Research on the Lubrication Properties of Impurities Accumulation in Marine Water-Lubricated Bearings

Yiyang Liu, Yao Zhao, Yihu Ouyang, Hua Yuan
School of Naval Architecture and Ocean Engineering, Huazhong University of Science and Technology
Wuhan, Hubei, China

ABSTRACT

Water-lubricated bearing is a new type of bearing with water as the lubrication medium, which is widely used. However, because of its work in the waters outside the port, water quality is not easy to ensure, vulnerable to the impact of aquatic organisms and particles in the water and other impurities, resulting in these impurities in the bearing memory, change the lubrication between the shaft and bearing state, thereby increasing wear between the shaft and bearings. Using FLUENT finite element method and Finite difference method in MATLAB, a water lubrication bearing water film model of impurities accumulation is established, the influence of impurity accumulation position, size and quantity on the maximum pressure and carrying capacity of water film is analyzed, and the critical speed of water film formation is studied.

KEY WORDS: Water-lubricated bearings; impurities accumulate; water film loading capacity; critical speed.

INTRODUCTION

Ship propulsion shafting is the key equipment for ship navigation. The power generated by the main engine of the ship is transmitted to the propeller through the shafting, and the thrust generated by the rotation of the propeller is transmitted to the hull through the shafting, so that the ship can sail normally. Sometimes due to some special circumstances, the ship’s propulsion shafting needs to pass through the hull and protrude outboard, and water-lubricated bearings are often used to support the shafts that protrude outboard. However, because the water quality of the outboard is not guaranteed, it is easy to cause impurities such as aquatic organisms or particles to accumulate in the bearing, thus affecting the lubrication of the bearing. At present, the research on water lubricated bearings at home and abroad mainly focuses on the selection of water-lubricated bearing materials, the lubrication characteristics of water-lubricated bearings, the mechanism of friction and wear, and the optimization of bearing structure(Li, Z,2015). At this stage of research on water-lubricated bearing impurity accumulation is less, generally focused on the form of impurities and water mixture. Most scholars analyze the lubrication characteristics of bearings based on the fact that the bearings are in a normal state. In this paper, for the impurities that have accumulated on the bearing surface, numerical simulation methods are used, and the FLUENT software is used to analyze the water film models of different impurities accumulation, to explore the influence trend and law of the position, size and quantity of impurities on the maximum pressure of the water film and the bearing capacity of the water-lubricated bearing, so as to provide a reference for the structural optimization design of the water-lubricated bearing.

LOADING PRINCIPLE AND BASIC EQUATION OF WATER LUBRICATED BEARING

The dynamic pressure lubrication principle of water-lubricated bearings can be analogized to the flow between two inclined plates. As shown in Fig. 1(a), plate B is inclined at an angle, and a convergence gap is formed between plate A and plate B. The velocity distribution between the two will be as shown, since the flow continuity condition needs to be satisfied. At the inlet end aa, due to the large cross-sectional area, the velocity distribution will be convex upward, while at the outlet end cc, the cross-sectional area will be small, and the velocity distribution will be convex downward. This results in a non-constant rate of pressure change of the fluid along the flow direction, thus resulting in a parabolic pressure distribution between the two plates as shown. A pressure liquid film is formed in the gap, which can bear a certain load F(Gan, T, B,2013; Xiong, Y, Q,2011). When the water lubricated bearing runs stably, it will form a state as shown in Fig. 1(b), a convergence gap is formed between the shaft and the bearing, the pressure generated by the liquid film in the gap can balance the external load F, and the bearing is in a state of hydrodynamic lubrication. At this time, since the shaft and the bearing are not in direct contact, but are separated by a thin layer of viscous fluid, the frictional resistance between the shaft and the bearing is very small, only the friction of the molecules inside the fluid lubricating medium, and the friction coefficient is very small(Santos, E, N, Blanco, CJC, Macêdo, EN,2012).

The equation of motion for viscous fluids, the Navier-Stokes equation, is the basic equation for studying fluid lubrication. Reynolds is based on

(a) Flow between two inclined plates (b) Flow between the water-lubricated bearings

Fig. 1 Loading principle of water-lubricated bearing