Modal Analysis of Propulsion Shafting of a 48,000 tons Bulk Carrier

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Abstract

To avoid resonance, suppress vibration and reduce the noise, the vibration characteristics of the propulsion shafting must be calculated during the process of design. In this paper, the vibration noise of the propulsion shafting of a 48000 tons bulk carrier is analyzed. Three-dimensional modeling of the propulsion shafting is constructed accurately to perform modal analysis. The natural frequency of the propulsion shafting is obtained by finite element analysis. Considering the natural frequency and vibration mode analysis results, to avoid the use of propulsion shafting in the process of resonance phenomenon, the excitation frequency is controlled outside the resonant frequency range. The analysis results can provide the necessary theoretical basis for further kinetic analysis.

Keywords

Modal analysis, propulsion shafting, bulk carrier.

1. Introduction

As a high noise vibration equipment, propulsion shafting in the course of the operation of the vibration and noise problems are clearly affected the working environment and equipment reliable operation. In order to ensure the reliability and comfort of the ship operation, it is necessary to suppress the equipment vibration and reduce the noise at the beginning of the design. Two propulsion shaftings are installed in the 48000 tons bulk carrier. The long-term work of the staff in this high-noise environment will endanger their physical and mental health. Therefore, in order to find the vibration reason of the system, this paper uses the finite element method to establish the three-dimensional model of the propulsion shafting, its modal analysis, calculate the natural frequency of the propulsion shafting, the propulsion shafting vibration and noise mechanism. This study provides a theoretical basis for optimizing the design of propulsion shaftings. This paper takes a 48000 tons bulk carrier as the research object, and studies the vibration characteristics of propulsion shafting with the finite element software ANSYS.

2. Theoretical Analysis and Modeling

2.1 Theoretical Analysis

As an inherent vibration characteristic of the structure, modal is a method of studying the dynamic characteristics of the structure. Each structure has its own modal parameters, each modal including modal frequency, modal damping, and modal shapes. Modal parameter identification can be divided into two methods, one is calculated by the computer's finite element calculation software; the other is the modal test method. The output signals collected by the test equipment are parameterized to obtain the modal parameters. The calculation involved in this paper belongs to the analytic mode analysis method, mainly through the finite element calculation software ANSYS to obtain the hull structure of the various modes.

Since the modal of the structure is not related to the external load and the effect of damping on the free vibration is small, the inherent characteristic of the structural vibration can be calculated by the undamped free vibration equation. According to Newton's second law, the differential equation of multi-degree-of-freedom system vibration can be expressed as follows:

$$M\ddot{x} + C\dot{x} + Kx = f(t) \tag{1}$$

Where M, K, C and f (t) are Mass matrix, stiffness matrix, damping matrix and excitation force array. For free vibration of undamped system, the equation can be simplified as follows:

$$M\ddot{x} + Kx = f(t) \tag{2}$$

2.2 3D Modeling

In order to carry out modal analysis of the propulsion shafting more accurately, the 3D model of the propulsion shafting and its nearby support structure is established. As the structure is complex, three-dimensional model of the propulsion shafting of the 48000 tons bulk carrier is established in Pro/E according to the design paper. The element of beam188 is used in the integrated ANSYS meshing tool for meshing. The finite element model contains a total of 1920 elements, and 5052 nodes. The FEM of the propulsion shafting is showed in Fig.1.

