Vibration Characteristics Analysis of Hydraulic Pump

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Abstract

The vibration and noise of the hydraulic system is a fairly common problem. As the dynamic element of the hydraulic system, hydraulic pump is the main noise source of the hydraulic system. The finite element analysis and harmonic response analysis of the hydraulic pump and its supporting structure and the nearby hull is carried on, and the local natural frequency are calculated. In order to analyze the vibration characteristics of the hydraulic pump, the harmonic response analysis was adopted to find out the relationship between the resonant frequency and the related vibration data, which lays the foundation for the reliability design and optimization of the hydraulic pump and its supporting structure. The study lays the foundation for the reliability design and optimization of hydraulic pump and its supporting structure.

Keywords

Modal analysis, hydraulic pump, Vibration Characteristics Analysis, harmonic analysis.

1. Introduction

The vibration and noise of the hydraulic system is a fairly common problem. The hydraulic system consists of five parts, the dynamic element, the actuator, the control element, the auxiliary element (accessory) and the hydraulic oil. As the dynamic element of the hydraulic system, hydraulic pump provides the pressure oil for the hydraulic system. The main noise source of the hydraulic system is the hydraulic pump. The vibration noise is the same as the technical equipment is prone to a variety of failures, which can reduce the reliability of equipment, result hydraulic system failure, and even ship fault. Two hydraulic pumps are installed in the 1500t fishery administration ship. Therefore, this paper takes 1500 tons of fishing vessel hydraulic pump as an example, carries on the finite element analysis to the hydraulic pump and its supporting structure and the nearby hull, calculates its local natural frequency, and carries on the harmonic response analysis. 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, calculate the natural frequency of the hydraulic pump. The vibration and noise analysis of the hydraulic pump is the basis of vibration and noise testing and equipment status monitoring, which provide theoretical basis to the optimal design for the hydraulic system.

2. 3D Modeling and Meshing

The structure of the hydraulic pressure system of the 1500t fishery administration vessel consists of hydraulic pump, motor, piping system, supporting structure. In order to carry out vibration characteristics 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 is established in Pro/E according to the design paper. 3D geometric model of the hydraulic pump is showed in Fig.1. The established 3D model is imported into ANSYS for meshing. The finite element model of the hydraulic pump is showed in Fig.2. The FEM of the hydraulic pump contains a total of 2730 shell elements, 5520 elements, and 6601 nodes.

