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NOISE CONTROL FOR A BETTER ENVIRONMENT

Experimental Study on the Influencing Factors of Radiated Noise at the Nozzle of fluid Pipeline

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ABSTRACT

Some pipelines of the ship fluid piping system are directly connected with outside. The fluid pulsation noise generated by pumps and valves in the system radiates from the nozzle of the pipeline through the absorption and discharge of the fluid, which directly affects the concealment of ships. By carrying out the experimental study on the radiated noise of the simulated ship fluid piping system, the radiated noise characteristics of the fluid piping system under different conditions are obtained, and the important factors affecting the radiated noise of the nozzle of the pipeline are given, which provides a basis for guiding the radiated noise control of the ship fluid piping system.

Keywords: Fluid piping system, Nozzle, Radiated Noise
I-INCE Classification of Subject Number: 76

1. INTRODUCTION

Fluid piping system is widely used in ships, such as ventilation system, hydraulic system, fuel oil system, cooling water system, etc. The vibration of the pipe wall of the system and the pressure pulsation of the fluid in the pipe interact with each other which propagates along the pipe wall and the fluid in the pipe and radiates outward. For the cooling water system, it is connected with the water outside, the fluid pulsation noise generated by pumps and valves in the system will radiates out from the nozzle through the absorption and discharge of the water, which directly affects the stealth of ship.

In order to study the radiated noise characteristics of fluid piping system, experts and scholars at home and abroad have carried out a lot of research. In 1984, KS Wang et al. studied the acoustic radiation characteristics of the finite length thick shell and the thin shell filled with liquid separately[1]; In 1995, Schlesinger, Tso and Hansen studied the acoustic propagation characteristics of liquid-filled pipeline with baffle at the end [2-3]; In 2002, Lou Hongwei et al. established a simple SEA theoretical model of acoustic propagation and nozzle acoustic radiation of seawater piping system by using statistical energy analysis method[4]; In 2004, Liu Bilong et al. studied the acoustic

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radiation of the finite length liquid pipeline with elastic baffle for the ship cooling water system, and established the theoretical model of the nozzle acoustic radiation of the pipeline system with elastic baffle[5] ; In 2005, Cheng Guangfu et al. used the boundary element method to calculate the noise and radiation characteristics of the inlet and outlet of water pipeline [6] ; In 2017, Sun Yunping et al. designed an active noise attenuation system to solve the problem of low-frequency line spectrum noise in liquid-filled pipeline and carried out experimental verification[7].

In this paper, by simulating the test bench of the ship fluid piping system, the influence of equipment frequency conversion, hose connection, valve regulation, water tank water supply and bubbles on the radiated noise at the nozzle of fluid piping system are studied, and the important factors affecting the radiated noise at the nozzle of fluid piping system are given.

2. Test equipment and test system

The test bench for fluid piping system is mainly composed of a frequency conversion pump (The rated flow of pump is 25t/h), auxiliary pipelines, pipeline fittings, water tank and configuration parameters measuring devices. The measuring points mainly include equipment and pipeline vibration measuring points and hydrophone measuring points. The test bench schematic diagram is shown in Fig.1, the site diagram of bench test is shown in Fig.2.