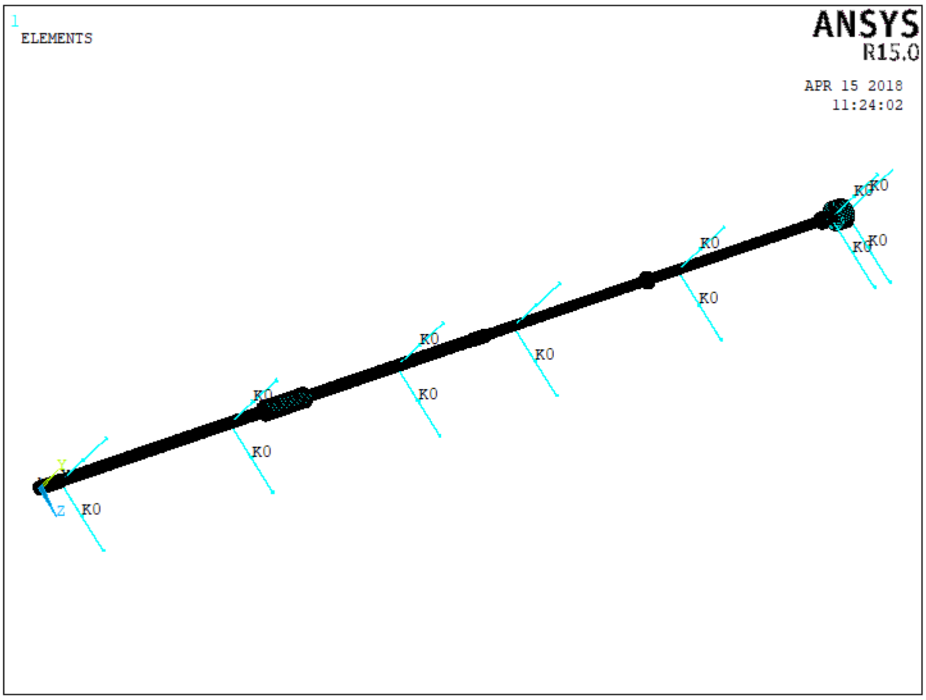


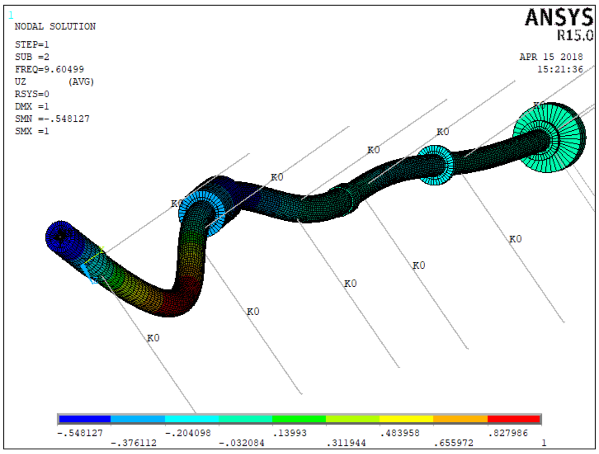
Fig.1. Finite element model of the propulsion shafting

3. Calculation Results Analysis

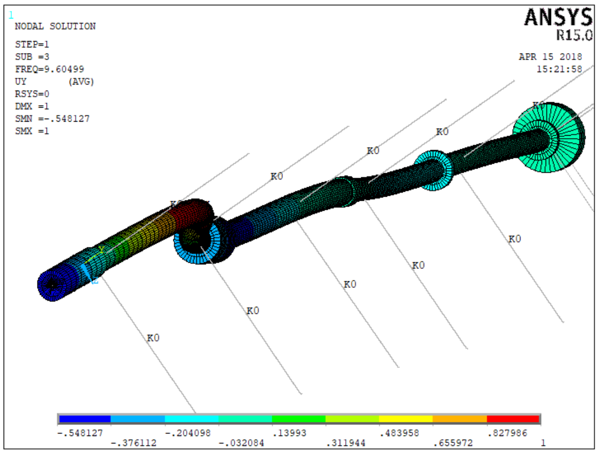
To calculation the natural frequencies and mode shapes of a structure, the modal analysis is needed. These are important parameters in the design for dynamic loading conditions, and required to perform a spectrum, mode-superposition harmonic, or transient analysis. In this paper, the modal analysis of the propulsion shafting is obtained without imposing any boundary conditions, that is, free modal analysis. The natural frequency of the propulsion shafting is calculated in ANSYS.

The natural frequency of the propulsion shafting is calculated by modal analysis. The first three natural frequencies in the vertical vibration of the propulsion shafting are 9.6Hz, 12.3Hz, and 13.7Hz. The first three natural frequencies in the horizontal vibration of the propulsion shafting are 9.6Hz, 12.3Hz, and 13.7Hz. The first three modes in vertical and horizontal vibration of the propulsion shafting is showed in Fig.2.

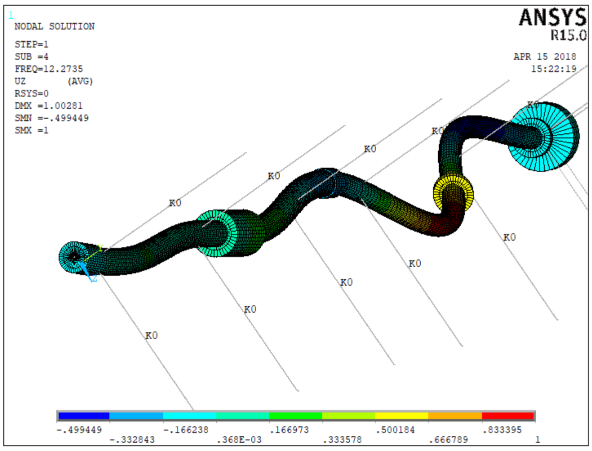
The first three natural frequencies in the longitudinal vibration of the propulsion shafting are 22.3Hz, 82.6Hz, and 125.1Hz. The natural mode in the longitudinal vibration of the propulsion shafting in first three order natural frequency is showed in Fig. 3. The first three natural frequencies in the X, Y and Z direction is showed in table 1.



