Vibration and Noise Test Analysis of Reciprocating Compressor

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Abstract

According to the traditional reciprocating compressor vibration and noise problem, a model of the compressor were studied using spectrum analysis technology in load, with suction exhaust valve vacuum, exhaust pipe in light, the light under four different influence on the compressor noise radiation.Through the spectrum analysis, vacuum exhaust valve piece is not high frequency noise is the main source of compressor, the exhaust pipe in about 630 hz noise elimination effect is obvious, at 2000 hz, compared with that without the exhaust pipe in no-load noise spectrum produced different high frequency noise.The corresponding improvement measures are put forward. On the one hand, the resistance muffler is reasonably designed on the inner exhaust pipe to eliminate part of high frequency noise.On the other hand, the shock absorber spring is installed at a reasonable position on the inner exhaust pipe to reduce the instantaneous impact caused by the refrigerant pulsation.

Keywords

Compressor;Noise;Spectrum;Internal exhaust pipe;The mute package;Natural frequency.

1. Introduction

Compressor is the important industrial refrigeration equipment, also is the main noise source of refrigerator, air conditioner, the current "high efficiency, low noise" has become a leading indicator to measure the electrical appliances product quality [1], including the noise of the electrical home appliances products, energy consumption and environmental performance, especially the noise index of the home appliance product.So buy home appliance products, the products are the noise level of high and low, whether of high and low energy consumption and environmental protection as one of the important indicators to measure inner quality, and even some users electrical appliances product of the noise level as the preferred factors.Therefore, the noise problem of home appliances seriously restricts the market share of products and affects the economic benefits of manufacturers.It is an inevitable trend to reduce the noise and energy consumption of home appliances and improve the internal quality of products.Therefore, it is of great practical value to improve the vibration noise, energy consumption and comfortable home environment of compressors.For this reason, relevant scholars have conducted in-depth research on vibration and noise reduction of compressors.Literature [2], for example, the numerical analysis method for radiation noises of the compressor shell under different shell parameters was studied, the results show that the pump body with support at the bottom of the connection way and shell;Increase the radius of the circle of the upper shell;Increasing the thickness and damping of shell can effectively reduce the noise radiation of compressor.CAE tools used to analyze the literature [3], through the NX - CAD modeling suction muffler, using ANSYS to draw the transmission loss curve and pressure drop calculation, analysis of the compressor suction muffler inserted into the pipe length, the volume of expansion chamber, different refrigerant medium sound of suction muffler characteristic of sound transmission loss and the influence of the pressure loss.[4] 2 degrees of freedom dynamic model established a refrigerator compressor, the compressor vibration isolation system for dynamic characteristics analysis, analysis of the force transmission rate, the influence of parameter change on the theoretical analysis is verified by modal experiment method of reliability.[5] the method of finite element simulation analysis, analysis of the crankshaft connecting rod piston motion system of the compressor vibration response caused unbalance force and moment, through the comparison with the experiment, and suggests that numerical simulation

can be applied to the compressor vibration response analysis, and mechanical excitation caused by shell surface velocity distribution.

2. Theoretical Analysis of Vibration and Noise

Compressor structure is complex, noise sources are more, in summary, mainly divided into three categories: electromagnetic noise, aerodynamic noise and mechanical noise.Motor running, the fundamental magnetic flux and higher harmonic magnetic flux along the radial direction into the air gap, and produced in the stator and rotor radial force and tangential force and axial force, the resulting radial, tangential and axial vibration and noise caused by electromagnetic noise [6].When the compressor is running, the noise caused by the refrigerant flowing in the closed compressor is aerodynamic noise.When crankshaft - connecting rod - piston motion produces reciprocating inertia force and rotary inertia force causes compressor vibration and noise is mechanical noise.By theoretical analysis, the mechanical noise frequency is integer times the rotation frequency of the motor shaft, this paper studies the actual compressor rotor speed of 2950 r/min, so by the piston - connecting rod - crankshaft institutions unbalanced force and the torque caused by noise frequency of 49.2 Hz, 98.4 Hz, 147.6 Hz, etc., and these are random noise, and presents the wide-band characteristics.