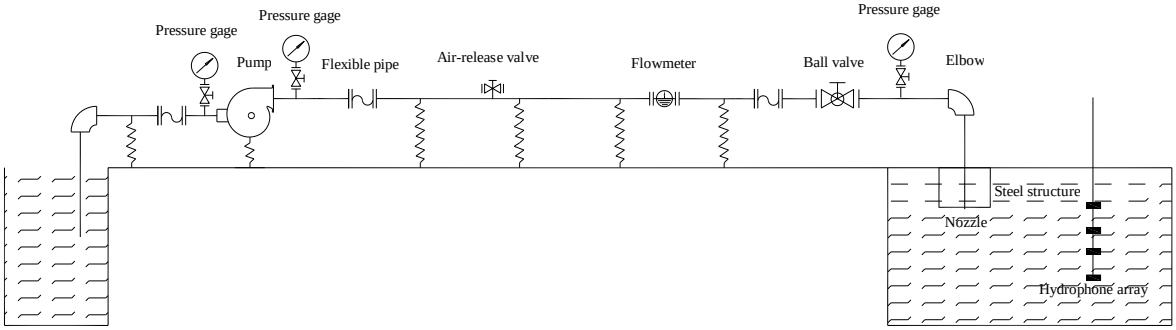

Figure 1: *Test bench schematic diagram*

Figure 2: *Site diagram of bench test*

3. Analysis of test results

3.1 Influence of equipment frequency conversion on the nozzle radiated noise

When the pump is frequency-converted, the flow rate is changed by changing its working frequency. When the influence of equipment frequency conversion is studied, the radiated pressure level at the nozzle of the fluid pipeline is compared and analyzed. Table 1 shows the pipeline flow rate and the nozzle radiated pressure level at different pump working frequencies; Fig. 3 shows the curve of the radiated pressure level at the nozzle of the fluid pipeline varying with the flow rate of the pipeline. By adjusting the working frequency of the pump, the pipeline flow rate increases. With the increase of the flow rate, the radiated pressure level at the nozzle of the pipeline shows an upward trend, and the variation law is approximately linear with the pump flow rate.

Table 1: *The flow rate and pressure level at different pump working frequencies*

Frequency（Hz）	Flow rate（t/h）	Pressure level（dB）
20	17.4	108.1
25	22.0	111.8
30	26.4	113.8
35	30.8	114.7
40	35.4	117.2
45	39.7	119.7
50	40.7	123.0

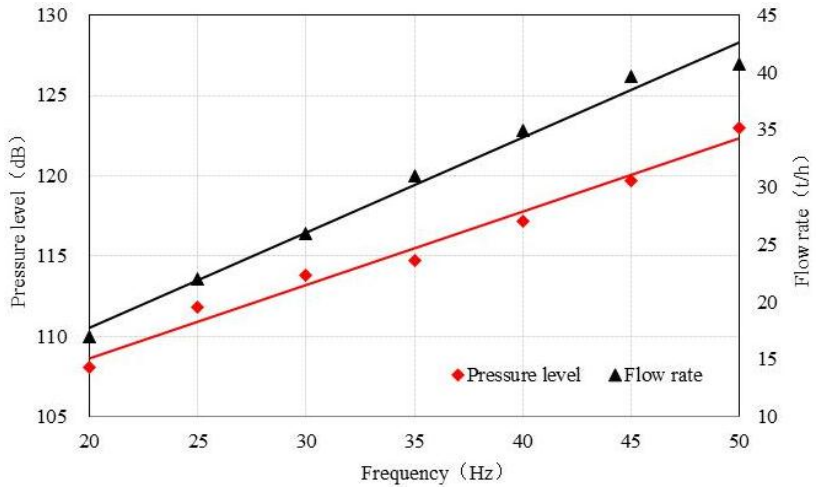

Figure 3: *The relation of working frequency, flow rate and pressure level*

3.2 Influence of hose connection on the nozzle radiated noise

A section of hose is connected to the outlet of the pump and then connected to the pipeline, to study the influence of hose connection between equipment and pipeline on the nozzle radiated noise. Table 2 shows the nozzle radiated pressure level when the pump is connected to the pipeline with hose or not at two different flow rates; Fig. 4 is a comparison of radiated pressure level at the nozzle of the fluid pipeline when the pump is connected to the pipeline with hose or not at the pipeline flow rate of 49 t/h. It can be seen that when the pump is connected with the pipeline by a hose, the radiated pressure level at the nozzle is reduced, mainly in the middle and high frequency bands.

Table 2: *The nozzle radiated pressure level*

Flow rate（t/h）	Pressure level（dB）	
	No hose	Have hose
48.2	122.9	120.7
49	124.5	120.9