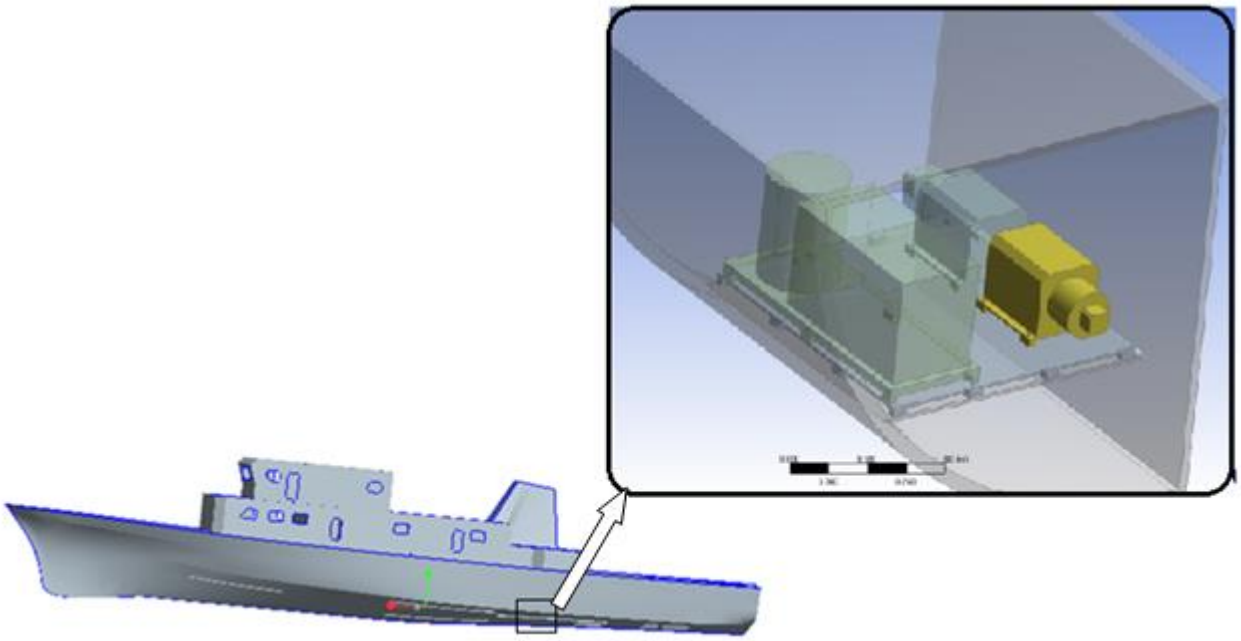


Fig. 1 Three-dimensional geometric model of the hydraulic pump

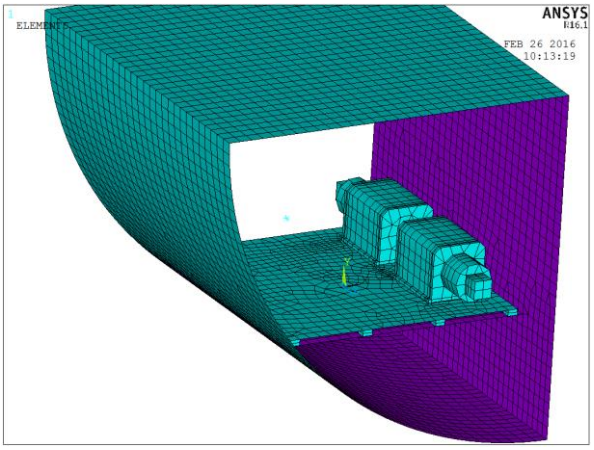


Fig.2 Finite element model of the hydraulic pump

3. Calculation Results 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. Through the simulation analysis, the first 10-order mode of the hydraulic pump and its related structure are calculated, as shown in Table 1. According to the vibration theory, the low order mode plays an important role in the process of structural vibration. The contribution of the high order mode to the response is small and the vibration decays faster. Therefore, the paper only need to consider the low-order mode.

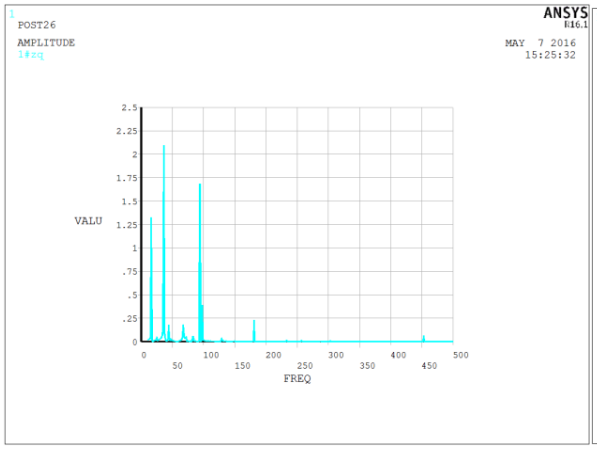
The input load of the harmonic response analysis changes along sinusoidally with the dimensionless time. The load can be in the form of force, pressure and displacement. The parameters are mainly frequency and amplitude. The calculation result is usually expressed by the displacement, stress and strain of the nodes. As the basis for the structural vibration mechanism analysis and vibration reduction design, the peak response frequency and the response amplitude can be obtained by analyzing the curve of the output value versus frequency.

In the harmonic response analysis, the frequency range must be specified. In the dynamic response of the hydraulic pump and its supporting structure, the low order mode occupies the main position, but

