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WATER LUBRICATED MAIN SHAFT BEARINGS WITH THREE LAYER BUSH – MODERN SOLUTION FOR MARINE INDUSTRY

TRACK OR CATEGORY
Fluid Film Bearings III

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INTRODUCTION

Water lubricated sliding bearings are increasingly popular in marine and hydro power industry. Such popularity is partly due to their simple construction which also means a relatively affordable price. Properly designed and installed water lubricated bearings may well last for over a decade.

Thanks to research efforts carried out by R&D departments of major bearing manufacturers and scientific centers all over the world, both the durability and the reliability of this bearing type have improved.

The work presents results of experimental research conducted on modern, comparable sliding bearings with various bush materials and geometry. All tested bearings were approved for marine application. Movement resistance, pressures in bearing interspace and shaft orbits were measured, compared and analyzed.

Additionally conducted research determined that three layer bearings with PTFE surface continue to work properly despite lack of lubricant flow and cooling. This is due to low motion resistance levels resulting with low friction so heat generated in the friction zone of such bearings is sufficiently low to be dispersed into surroundings once bearing temperature rises and stabilizes at a safe level.

BEARINGS, TEST RIG AND TEST CONDITIONS

Selected bearings main parameters were presented in table 1. It is possible to notice a diameter clearance difference measured in vertical and horizontal plane of each bush. Often a shape imperfection happens, results of difficult machining, assembly and water absorption. All bearings were delivered by manufacturer from all around the world as ready to apply part (with recommended by manufacturer diameter clearance). All tested bearings length to diameter ratio (L/D) was 2.

The test rig offers extensive research possibilities [1][2]. It allows for recording friction moment of tested bearing (with following calculations of friction coefficient), shaft trajectory, clearance circle, as well as pressure distribution at selected locations in the space between bush and journal. However, the test rig has also certain limitations, resulting from the method of applying radial force on the tested sliding bearing. The load is applied through two rollers equipped with ball bearings. This is why the recorded value of the friction coefficient is increased by additional factors - the resistance of movement of the load applying rollers, as well as of the two sealing rings which allow for supplying water inside the enclosed area of the bearing assembly. This is why the moment of friction measurements are marked by certain error, and the measurement accuracy increases with higher levels of resistance, for example, during start-up. In addition, the method of supporting the bearing at two points may lead to its misalignment to the shaft, for instance as a result of pressures appearing in the bearing's lubrication film. Tests were conducted for shaft rotational speed up to 11 rev/s. For shaft diameter equal 100 mm it gives sliding speeds up to 3,5 m/s. The measurements were made for three load values of 4, 8, and 12 kN, which corresponded with calculated pressure values of 0.2, 0.4, and 0.6 MPa.

Table 1. Tested bushes types, geometry and details

No.	Bush type and geometry / bush thickness [mm] / modulus of elasticity (E) if available	Approximate diameter clearance [μm] horizontal / vertical	
		Left side of bush	Right side of bush
1	Three layers – eight grooves along entire circumference / PTFE 5 mm, NBR 5 mm, brass 3 mm	450 / 500	500 / 500
2	Three layers – partial arc, five grooves in upper part / PTFE 5 mm, NBR 5 mm, brass 3 mm	480 / 600	500 /480
3	Rubber – NBR – ten grooves around entire circumference / 12 mm	900 /800	800 /1000
4	Rubber – NBR – partial arc, grooves in upper part / 12 mm	500 /600	600 /600
5	Elastic polymer – partial arc, grooves in upper part / 12 mm / E = 600 MPa	300 /400	180 /200
6	Stiff composite – partial arc, grooves in upper part / 12 mm / E = 4000 MPa	300 /350	250 /300

RESULTS

Each new bearing was run-in. The bush surface became smooth after only a few dozen hours of work at low revolution speed with gradually increasing load.

Selected measurement results of movement resistance, shaft trajectories and pressure distribution in the lubrication film are presented below (Fig. 1 – 3) [3].