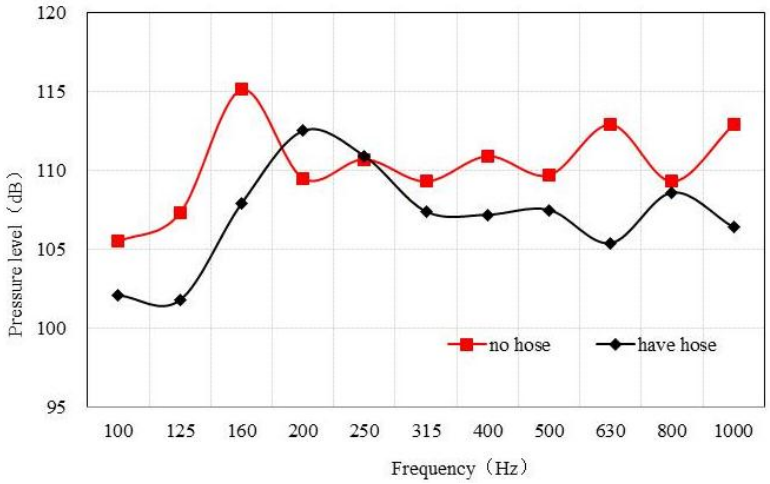

Figure 4: *Comparison of the nozzle radiated pressure level*

3.3 Influence of valve regulation on the nozzle radiated noise

By adjusting the opening of the ball valve in the fluid pipeline, to change the differential pressure and flow rate of the system, and study the influence of different opening degrees of the valve on the nozzle radiated noise, then use the nozzle radiated pressure level to analysis. Fig. 5 shows the variation curve of the nozzle radiated pressure level and the flow rate of the pipeline with the opening of the valve; Fig. 6 shows the variation curve of the vibration acceleration level of the structure at the nozzle with the opening of the valve. As the opening of the valve increases, the flow rate of the pipeline keeps increases and tends to be balanced. The nozzle radiated pressure level and the vibration acceleration level of the structure at the nozzle decrease sharply and gradually stabilize with the flow rate. It can be seen that by adjusting the opening of the pipeline valve to make the fluid piping system works at a lower flow rate, as the system pipeline is in a pressure-holding state and the fluid state in the pipeline is disordered which aggravates the structural vibration of the pipeline and its nozzle, thus the lower nozzle radiated noise is not necessarily obtained.

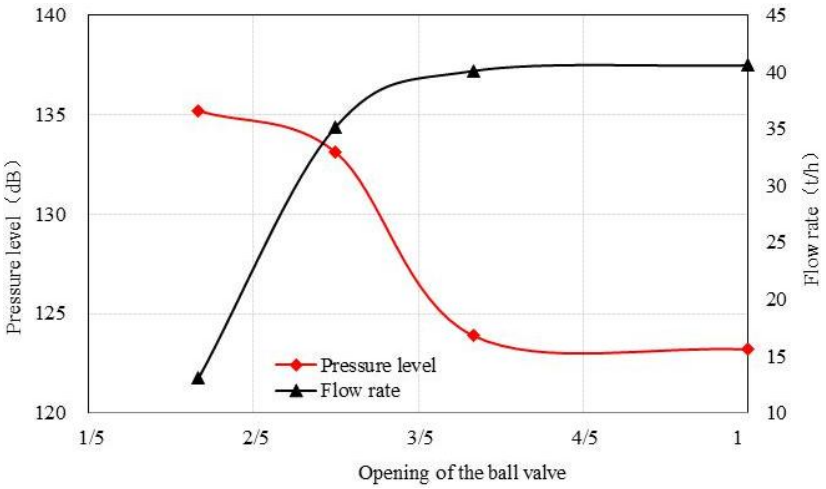

Figure 5: *Relationship between pressure level and flow rate*

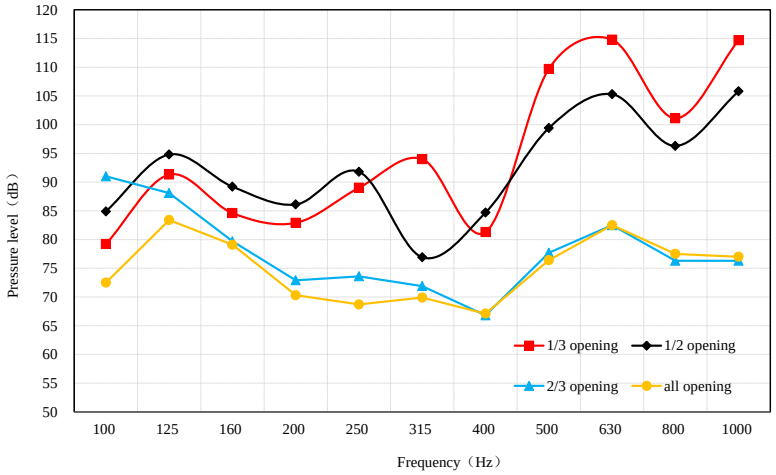

Figure 6: *Relationship between vibration acceleration level and valve opening*

3.4 Influence of water tank water supply on the nozzle radiated noise

Replace the pump with a water tank, by adjusting the valve of the water tank, to study the influence of water tank water supply on the nozzle radiated noise. Table 3 shows the pipeline flow rate and the nozzle radiated pressure level when the pump works and the water tank supplies water respectively. Fig. 7 is a comparison of the pipeline flow rate and the nozzle radiated pressure level when the pump works and the water tank water supplies respectively. It can be seen that even if the pipeline flow rate is less than that of the water tank supplies, the nozzle radiated pressure level is still much higher when the pump is working. By the increase of the flow rate alone has little effect on the nozzle radiated noise. The structural vibration and the fluctuating pressure in the pipeline caused by pump operation are the main noise sources of the nozzle radiated noise.

