Modal Analysis of Hydraulic Pump of a 1500 tons Fishery Administration Ship

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Abstract

To avoid resonance, suppress vibration and reduce the noise, the vibration characteristics of the mechanical equipment must be calculated during the process of design. In this paper, the vibration noise of the hydraulic pump of a 1500 tons fishery administration ship is analyzed. Three-dimensional modeling of the hydraulic pump is constructed accurately to perform modal analysis. The natural frequency of the hydraulic pump is obtained by finite element analysis. Considering the natural frequency and vibration mode analysis results, to avoid the use of hydraulic pump 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, hydraulic pump, fishery administration ship.

1. Introduction

As a high noise vibration equipment, hydraulic pump 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 hydraulic pumps are installed in the 1500t fishery administration ship. 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 hydraulic pump, its modal analysis, calculate the natural frequency of the hydraulic pump, the hydraulic pump vibration and noise mechanism. This study provides a theoretical basis for optimizing the design of hydraulic pumps. This paper takes a 1500 tons fishery administration ship as the research object, and studies the vibration characteristics of hydraulic pump 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 hydraulic pump more accurately, the 3D model of the hydraulic pump and its nearby support structure is established. As the structure is complex, three-dimensional model of the hydraulic pump of the 1500t fishery administration vessel is established in Pro/E according to the design paper. 3D geometric model of the hydraulic pump is showed in Fig.1. The element of shell 63 solid 45 are used in the integrated ANSYS meshing tool for meshing. The finite element model contains a total of 2730 shell elements, 5520 elements, and 6601 nodes. The FEM of the hydraulic pump is showed in Fig.2.

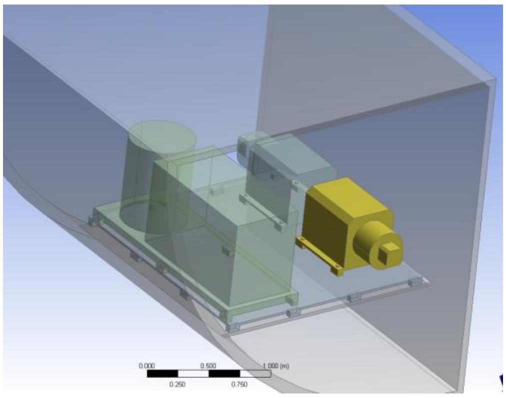


Fig. 1 Three-dimensional geometric model of the hydraulic pump

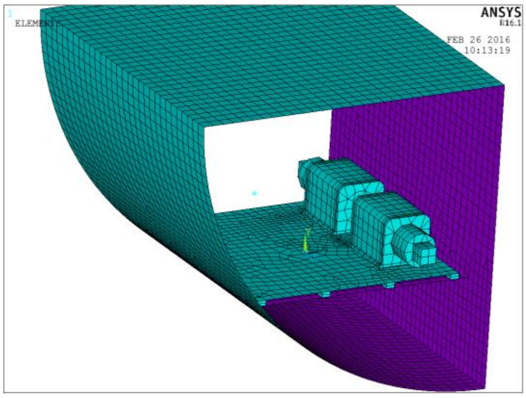
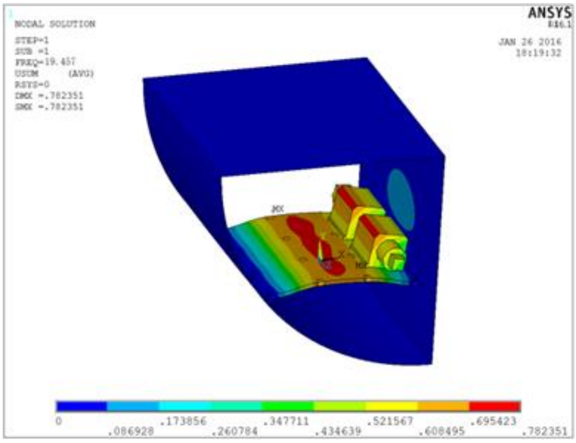


Fig.2 Finite element model of the hydraulic pump

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 hydraulic pump is obtained without imposing any boundary conditions, that is, free modal analysis. The natural frequency of the hydraulic pump is calculated in ANSYS.

The natural frequency of the hydraulic pump is calculated by modal analysis. The first six natural frequencies of the hydraulic pump are 19.46Hz, 36.06Hz, 39.91Hz, 43.76Hz, 67.40 and 71.82Hz. The natural mode of the hydraulic pump in first six order natural frequency is showed in Fig. 3. The mode of vibration of first-order nature frequency is a first-order lateral vibration. The first-order natural frequency of the hydraulic pump is close to the natural frequency of the support structure. In order to prevent partial resonance between the hydraulic pump and the support structure, the natural frequency of the hydraulic pump should be changed by optimizing the design. The mode of vibration of second-order nature frequency is a first-order vertical vibration. The mode of vibration of third-order nature frequency is a first-order longitudinal vibration. The mode of vibration of fourth-order nature frequency is a second-order vertical vibration. The mode of vibration of fifth and sixth-order nature frequency is a mixed vibration of various directions.



