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Noise Reduction Technology for Inverter Controlled Rotary Compressor

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ABSTRACT

Inverter controlled rotary compressor is taken as a study object. During 'run-up' a series of compressor noise are measured to determine the behavior of the structure and to determine the rotational speed, and the compressor noise at each operating speed is measured. Also modal analysis results show that the noise is caused by the resonance mode existing in the accumulator pipe. Based on the results of the noise experiment and modal analysis, a design change of the inner attachment of the accumulator using the dynamics modification theory has been done, and the undesired resonance mode is removed. Noise experiment of a compressor with the improved accumulator is performed, and not only a reduction of 5dB(A) in the noise of the compressor, but also a sound reduction of 15dB(A) in the resonance mode of former accumulator has been confirmed.

1. INTRODUCTION

To detect the noise source character, Sound power radiated from the compressor is measured, and during 'run-up' a compressor noise experiment is conducted.

To understand the structural characteristic of the compressor, FE model of the rotary compressor composed of all the components is built for the modal analysis. And a test modal analysis is conducted.

Based on the noise detection and modal analysis, a dynamics modification of the inner attachment of the accumulator has been done. Proposed design changes are applied and verified to eliminate aimed resonance modes in sound measurement experiment.

2. NOISE SOURCE DETERMINATION

During 'run-up' a compressor noise experiment is conducted, as shown in Figure 1. The results show that there is a noise mutation during the compressor's 'run-up'. Also a sound power versus the rotation speed of the compressor is measured, as shown in Figure 2, and the results show that there is a sound peak when the compressor is running at the speed of about 2700 rpm. Noise waterfall of a compressor is measured to determine the noise characteristic, as shown in Figure 3. The results show that there is a serious problem of noise caused by the coupling effect of the behavior of the structure and the rotational speed, which is marked with a red circle in Figure 3.

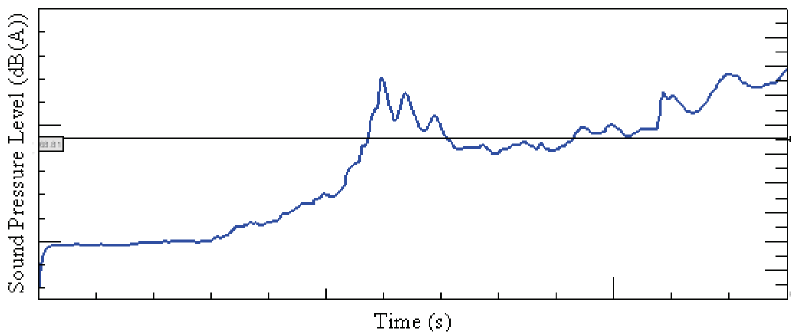

Figure 1 Noise of Compressor During 'run-up'

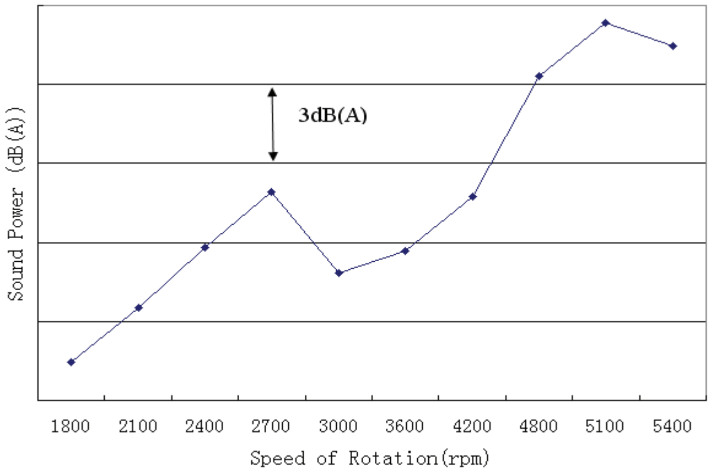

Figure 2 Sound Power versus speed of rotation

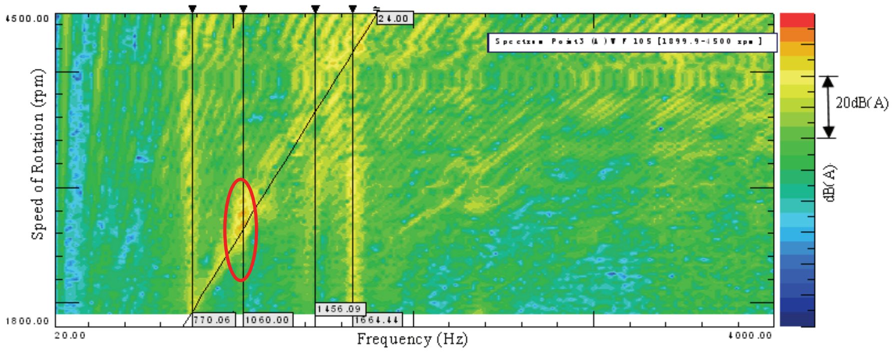

Figure 3 Noise Waterfall

3. MODAL ANALYSIS AND EXCITING FORCE DETERMINATION

To study the behavior of the structure, Impact modal tests are conducted. Based on the stabilization diagram shown in Figure 4, a modal frequency existing in the 1081.3Hz is found. This modal shape is shown in Figure 5. A study with finite element modal analysis is performed on a compressor. The calculated modal frequency is 1108.5Hz, and its modal shape is shown in figure 6.