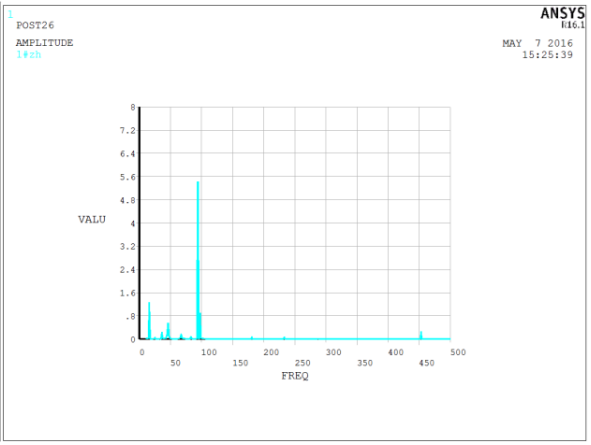
the amplitude of the high order mode is very small. Figure 3 is the structural response of hydraulic pump foot in the 0-500Hz frequency range. Due to the effect of structural damping, the vibration attenuation of high-order partial in response is also fast. Therefore, only the structural response in the 10-100Hz frequency range is considered.

Table 1. Natural frequency of the hydraulic pump

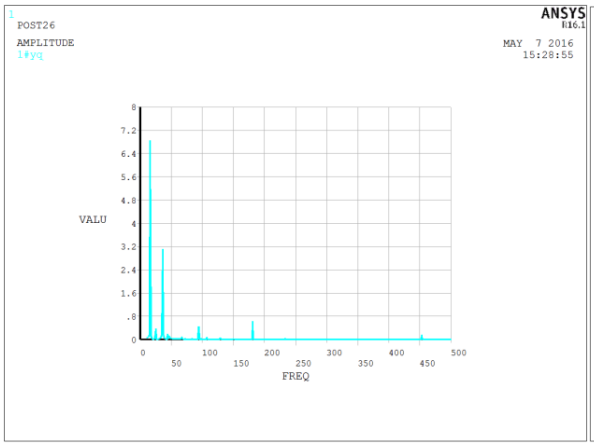
Order	natural frequency(Hz)	mode of vibration
1	19.5	1st lateral vibration
2	36.4	1nd vertical vibration
3	39.1	1st longitudinal vibration
4	43.7	2nd vertical vibration
5	67.4	2nd longitudinal vibration
6	71.8	mixed vibration



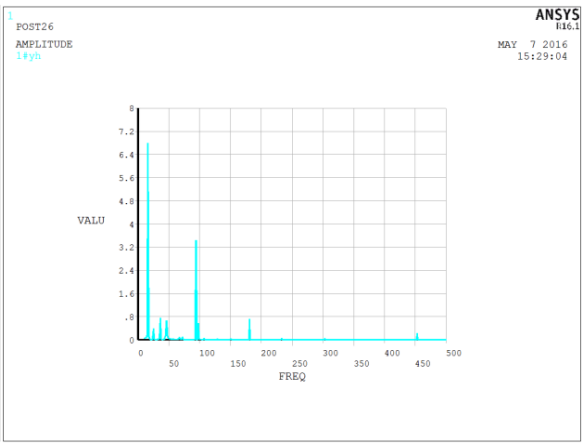
（1）Left front foot machine



（2）Left rear machine feet



（3）Right front foot machine



（4）Right after the machine feet

Fig. 3 Displacement Response Curve of the hydraulic pump Locomotive

As the excitation frequency changes, the vibration displacement of the different measuring points produces a peak at the corresponding resonant frequency. The resonant frequencies of the different measuring points are similar, and they respond at 16HZ, 36Hz and 94Hz, which is close to the first order natural frequency of the structure (19.5Hz), 2nd order natural frequency (36.4 Hz), and tenth order natural frequency (98.1 Hz). For low-order frequencies, the hull vibration is smaller.

4. Summary

In order to analyze the vibration characteristics of the hydraulic pump, the harmonic response analysis was adopted to find out the relationship between the resonant frequency and the related

vibration data, which lays the foundation for the reliability design and optimization of the hydraulic pump and its supporting structure. This study lays the foundation for the reliability design and optimization of hydraulic pump and its supporting structure. 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 19.5Hz, 36.4Hz, 39.1Hz, 43.76Hz, 67.4 and 71.82Hz.

(2) The resonant frequencies of the different measuring points are similar, and they respond at 16HZ, 36Hz and 94Hz, which is close to the first order natural frequency of the structure (19.5Hz), 2nd order natural frequency (36.4 Hz), and tenth order natural frequency (98.1 Hz).

(3) For low-order frequencies, the hull vibration is smaller.

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