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Research Article

STRENGTH AND DENSITY (TIGHTNESS) TEST OF CENTRIFUGAL COMPRESSOR CASING

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ABSTRACT

The paper deals with the issues of testing of centrifugal compressor casings for strength and density. Based on the literature review of theoretical analyses of previously developed test benches at the compressor engineering and manufacturing company "Kazankompressormash" and their shortcomings identified, a modernization of the density test bench was carried out. For more efficient testing on the new modernized test bench, a notional layout of the site was designed. Presented a brief description of the new test bench and justified its operational safety and productivity. Provided are conclusions on the application of the conditional site layout and on test methodology.

KEYWORDS

Centrifugal compressor, casing, bench, strength, density, fluid.

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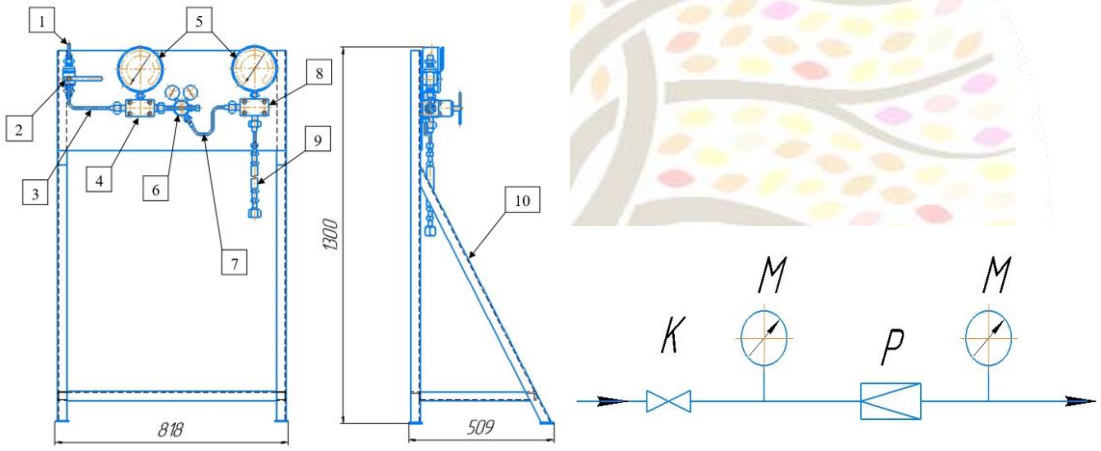
INTRODUCTION

As it is known, centrifugal compressor machines are widely used in chemical, oil, gas and many other industries. The relevance of the study lies in the fact that the use of centrifugal machines in production cycles of increased danger makes significant demands on the reliability of their casings. The housing must be fully hermetically sealed and withstand the stated characteristics. Otherwise, the housings of high-pressure machines represent a potential hazard that can lead to severe consequences under certain conditions. For example, loss of tightness is often accompanied by explosion and fire. Thus, operating personnel can receive thermal burns, if the depressurized compressor contained corrosive gases, there is a risk of poisoning of personnel. It is therefore essential for the safety of the personnel operating the compressor that the compressor remains hermetically sealed during operation.



a) b)

Figure 1. a) The figure is showing the schematic drawing of the bench under the code №7029-6433 for pneumatic tests, which was developed and operated at the manufacturing company "Kazancompressormash" and contains the following elements: 1,3,7 - pipeline; 2 - ball valve; 4,8 - casing; 5 - pressure gauge (MO-11203 0-100 kgf/cm2); 6 - air reducer RV-90; 9 - metal hose (D4.498094-2-6-350-2,5); 10 - frame. b) The figure is presenting the pneumatic principle diagram of the bench with designations such as K-ball valve, M-pressure gauge, P-air reducer.

Brief conclusions. Identification of shortcomings and statement of task.

- There are no safety valves in the body 8, which is located up to the supply line, i.e. up to the hose 9 and located under the second pressure gauge on the left side;
- The pressure reducer is mounted on the same housing as the meter and supply line, making them difficult to service;

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- According to the circuit diagram it can be seen that there is no separate line for depressurization after the end of the test;
- The test product is connected by means of a metal hose to a housing that is connected to the second control gauge, which adversely affects the performance and reliability of the instrument;
- In accordance with Fig. 1 (a), this design is not suitable from the point of view of safety for the operating personnel, since the test bench must be located outside the test area.
- The bench does not provide a reference timeclock to measure time during testing, resulting in lost time for operators.

In addition, it is recommended to design a conditionally optimal site layout for a more efficient operation of the bench.

Description of the modernized bench.

