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TECHNOLOGY FOR ASSESSING THE TECHNICAL STATE OF A HERMETIC CHILLED COMPRESSOR

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ARTICLE INFO	ABSTRACT
Article history: Received:2025-09-28 Received in revised form:2025-10-09 Accepted:2025-11-10 Available online:2026-06-30	The above technique of instrumental control of the technical state of a hermetically sealed refrigerant compressor makes it possible to perform qualitative and quantitative analysis of sound radiation from the constructive state of the device without analyzing it. Acoustic research of a domestic compressor is usually evaluated using mathematical-mechanical models, and many decisions are made on the basis of modeling. However, such an investigation is usually performed in a deterministic structure that cannot consider the epistemic uncertainties arising, for example, by the processes of colliding elements of the gas distribution mechanism. The known methods for studying the sound emission of a gas-distributing mechanism, as a source of noise, do not consider the interaction factor of the conjugate noise sources. The article compares the method of instrumental control, which makes it possible to determine the acoustic parameters on an open casing and the method of non-destructive testing of a compressor. The obtained results demonstrate reproduced and the accuracy of the study.
Keywords: technical state inspection; hermetic reciprocating compressor; hermetic refrigeration compressors; non-destructive check; acoustical radiation.	
JEL Classification: O32, L64, D24	

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1. INTRODUCTION

Reliable and safe operation of refrigeration equipment is largely associated with the analysis of these reliability parameters of the operating properties and parameters of a hermetic compressor or its individual components [1]. In this case, the control must be carried out without removing it from an operational state, i.e. without dismantling the parts of the casing that ensures the tightness of the product, the so-called non-destructive testing includes [2,3]: mean time between failures, trouble-free operating time, specified service life of the compressor. The listed compressor parameters objectively determine its main quality indicators.

Monitoring the level of technical operation of a hermetic compressor based on indicators of the actual condition of the equipment requires accurate and reliable measurement results of these indicators [4].

2. PURPOSE OF WORK

The purpose of this study is to analyze methods for assessing the technical condition of a hermetic refrigeration compressor using the example of using the acoustic method [2]. To achieve this goal, it was necessary to solve the following tasks:

1. Conduct an analytical (based on literary sources) comparison of methods for assessing the technical condition of a hermetic refrigerated compressor, in particular the acoustic method [2].
2. Conduct an analysis of the acoustic method [2] for assessing the technical condition of a hermetic cold compressor and determine approaches to solving the problem of identifying the acoustic signal generated by the processes of colliding elements of the gas distribution mechanism.

3. RESEARCH METHODOLOGY

Based on the provisions of GOST 20911-89, the concept of “technical condition” can be interpreted as a characteristic of compliance with the requirements of technical documentation. This characteristic can be expressed either in qualitative form - by designated fixed types of technical condition (serviceable, faulty, etc. GOST 27.002-89), or in quantitative form - the numerical value of the available performance resource. Characteristics can be given, compiled, found out, studied, checked. At the first stage - examine the object (characterize its technical condition). The technology of this process is quite fully presented in the following works [5, 6, 7].

The main indicators of the gas chemical complex and the determined technical level are [6]:

Efficiency coefficient K_e (COP), W/W 1.3÷1.65

Sound power level, L_a , dBA 32÷36

Mass of gas chemical complex, m kg no more than 8

Currently, the acoustic method [2] is a high-tech method for assessing the technical condition of various mechanical components, including components of a hermetic refrigerant compressor. At the same time, the method is complex, which is due to the kinematic complexity of the objects of study and the factors of acoustic interaction of vibrations from various sources of noise and vibration and the complexity of the technical equipment for conducting and analyzing the study.

The acoustic study of a compressor is usually evaluated using mathematical-mechanical models, and many decisions are made based on simulations [6, 7]. Such research is usually carried out in a deterministic framework, which cannot consider the epistemic uncertainties generated, for example, processes colliding elements of the gas distribution mechanism. Known methods for studying the process of sound radiation do not take into account the interaction factor of the associated parts of the gas distribution mechanism.

The main methods of acoustic determination of technical condition, which are used in solving problems of monitoring and functional diagnostics of refrigeration machines, are:

- measurement of vibration parameters;
- spectral analysis of the acoustic signal
- analysis of the characteristics of the rotational movement of the components of the
- compressor unit;
- peak loads;
- contour characteristic;
- shock pulse method (SPM-method Shock Pulse Method).

It is worth noting that a significant part of acoustic monitoring methods are intended for specific types of research into the acoustic characteristics of certain components and assemblies of machines.

The simplest of these methods is to measure the overall noise and vibration levels. In this case, the root mean square or peak values of the mechanical vibration parameters are measured over wide frequency ranges.