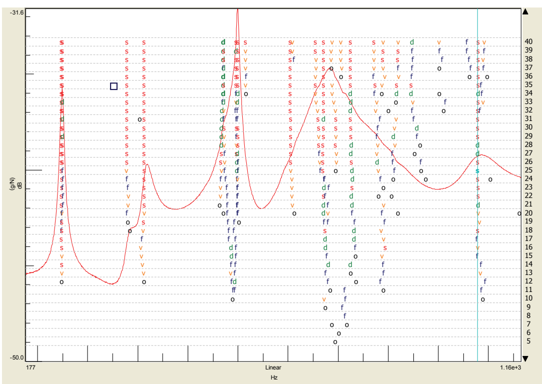

Figure 4 Stabilization Diagram

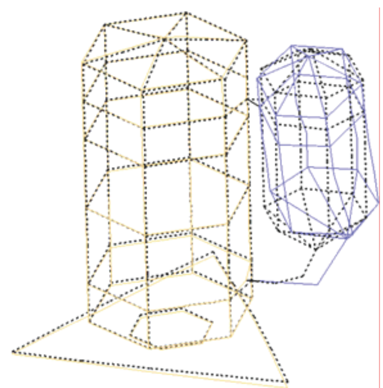

Figure 5 Tested Modal Shape

Figure 6 Calculated Modal Shape

The error between the tested frequency and the calculated frequency is about 2.5%, and there is comparability between the tested mode and the calculated mode.
The compressor is equipped with a distributed winding motor, which is equipped with a 4-pole 24-slot IPM synchronous motor. The motor induces the 24-th harmonic magnetic force. When the compressor is operating at the speed of about 2700 rpm, the frequency of the 24-th harmonic magnetic force is 1080 Hz.

4. VERIFICATION WITH EXPERIMENT

The results of the noise experiment and modal analysis indicate that the 24-th harmonic magnetic force induces the resonance mode existing in the accumulator pipe, and the sound level become bad when the compressor is operating at the speed of 2700 rpm.
To validate it, a dynamics modification of the inner attachment of the accumulator has been done. The original accumulator is shown in Figure 7, and the modificatory accumulator is shown in Figure 8.
The undesired resonance mode is removed from 1080Hz. Noise experiment of a compressor with the improved accumulator is performed, and not only a reduction of 5dB(A) in the noise of the compressor, but also a sound reduction of 15dB(A) in the resonance mode of former accumulator has been confirmed, as shown in Figure 9.

Figure 7 Original Accumulator

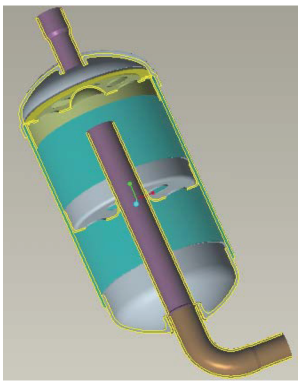

Figure 8 Modificatory Accumulator

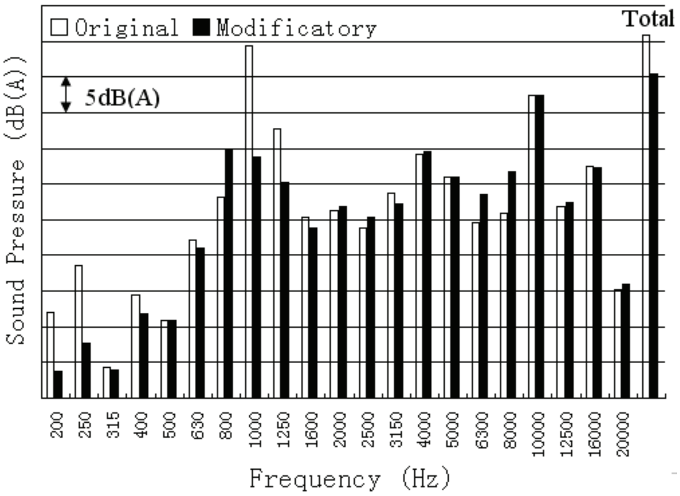

Figure 9 Comparison of sound power

5. CONCLUSIONS

The noise experiment results and modal analysis results show that a resonance modal frequency coincides with the 24-th harmonic magnetic force when the compressor is operating at the speed of 2700 rpm, which inducing the resonance mode existing in the accumulator pipe.

When the undesired resonance mode is removed, the noise level of the compressor is improved. When the compressor is running at the speed of 2700 rpm, not only a reduction of 5 dB(A) in the noise of the compressor, but also a sound reduction of 15 dB(A) in the resonance mode of former accumulator has been confirmed.

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