The energy flow transmission characteristics between the supporting bearings and the flexible basis in marine propulsion shafting system

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Energy flow analysis provides a technique which is able to model the dynamic responses of structural systems. Compared with the traditional vibration analysis theory, the method based on energy flow is easier to explain the energy distribution and transmission of mechanism. The energy flow transmission characteristics of a marine propulsion shafting system is numerically investigated. Firstly, the distributed pressure on the coupled shafting and flexible basis is computed according to the statistical characteristics of the shafting system. Next, the function of flexible deformation under the launched condition is applied on the basis and the associated vibration responses of the shafting system are computed by using the nonlinear power flow method. Finally, vibration characteristics between the supporting bearings and flexible basis are analysed with different dynamic parameters of the system. In this paper, the nonlinear energy flow behaviour of a marine shafting system between the supporting bearings and the flexible basis is investigated as an attempt to address the above problem.

Keywords: propulsion shafting system, energy flow analysis, supporting bearings, flexible basis

1. Introduction

The research on the theory and diagnostic methods for propulsion shafting condition monitoring of large marines is one of the problems that has not yet been completely overcome. It has certain practical value for the safe navigation of marines. With the advent of large-scale and high-speed marines (Figure 1), and the emergence of a new generation of giant super tanker VLCC and ultra-large tanker ULCC, the diversification in size and speed of marines has increased the complexity of static and dynamic factors affecting the marine propulsion shafting system. The dynamic performance has been highly rated by the marine industry. Modern large-scale marine propulsion systems mostly adopt low-speed diesel direct drive transmission methods. Propulsion shafting is an integral part of the marine, and the operation of the shafting system is affected by the entire hull.
The hull is a deformed body (Figure 2), the propulsion shafting is supported on a large elastic body, and the operation of shafting system is affected by the elastic deformation of the hull. The rigidity of the shafting system increases while the flexibility of the hull increases. On the one hand, the displacement of the bearings of the shafting system becomes more obvious with different working conditions as the stiffness of the hull decreases; on the other hand, when the shafting axis of the supporting bearings deviate from the initial position, the adaptability of the shafting to its variation gradually decreases as the shafting stiffness increases.\textsuperscript{[1,2]}

![Figure 2: Hull’s middle arch deformation.](image)

2. The Propulsion Shafting System

Marine shaft alignment is an important part of the shafting design. The shafting system is laid in an axial state according to a certain principle and method, so that the additional bending stress of the shaft and each supporting bearing load is within the permissible range to ensure the safe and reliable operation of the marine shafting system.\textsuperscript{[3]} The essence is to accurately determine the position of each bearing of the marine shafting system.

![Figure 3: The shafting system is being installed.](image)

![Figure 4: The shafting system is installed.](image)
3. Application of Energy Flow Method

The power flow contains two physical quantities, force and speed, the collective effect of forces and speeds are taken into account in the method, in Figure 5. Both the dynamic forces transmitted to the structure and the resulting dynamic response of the structure are calculated, the effects of forces and moments are unified into energy metrics. Complex vector operations are transformed into relatively simple scalar additions and subtractions. The spatial vector image of the power flow in the structure can be used as an important diagnostic tool. \[4,5,6\] It is intuitive to determine the propagation characteristics of energy. The power flow theory is used to reveal the energy transfer characteristics of the marine propulsion shafting subsystem and the journal-bearing-flexible basis coupling system and the interaction between each bearing. \[7,8,9\] It is both scientifically and rationally applied both theoretically and practically.

![Energy Flow Diagram](image)

Figure 5: Energy transfer relationship among the journal-bearing-flexible basis coupling system.

4. Conclusion

In this paper, the power flow theory is applied to study the energy transfer characteristics of the journal-bearing-flexible basis coupling system and the interaction mechanism of each support bearing in marine propulsion shafting system, vibration characteristics between the supporting bearings and flexible basis are analysed with different dynamic parameters of the system. At the same time, the concept of energy shafting alignment based on the theory of power flow was put forward to reveal the basic theory of motion and response of ship propulsion systems.

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