An examination by spectral analysis of noise and vibration consists of detecting periodically repeating, usually shock, processes in the operation of a machine and comparing them with possible sources of shock elastic vibrations.

Defects that affect vibration parameters, during the operation of a faulty valve mechanism, form a vibro-acoustic signal consisting of damped oscillations with different frequencies of shock origin and characterized by a significant excess of the oscillation amplitude. In most cases, by analyzing the frequency of these impacts, it is possible to identify the faulty element. A more detailed analysis is presented in [4]. Technical regulations, definitions of noise and vibration according to 17008-85, allow you to determine acoustic parameters, for example, the adjusted sound power level and vibration level, the total sound power of a hermetic compressor. The measurement result allows you to evaluate the permissible, normalized range of acoustic characteristics of the compressor and perform a comparative analysis of compressors as sources of different noise levels. The proposed methods do not allow us to identify the components of compressor noise, which in turn does not allow us to determine the influence of the design factor on the process of formation of sound vibrations of the compressor.

The structure of the proposed methodology is based on the study of structure-borne noise processes in a compressor [9]: excitation of structure-borne noise (sound radiation of impact origin); transmission of structure-borne noise (sound vibrations propagated in a solid) from the point of excitation to the point of radiation; transformation of structure-borne noise [7].

To determine the technical condition of the gas distribution mechanism of a hermetic cold compressor using a vibro-acoustic signal, it is necessary to know not only the actual, but also the corresponding reference values of elastic vibrations in compressor mechanism. The difference between the actual θ_f and the reference θ_{et} values of the diagnostic parameters is called the diagnostic symptom Δ .

$$\Delta = \theta_f - \theta_{et} \quad (1)$$

Thus, the assessment of the technical condition of the mechanism is determined by the deviation of the actual vibro-acoustic values of its parameters from their reference values.

The reference values are measured at the source of its occurrence - on the compressor housing part (2) Fig.1. Two measurements are performed: in the first measurement, the crankshaft and the movement mechanism that drives the piston in the cylinder without load.

4. DISCUSSION OF RESULTS

During the next measurement, the valve mechanism operating in backpressure mode (GOST 17008-85* not less than 10 kg/s) is brought into operation. The difference between the actual and reference values of acoustic parameters (diagnostic symptom Δ) is formed in the analyzer (6), a graphical representation is shown in Fig.1.

In accordance with the above principle, acoustic tests are carried out on a hermetic compressor, but using the non-destructive testing method, i.e., measurements are carried out with a hermetically sealed casing (in the area of the discharge pipe). The method of instrumental non-destructive testing [6], developed in collaboration with professor Naberezhnykh A.I. [1,2] allows you to determine the vibration-acoustic parameters of the gas distribution mechanism, with less labor intensity of the measurement experiment and the necessary reliability.

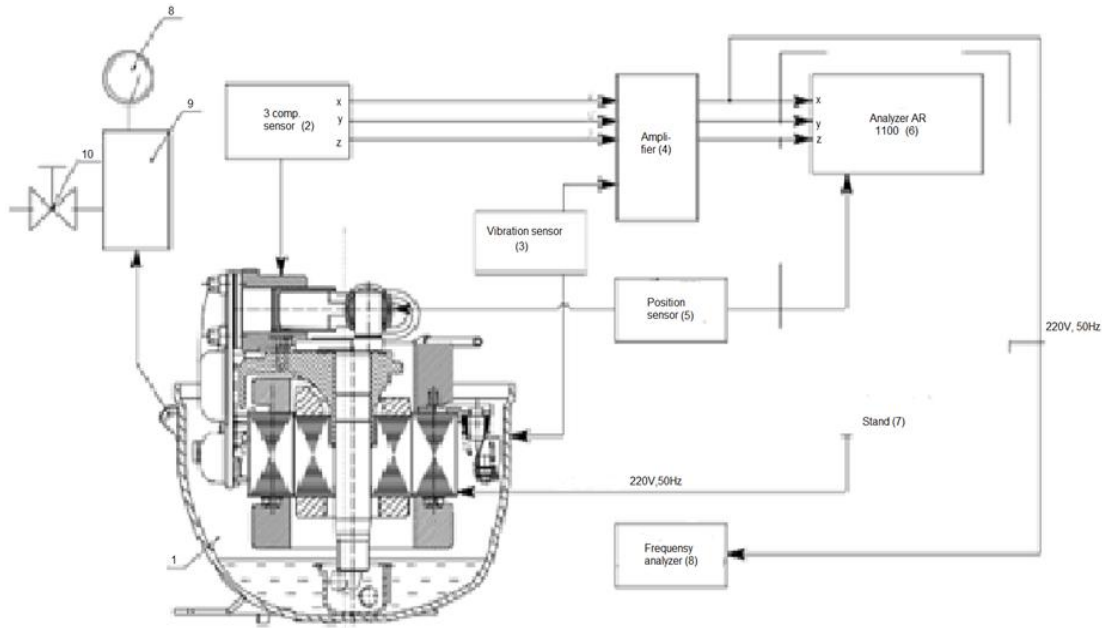


Figure 1. Functional diagram for determining the vibro-acoustic parameters of the KVO compressor in the required configuration with an open casing

