Mechanical Performance Analysis on Marine Spherical Water-lubricated Stern Bearing Based on FEM

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ABSTRACT

In order to improve the mechanical performances of marine water-lubricated stern bearing, a traditional stern bearing is replaced with a spherical stern bearing which can automatically adjust its status to reduce the "edge effect" of the traditional stern bearing. In this paper, the deformation, contact pressure, vibration and fatigue of two kinds of bearings were investigated with finite element method. The study results show that the deformation, maximum contact pressure, fatigue life of the water-lubricated spherical stern bearing are all superior to the traditional stern bearing, which can provide theory support for the optimization design of the stern bearing.

KEY WORDS: Contact pressure; deformation; finite element model; spherical stern bearing; ring; vibration; fatigue life

INTRODUCTION

In marine propulsion shafting, the stern bearing is one of the worst working conditions of the parts, whose effect is extremely important (Liu et al., 2009). With development of the large-scale ship, propeller weight and shaft diameter are increased so that the working load of stern bearings is enhanced. Due to the overhung effect of propeller gravity, the contact area between propeller shaft and stern bearing is reduced, which can cause higher local contact pressure, poor lubrication and higher temperature, and eventually both uneven wear of stern bearing lining and shafting vibration are brought about (Zhang et al., 2011; Zheng et al., 2012). This kind of phenomenon is known as "edge effect". In order to reduce the "edge effect", decrease the peak contact pressure of the stern bearing for the homogeneous distribution of contact pressure and realize the vibration noise reduction and fatigue life improvement, both water-lubricated traditional stern bearing and joint bearing will be integrated a water-lubricated spherical stern bearing which can automatically adjusted its posture to overcome the weakness of traditional water lubricated stern bearing.

Joint bearing is a kind of spherical plain bearing which consists of both outer ring and inner ring (see Fig.1) and is of automatic regulating function such as rotation and lower friction coefficient, stronger resistance of both corrosion and impact and longer life. Joint bearing is widely used in engineering machinery and traffic fields. So far, foreign scholars have made a lot of theoretical and experimental researches in such as structure, material selection of joint bearings. Especially, the composite performance research of self-lubricating spherical bearings is a key spot including metal backing composites, polymer composites, ceramic matrix composites, and PTFE fabric, etc (Rushma et al., 2011; Aleksandrov et al., 2007). It is paid wide attention to by many scholars both at home and abroad, that internal spherical surface on the outer ring of a self-lubricating joint bearing is usually bonded with gasket material which can influence the self-lubricating performance of the bearing. Scholes made Pin-on-plate wear tests of CFR-PEEK/CoCrMo materials. This study gives confidence in the likelihood of this material which can be used as artificial joint bearing materials (Scholes et al., 2009). Wojciech Litwin studied the water lubricated bearing materials with three layer composite. Each layer of the composite has an important function. Experiment results indicates that the material is of minimum resistance and good vibration damping properties, and insusceptibility to shaft axis misalignment compared with a traditional rubber bearing of similar geometry (Wojciech et al., 2014).

Yang Xian-qi, etc. introduced the excessive wear and complicated influence factors of the spherical plain bearing, and presented the estimating method of wear-life of the bearing by examples (Yang et al., 2009). Su Gao-feng analyzed the fatigue life of parts with transient dynamic analysis module and gained the part fatigue life under actual conditions (Su et al., 2013). Wang Sen analyzed the stress distribution of a joint bearing under axial, radial or composite loads with ANSYS method respectively, and studied the influence of guide groove structure on contact stress. The results show that under the three kinds of load, their stress distribution and stress concentration state are different. The maximum stress of the outer ring of the bearing is higher than one of inner ring. The research indicates that reasonable guide groove can reduce the stress concentration phenomenon (Wang et al., 2013). Wei Yingchun, etc. did vibration reduction effect tests of both spherical and traditional stern bearings on the shafting test bench, the test results show that the damping effect of the spherical stern bearing is better than the traditional one (Wei et al., 2012). In general, the spherical bearing research is deeply carried out and its application range is continuously expanded. Now, oil-lubricated spherical sliding bearings are used in marine intermediate bearing instead of traditional sliding bearing to improve the contact status between shaft and bearing. At home, oil lubricated self-aligning ball bearing is used as stern bearing which is limited in individual small vessel and relative researches also are less. The water-lubricated self-aligning spherical sliding stern bearing research can realized the integration of both self-