3. Test Environment Requirements

The noise of the compressor was tested by GB/9098-2008 test standard of fully enclosed motor - compressor for refrigerator.Testing process using lande company (HEAD) Recorder4.0 noise data, the data acquisition system is imported computer after using lande Artemis Suite6.0 data analysis software for acoustic power spectrum analysis and calculation, finally it is concluded that the compressor noise spectrum data, the testing environment, balancing system, as shown in figure 1, introducing the compressor ten point position as shown in figure 2.

Fig 1. Structure diagram of noise test system

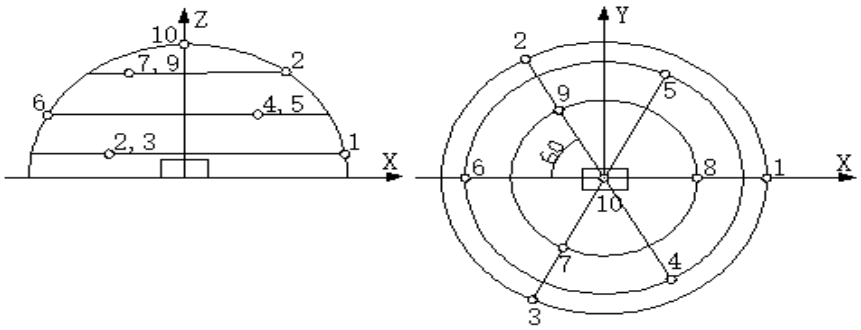

Fig 2. Position of 10 measuring points on the measured surface of the hemisphere

The calculation formula of the average A sound pressure level on the surface of the test stand at 10 test points in the semi-muffler room is as follows:

$$\overline{L}_{pA} = 10\lg[\frac{1}{10}\sum_{i=1}^{10}10^{0.1(L_{pAi}-K_{1i})}]$$

Where: $\overline{L}_{pA}$ - average A sound level dB (A) in the measuring scale; L_{pAi} - A sound level dB (A) measured at the ith measuring point; K_{1i} - correction of background noise at point I.

4. Spectral Analysis

To filter noise influence on the compressor vibration noise, we pass the test system of compressor in load, with suction exhaust valve vacuum, exhaust pipe light, the light within four different condition of compressor vibration and noise test, the test spectrum is shown in figure 3.

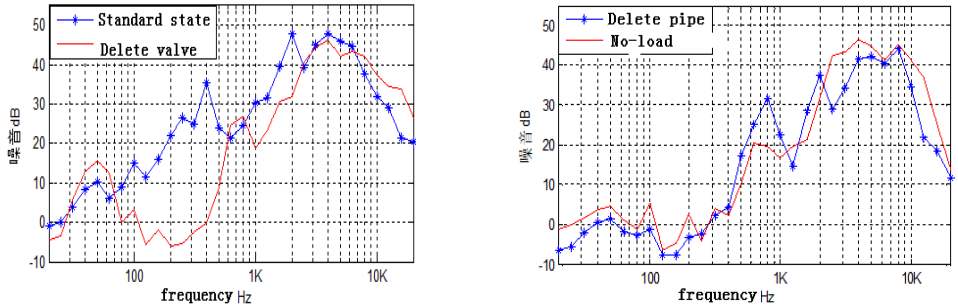

Fig 3. 1/3 frequency range noise spectrum

As much as possible in order to eliminate the effects of gas pulse noise of compressor suction exhaust valve was designed to vacuum test, the residual noise is mainly mechanical noise and electromagnetic noise, the noise spectrum is compared with load, in 63 hz - 500 hz, 800 hz - 1800 hz, motor drive the crankshaft connecting rod - suction exhaust valve piston reciprocating motion impact larger noise influence factors.At 2000hz-5000hz, there is no significant difference. Above 5000Hz, the vacuum noise of the exhaust valve disc is greater than that of the load, indicating that the suction and exhaust valve disc is not the main source of high-frequency noise of this type of compressor.By comparing the compressor racing (not add refrigerant), to the exhaust pipe in no-load noise spectrum, within 200 hz with the exhaust pipe in no-load noise big, especially in the axis of rotation frequency, as well as the frequency doubling difference obvious, at about 630 hz, go to the exhaust pipe in no-load noise is bigger than normal no-load noise, instructions inside the exhaust pipe to 630 hz or so to have certain silencing effect, at more than 2000 hz to high frequency in the exhaust pipe no-load noise is less than the no-load noise, especially in the 2160 hz noise is the most obvious difference, that may be within the 2000 hz exhaust gas pulse noise.

