Analysis and Optimization on Vibration Characteristics of Twin Screw Pump

Zhong Yan\textsuperscript{1,a*}, Zhou Pu\textsuperscript{1,b}, Fu Dongliang\textsuperscript{1,c} and Lu Zhen\textsuperscript{1,d}

\textsuperscript{1}Shanghai Marine Equipment Research Institute, Shanghai, China
\textsuperscript{a*}email: zhongyan704@163.com, \textsuperscript{b}email: puzhou@163.com, \\
\textsuperscript{c}email: 540874098@qq.com, \textsuperscript{d}email: 439253432@qq.com.

Corresponding author’s e-mail address: zhongyan704@163.com

Abstract. Based on double screw pump as the research object, the vibration of twin screw pump under different outlet conditions and different technological parameters were tested. The vibration characters of the pump under various technological parameters were analyzed from the experimental point of view. The key parameters influencing the vibration characteristic of twin screw pump were found out and corresponding optimization measures were taken. By using the numerical method of fluid mechanics, the three-dimensional flow field inside the pump chamber was analyzed, and the internal working mechanism and influencing factors were discussed. Local optimization was carried out to reduce the influence of fluid excitation force on structure vibration. The research results of this paper can provide necessary practical basis for the optimization of vibration and noise reduction of twin screw pump.

1. Introduction
Double screw pump has the advantages of strong self-priming ability, high efficiency, small pulsation, insensitive to the viscosity of the medium, so double screw pump has been widely used in the shipping and petrochemical industry. With the deepening of theoretical research, the level of vibration noise, vibration control measures and influencing factors of screw pump have gradually attracted the attention of designers\textsuperscript{[1,2,3]}. For example, in reference literature\textsuperscript{[4]}, the damping alloy was applied to the structure of the pump frame to change part of its material and structure, so as to reduce the vibration acceleration of screw pump and reduce the noise pressure in the pump room. There were few research on the vibration characteristics and influencing factors of screw pump\textsuperscript{[5]}.

In this paper the vertical screw pump was taken as a research object, through a series of experiments, the vibration characteristics and source of double screw pump were analyzed. The relationship between vibration intensity and operation parameters were established. The influence of machining accuracy, import condition, medium factors on vibration of screw pump was discussed. Then the experimental support was provided for the design of operating parameters of low noise screw pump.

2. Vibration characteristic analysis of twin screw pump
A vertical twin screw pump was taken as the test object to test the vibration acceleration of the pump foot. During the test, the pump speed was 2980r/min, the pump outlet pressure was 3.5MPa, and the flow was about 28m\textsuperscript{3}/h. The vibration spectrum of the pump was shown in figure 1.
Figure 1. Vibration spectrum of screw pump

The main vibration characteristic frequency of the pump set was the axial frequency, the odd multiple frequency of the axial frequency, the even multiple frequency of the axial frequency, the high-frequency electromagnetic frequency caused by the drive motor, the fluid excitation frequency generated by the fluid excitation, and the meshing frequency and multiple frequency of the gears.

In the low frequency band (10-315Hz), the shaft frequency vibration caused by the rotor rotation imbalance was the largest. The second was the even frequency of the shaft frequency. According to the calculation of the vibration source of screw pump, the vibrations of these frequencies were mainly caused by the dynamic load of the fluid acting on the rotor during the operation. The odd frequency of shaft frequency was caused by screw meshing excitation load. In the high frequency band, the meshing frequency and the doubling frequency of the gear were the main characteristic frequency, and the meshing impact of gear was the main factor affecting the vibration of screw pump.

From the screw pump vibration spectrum it can be see that, screw meshing excitation, gear meshing excitation and rotor unbalanced excitation were the main sources of vibration of screw pump, and also were the main parts of vibration control of screw pump.

3. Analysis on the relationship between operating parameters and screw pump vibration

3.1 Analysis on relationship between speed and vibration

In order to analyze the influence of rotating speed on shaft frequency vibration of screw pump, the power supply frequency was changed to make the motor obtain different rotating speed. The range of rotating speed was from 1200r/min to 3000r/min, and the interval was 300r/min. The relationship between rotating speed and shaft frequency vibration of screw pump was shown in figure 2.
Figure 2. Relation between rotating speed and shaft frequency vibration of screw pump

As shown in figure 2, the shaft frequency vibration of screw pump increased with the increase of rotating speed. In order to reduce the vibration of screw pump foot, the running speed of the pump set could be reduced appropriately under the premise of satisfying the performance.

