should be increased up to 10 mm, to facilitate the movement of water and decrease sedimentation and with this the abrasive effect.

Also, the application of Chockfast Orange resin for mounting bushings is recommended, thus ensuring the necessary seal.

Applied solution

Propeller shaft sleeve was manufactured using steel 1045 with a cementation treatment with quenching tempering, to obtain a surface hardness of 55 HRC, mounted in the position of the corresponding supports.

Those sleeves are manufactured in mechanical lathe, with an H7 external tolerance and H8 internal tolerance. Guarantee an interference of 0.1 mm and the welding points between the shaft and sleeve, to increase rigidity.

After positioning the sleeve should be checked the internal measure of the bushing and the outer dimensions of the sleeve, leaving a minimum clearance of 0.8 mm working.

The shaft is mounted without damaging the polymer of the bushing. It must be aligned in the position of fits into the telescopic tube. After mounting the shaft in the tube, the alignment should be checked for the propulsion system, together with the shaft line allowing a maximum misalignment deviation 0.001 mm.

3. CONCLUSIONS

1. Modify the material of the protective shaft sleeve for carbon steel coated Nickel Chrome Boron and a minimum thickness of 0.5 mm, or other coating with hardness 55-60 HRC.
2. If it is not possible to guarantee the lining, manufacturing of carbon steel bushing will significantly improve the work system and will extend its life.
3. Due to the high abrasiveness of the waters of the Amazon region, it is recommended to the firm Thordon Bearings Inc, that the thickness of the slots in the bushings should be increased up to 10 mm.

4. ACKNOWLEDGEMENTS

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