Table 3: *The flow rate and the nozzle radiated pressure level*

Pump flow rate（t/h）	Pressure level（dB）	water tank flow rate（t/h）	Pressure level（dB）
22.0	111.8	24	102.6
26.4	113.8	30.5	106.7
30.8	114.7	31.8	107.9
35.4	117.2	32.7	109.3

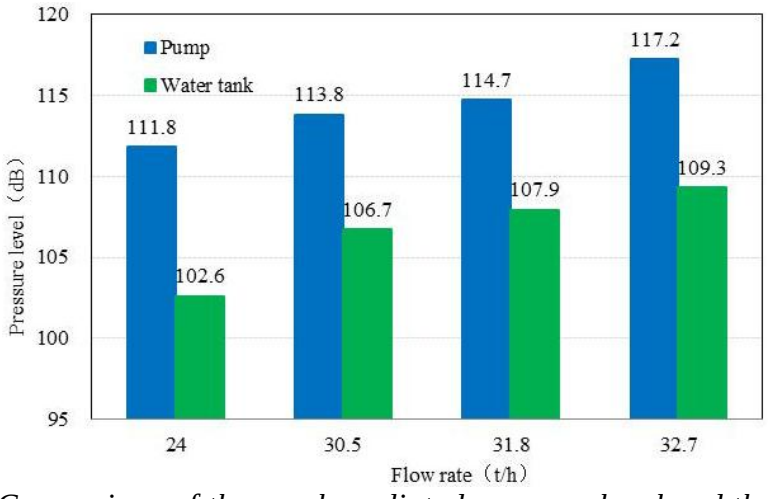

Figure 7: *Comparison of the nozzle radiated pressure level and the flow rate*

3.5 Influence of bubbles in the fluid pipeline on the nozzle radiated noise

Under the condition of water tank water supply, injecting gas into the pipeline to study the influence of bubbles in the pipeline on the nozzle radiated noise. Fig. 8 shows the comparison of the nozzle radiated pressure level with the fluid pipeline has bubbles or not. It can be seen that when there has bubbles in the fluid pipeline, the middle and high frequency range of the nozzle radiated pressure level increases obviously.

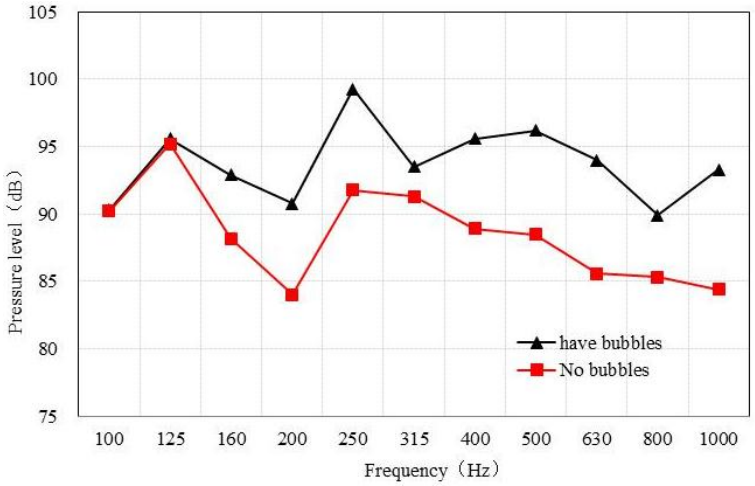

Figure 8: *Comparison of radiated pressure level*

4. CONCLUSIONS

The tests of the radiated noise characteristics of the nozzle under different operating conditions are carried out by simulating the fluid piping system, through the analysis of the test results, some useful conclusions are obtained:

1. The flow rate of the pump is closely related to the nozzle radiated noise, and the variation law is approximately linear with the pump flow rate;

2. The connection of the hose between the pump and the pipeline has a certain effect on the control of the nozzle radiation noise of fluid piping system;

3. By adjusting the opening of the valve, even if the fluid piping system works at a lower flow rate, as the system pipeline is in a pressure-holding state and the fluid state in the pipeline is disordered, the nozzle radiation noise is rather higher.

4. By the increase of the flow rate alone has little effect on the nozzle radiated noise. The structural vibration and the fluctuating pressure in the pipeline caused by pump operation are the main noise sources of the nozzle radiated noise.

5. When there are bubbles in the fluid pipeline, the nozzle radiated noise will increase, which should be avoided during the operation of the system.

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