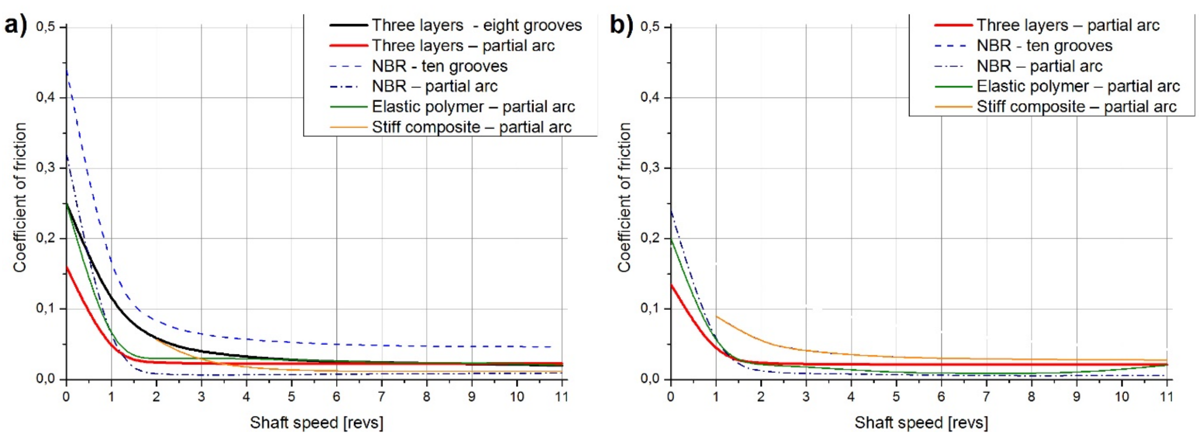

Fig. 1. Coefficient of friction diagrams, shaft speed 11 rev/s; a) load 0.4MPa, b) load 0.6MPa.

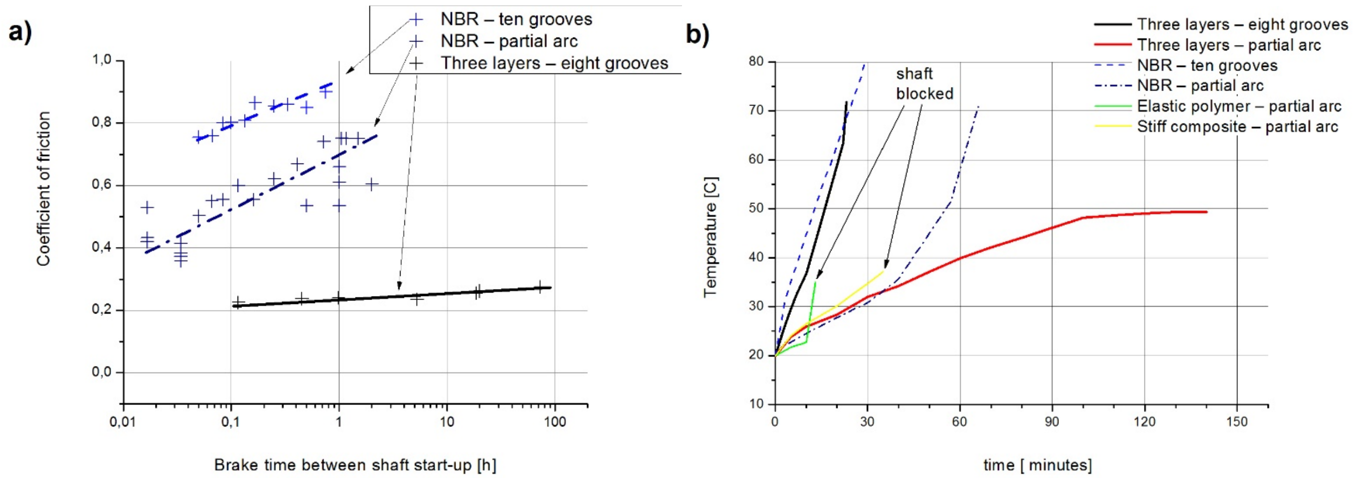

Fig. 2. a) starting friction as a function of time brake, load 0.2 MPa, b) bearing unit temperature – no water flow, 11 rev/s, load 0.4 MPa.