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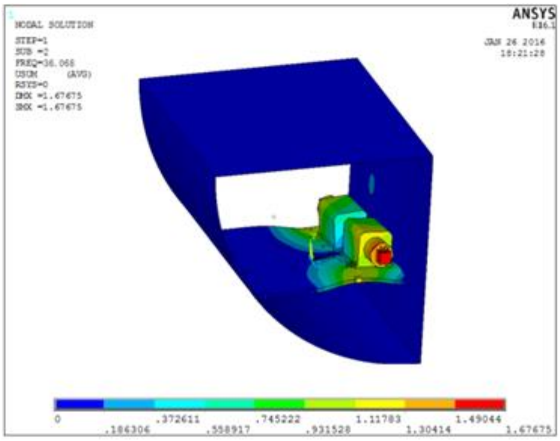

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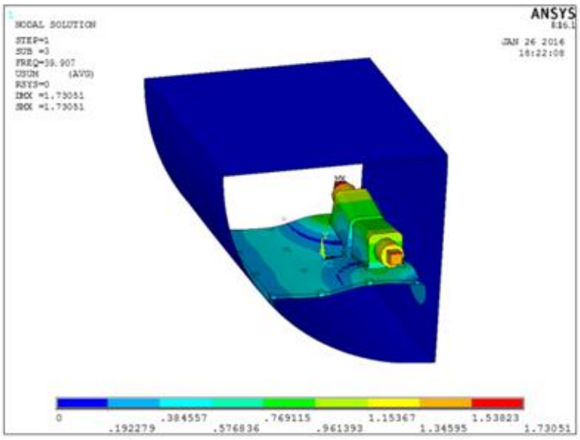

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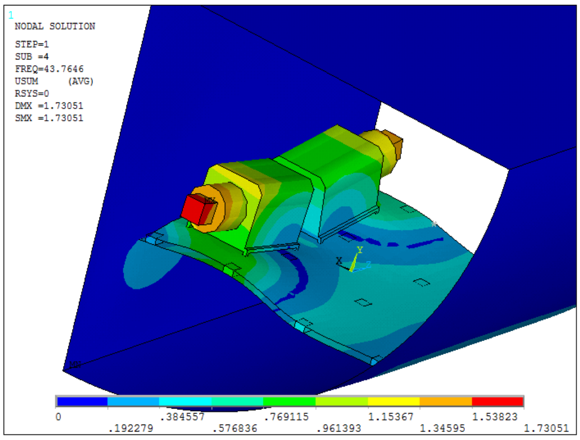

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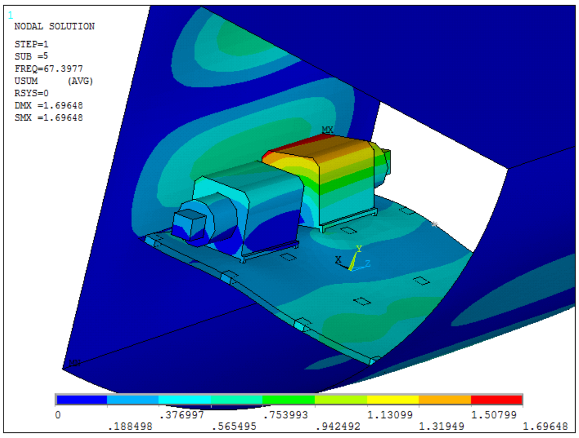

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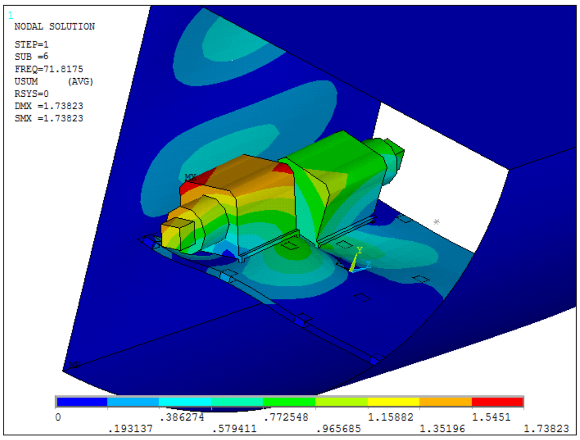

(6)

Fig. 3 the first six modes of the hydraulic pump

4. Summary

The modal analysis of the hydraulic pump 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 six natural frequencies of the hydraulic pump are 19.46Hz, 36.06Hz, 39.91Hz, 43.76Hz, 67.40 and 71.82Hz.

(2)The mode of vibration of first four natural frequencies are first-order lateral vibration, first-order vertical vibration, first-order longitudinal vibration and second-order vertical vibration.

(3) The first-order natural frequency of the hydraulic pump is close to the natural frequency of the support structure. In order to prevent partial resonance between the hydraulic pump and the support structure, the natural frequency of the hydraulic pump should be changed by optimizing the design.

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