1 – hermetic refrigerant compressor without a top compressor cover; 2 – three-axis vibration sensor DYTRAN 3143 M1 No. 237; 3 – Vibration sensor PCB ICP 353 B33; 4 – signal amplifier SVAN – SV 06A; 5 – Position sensor; 6 – Frequency analyzer RION-SA-27A; 6 –Yakogawa AR 1100 analyzer; 7 – stand; 8 – pressure gauge; 9 – receiver; 10 – regulating.

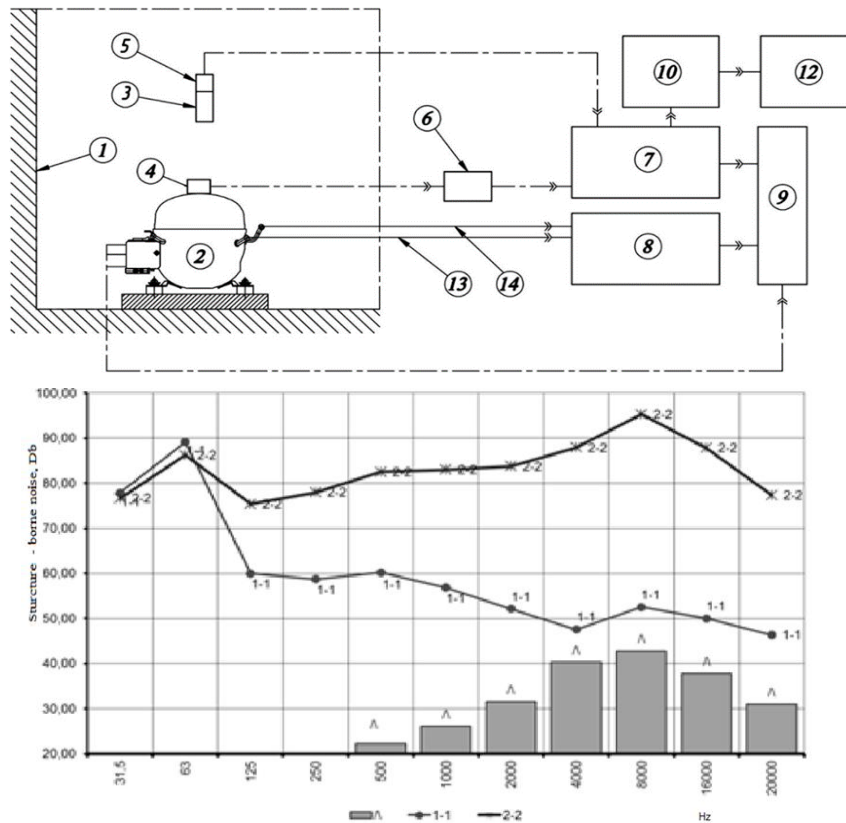


Figure 3. Vibration-acoustic characteristics of sound radiation from self-acting compressor valves:

1-1 – sound radiation of structure-borne noise of the compressor when operating in vacuum; 2-2 – acoustic radiation of structure-borne noise of a compressor under normal operating conditions, @ – logarithmic difference

5. CONCLUSION

An assessment of the technical condition of the gas distribution mechanism, determined by the deviation of the actual vibro-acoustic values of its parameters from their reference values, makes it possible to estimate the magnitude of the contribution of the operation of the gas distribution mechanism to the process of sound emission of the compressor with structural detail by the components of the mechanism.

The reliability of the method is determined by the convergence of the results (correlation coefficient $K = 0.82$) with the results of the vibration-acoustic test method with a disassembled casing, with the sequential addition of noise sources.

The practical value of the presented methodology is as follows:

- assessment of the technical condition of the gas distribution mechanism, based on the analysis of sound radiation from self-acting valves without disassembling the compressor;
- the possibility of carrying out acoustic diagnostics of a self-acting gas distribution device using non-destructive testing.

Thus, the stated goal of analyzing approaches to assessing the technical condition of a hermetic refrigerated compressor using the example of using the acoustic method has been successfully completed.

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