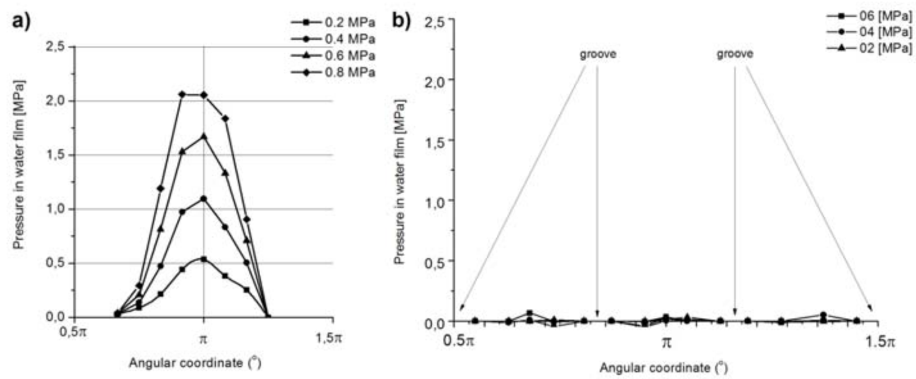

Fig. 3. Pressure distribution, shaft speed 11 rev/s; a) three layer partial arc bush, b)NBR bush with grooves. Additionally bearing operation conditions under lack of lubricant flow was simulated (Fig.2.a). Such a situation is a typical brake down case when lubrication pump is out of order or filter is blocked. All results were very interesting. In the author's opinion all bearings with full lower bush half operates under hydrodynamic regime with low frictional losses but only one bearing – three layer bearing is able to operate in such conditions. In other bearings temperature was increasing and experiment was finished when temperature reached value about 80ºC.

CONCLUSIONS

Based on the conducted research, it may be concluded that in the analyzed case the three layer bearings will prove to be the better performers (bush no. 1 and 2). It is also important to emphasize that despite its greater rigidity, the bearing still belongs to the elastic bush group, which tolerates well the common to shipbuilding phenomenon of shaft misalignment.

The minor resistance of movement as well as low static friction values of the three layer bearing with PTFE sliding surface (bush no. 1), is not without significant benefit for the life span of complete ship propulsion system.

The three layer bearing with grooves located in the upper side of the bush (bush no.2) has the superior performance. Geometry is optimal for hydrodynamic lubrication which appear in wide operation area even for low speeds and big loads. It is a result of optimum sliding surfaces parameters. Thanks to it, hydrodynamic lubrication takes place even for very thin lubrication films and possible local contacts especially when misalignment takes place.

Three layers bearings have superior safety performance even in brake down – lack of lubricant flow conditions (bush no. 1 and 2). It has to be taken into consideration that test rig conditions with lack of lubricant flow are worse than on real ship because of all heat generated in friction zone has to be taken by surrounding air (on ship by surrounding water). Three layers eight grooves bearing have operated without problems in the same lack of lubricant flow conditions when bearing unit was placed inside cooled water tank [4]. During conducted severe tests bearing was overheated and test was stopped. In the same simulated working conditions three layers partial arc bearing proved superior safety performance and operate without problems even for higher loads – up to 0.6 MPa.

Three layer bearings show an improved performance when used in a closed water system due to the application of a biodegradable, water base lubricant with higher viscosity. This higher viscosity can improve the hydrodynamic lubrication properties of the bearing. Such a solution helps to increase durability of this marine stern tube bearing.

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KEYWORDS

Applied Tribology: Marine; Friction: Hydrodynamic Friction; Lubricants: Water, Water-Based