3.2 Relationship between outlet pressure and vibration

In order to analyze the influence of outlet pressure on shaft frequency vibration of the pump, the valve opening was changed to make the pump working at different pressures, the range was from 0.2MPa to 3.5MPa with an interval of 0.2MPa. The relation between outlet pressure and shaft frequency vibration of screw pump was shown in figure 3.

Figure 3. Relationship between outlet pressure and shaft frequency vibration of screw pump

It can be seen from figure 3, shaft frequency vibration of screw pump fluctuated with outlet pressure. Due to the balance accuracy of screw pump, there was a balance value between the unbalanced and pulsating screw excitation under certain pressure conditions. When the outlet pressure was higher than the threshold pressure, the amplitude of axial frequency vibration increased with the increase of the pressure, and a linear upward trend was showed.

4. Analysis of influencing factors of screw pump vibration

4.1 Effect of screw precision on vibration

Screw was an important part of screw pump. Its machining precision had great influence on the performance and vibration noise level of screw pump. In this test, three kinds of precision screw were processed, the precision was rough machining, semi-finishing machining and finishing machining. Then the influence of screw precision on pump vibration characteristics was analyze.
It can be seen from figure 4, the screw precision level had a great influence on the low-frequency vibration of the pump set. The vibration of the finishing screw pump set was significantly better than other pump sets in the low-frequency.

With the improvement of screw precision, the matching clearance between screw and screw was more stable, the doubling characteristics of shaft frequency were decreased obviously. In order to reduce the vibration of screw pump, the machining precision of screw should be improved.

4.2 Influence of medium viscosity on vibration

The vibration spectrum of screw pump conveying different media was shown in figure 5.

It can be seen from figure 5, the medium viscosity had great influence on the low-frequency vibration of the pump. Below 31.5Hz, the smaller the viscosity, the lower the vibration was. The flow state in the screw cavity was affected by the viscosity of the medium and the vibrations of doubling shaft frequency were affected further. The smaller the viscosity was, the larger the frequency doubling vibration would be.

4.3 Influence of inlet back pressure on vibration

By changing the precision of filters, the inlet back pressure was changed. From the test data, the back pressure of the coarse filter was smaller than that of the fine filter. The vibration test results under different back pressures were shown in figure 6.
Figure 6. Effect of inlet back pressure on screw pump vibration

It can be seen from figure 6 that the back pressure had a constant influence on the vibration of screw pump in each frequency band. At frequencies above 31.5 Hz, the lower the back pressure, the lower the vibration was. In order to reduce the screw pump vibration, the pump inlet back pressure should be tried to reduce.

5. Conclusion
In this paper, the vertical screw pumps was taken as the research object, through the test and analysis, the following conclusions were obtained:

(1) The vibration characteristic frequencies of the pump were the axial frequency, the odd multiple frequency of the axial frequency, the even multiple frequency of the axial frequency, the electromagnetic frequency, the fluid excitation frequency, the meshing frequency and the multiple frequency of the gear.

(2) The shaft frequency vibration of screw pump increased with the increase of rotating speed, and there was a linear increasing relationship between the two. In order to reduce the vibration of screw pump foot, the running speed of the pump set should be appropriately reduced under the premise of satisfying the performance.

(3) In order to reduce the vibration of screw pump, the machining accuracy of screw should be appropriately improved and the back pressure at the inlet of the pump should be appropriately reduced.

Reference
[1] Wang Z. (2009) Research on Dynamic Characteristics of Vertical Rotor-Bearing System. Harbin Institute of Technology, Harbin.
[2] Zhang Y. (2014) Vibration analysis of a three screw pump unit. Harbin Engineering University, Harbin.
[3] Zhang Y. (2014) Characteristic Analysis of Volumetric Efficiency and Precision Forming Research of Rotors for Screw Pump. Chongqing University, Chongqing.
[4] Muhammed A R A. (2015) Vibration Modelling And Experimental Result Of Two Phase Twin screw Pump. Turbine Technical Conference and Exposition, 7: 15-19.
[5] Ameen R,A Muhammed, Dara W. Childs. (2012) Rotodynamic of a 2-phase flow twin screw pump. Proceedings of ASME Turbo Expo, 12: 59-65.