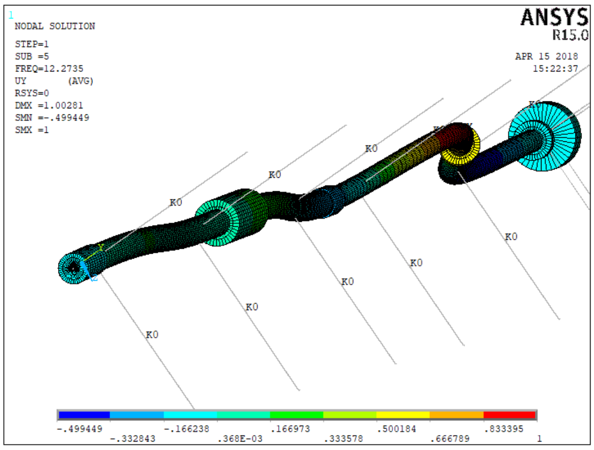
(1)1st mode in the vertical



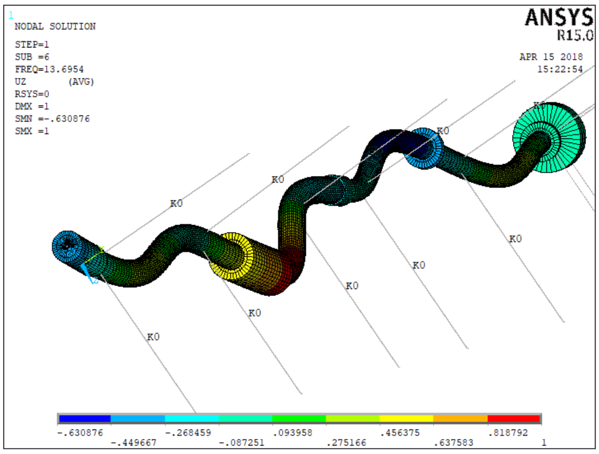
(2)1st mode in the horizontal



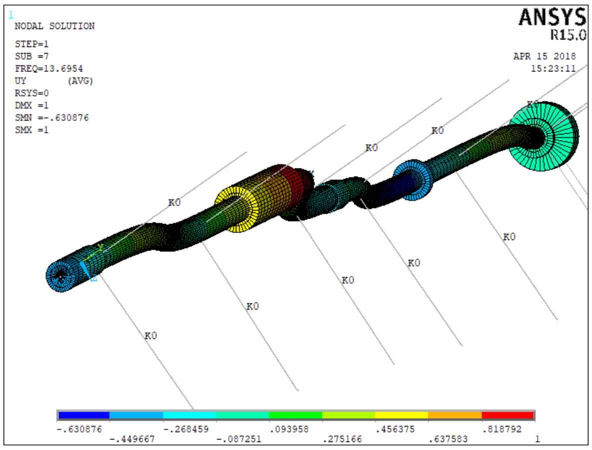
(3)2nd mode in the vertical



(4)2nd mode in the horizontal

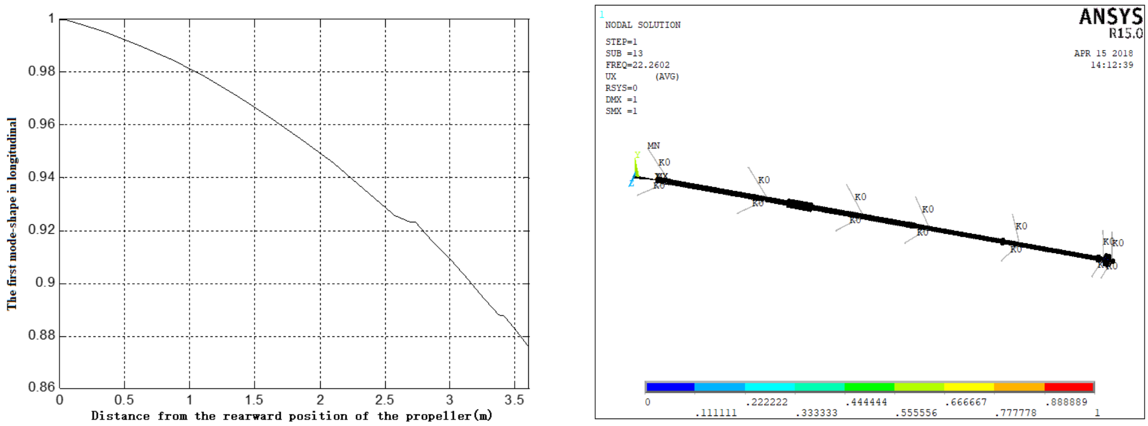


(5)3rd mode in the vertical



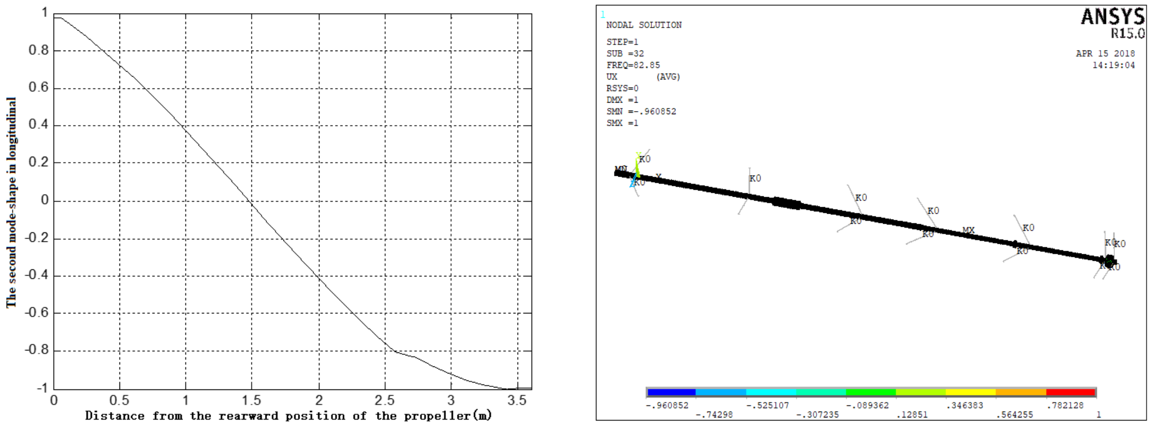
(6)3rd mode in the horizontal

Fig. 2. The first three modes in vertical and horizontal vibration of the propulsion shafting



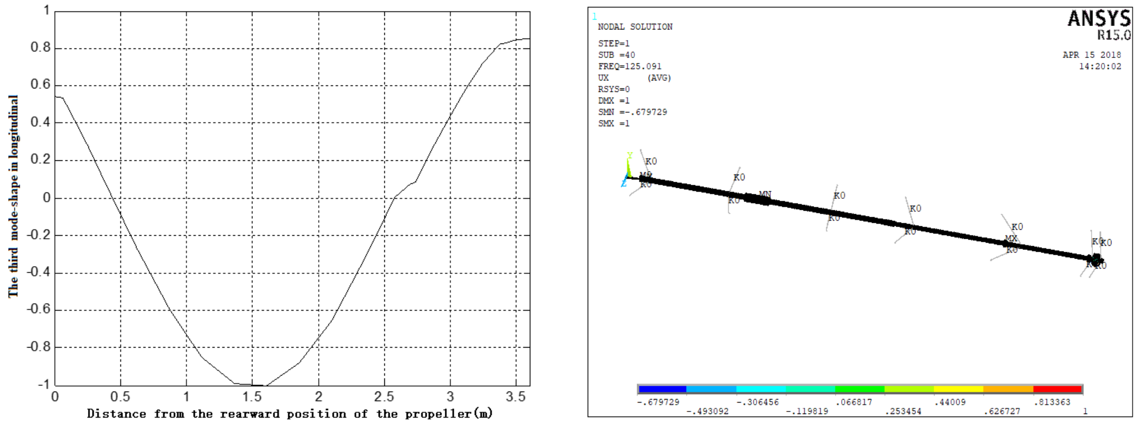
(a) (b)

(1) The first mode in the longitudinal vibration



(a) (b)

(2) The second mode in the longitudinal vibration



(a) (b)

(3) The third mode in the longitudinal vibration

Fig. 3. The first three modes in longitudinal vibration of the propulsion shafting

Table 1.The first three natural frequencies in the X, Y and Z direction

	vertical vibration	horizontal vibration	longitudinal vibration
1st	9.6	9.6	22.3
2nd	12.3	12.3	82.6
3rd	13.7	13.7	125.1

4. Summary

The modal analysis of the propulsion shafting provides the main modal parameters for the analysis of the whole system. Modal analysis provides a theoretical basis for improving and improving the reliability of the system. At the same time, modal analysis is a basic study for further kinetic analysis, structural optimization and fatigue life prediction. The main conclusions drawn from the results of this study are listed as follows:

(1) The first three natural frequencies in the longitudinal of the propulsion shafting are 22.3Hz, 82.6Hz and 125.1Hz.

(2) The first three modes in vertical and horizontal vibration of the propulsion shafting are 9.6Hz, 12.3Hz, and 13.7Hz.

(3) In order to prevent partial resonance between the propulsion shafting and the support structure, the natural frequency of the propulsion shafting should be avoided in ship operations.

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