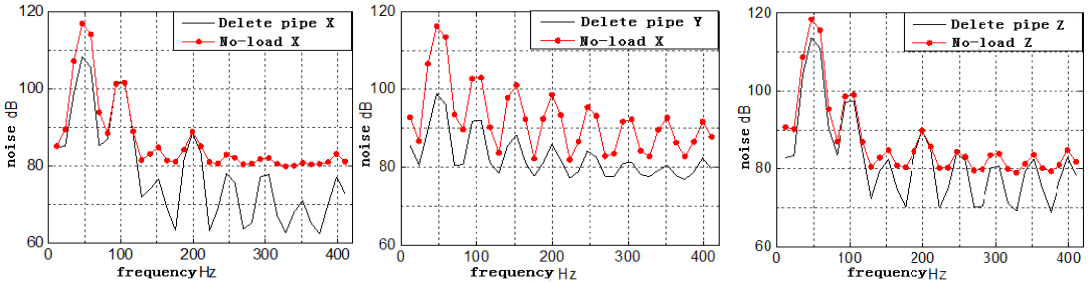

Fig 4. Vibration spectrum diagram

By comparing the compressor exhaust pipe light the same point in the light and go to three different direction vibration spectrum can be found that under the low frequency 49 hz, 98 hz vibration significantly larger, to verify the mechanical noise is the axis of rotation integer times the authenticity of this theory.Under the low frequency to the exhaust pipe in no-load vibration significantly lower than the no-load Y Y axis, and at 150 hz, go inside the exhaust pipe in the X/Y/Z three direction vibration should be below the light, from the inside the exhaust pipe may be related to the natural

frequency of the compressor rotor rotational frequency and its frequency doubling approach or overlap, inside the exhaust pipe with the compressor has a resonance.

To sum up, the main noise sources of compressor are low frequency noise and high frequency gas pulsation noise around 2000Hz.Therefore, if the low frequency vibration noise of compressor can be reduced and the high frequency noise around 2000Hz can be improved.However, it is recommended to reduce the low frequency vibration noise and the high frequency noise around 2000Hz as follows :(1) the resistance muffler can be reasonably designed on the inner exhaust pipe.On the one hand, the natural frequency can be changed by increasing the resistance muffler and changing the quality of the internal exhaust pipe. On the other hand, the design of the resistance muffler can eliminate some high frequency noise.(2) a damping spring can be installed at a reasonable position on the inner exhaust pipe to reduce the instantaneous impact caused by the refrigerant pulsation.

5. Conclusion

The sources of compressor noise are mainly divided into three categories: electromagnetic noise, aerodynamic noise and mechanical noise.Based on these three kinds of noise and the noise test experiment, using spectrum analysis technology analysis of the four different condition compressor noise spectrum, understand the vacuum exhaust valve is not the main source of high frequency noise.Remove the exhaust pipe in no-load than normal racing in the high frequency noise have a lower overall trends, especially the most obvious difference at 2000 hz, so that inside the exhaust gas pressure pulsation and radiated noise.Corresponding improvement measures are proposed :(1) the resistance muffler can be reasonably designed on the inner exhaust pipe.On the one hand, the natural frequency can be changed by increasing the resistance muffler and changing the quality of the internal exhaust pipe. On the other hand, the design of the resistance muffler can eliminate some high frequency noise.(2) a damping spring can be installed at a reasonable position on the inner exhaust pipe to reduce the instantaneous impact caused by the refrigerant pulsation.

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