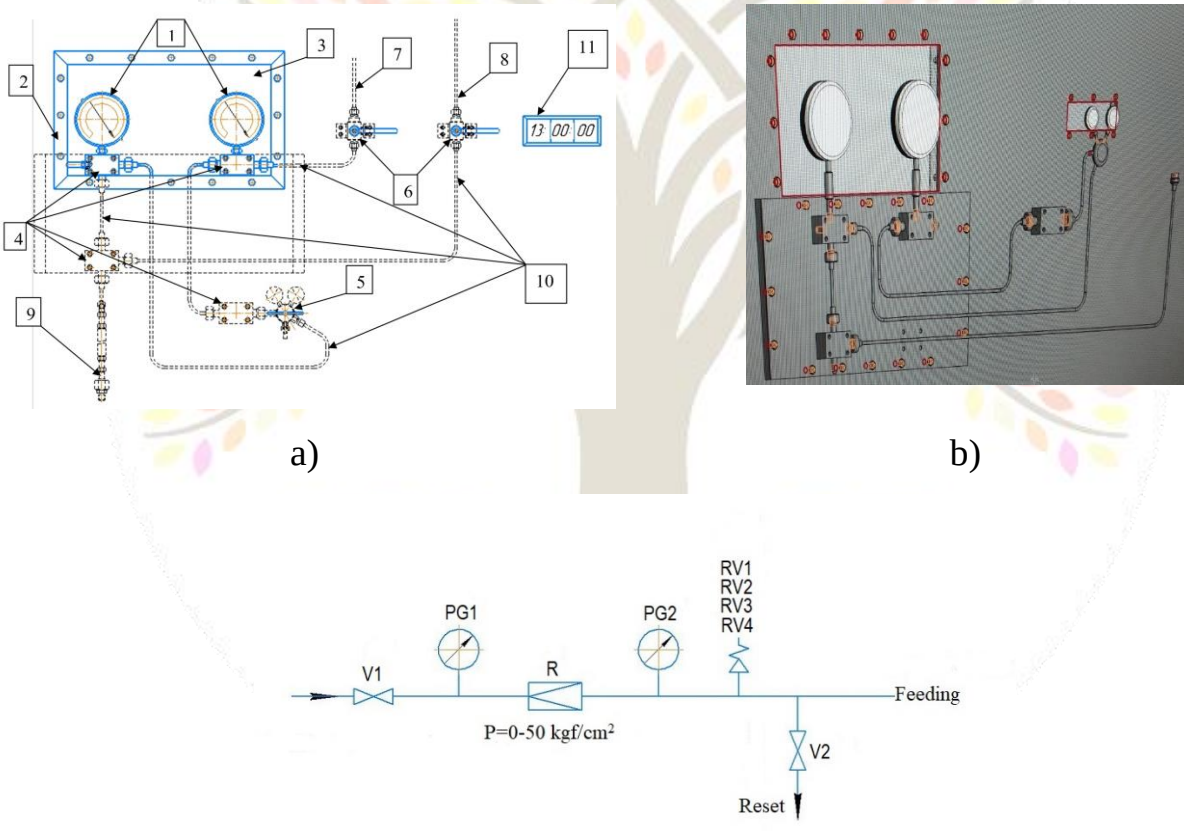

Figure 2. a) The figure is demonstrating the modernized pneumatic test bench and contains the following elements:

1- pressure gauge (MO-11203 0-100 kgf/cm2); 2 - ramp; 3 - viewing glass; 4 - casing; 5 - air reducer RV-90; 6 – ball valve (YGT 10SH.100.00.01.NJ2); 7 - feed line; 8 - reset line; 9 - metal hose

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(D4.498094-2-6-350-2,5); 10 - pipeline; 11-Electronic table clock Quartz -2 C.

b) 3D model of the developed bench, except for the ball valve.

The pneumatic test bench contains a protective wall made of 16 mm thick steel sheet, on which a frame is fixed on the front side with bolts and nuts, and a sight glass is placed inside the frame. On the rear side to the protective wall is welded frame, and to the frame of the body, for the installation of instrumentation such as two pressure gauges and pressure reducer. To connect the system with each other, 8 mm diameter stainless steel pipelines are used, and a high-pressure metal hose is used to connect the system with the test object. For gas supply and discharge, ball valves are used, which are parallel fixed on the rear surface of the protective wall by means of clamps. The test bench also has an electronic clock with a remote control for more accurate and efficient testing.

c) The figure is presenting the pneumatic principle diagram of the new bench.

Designation	Product Title	Quantity	Remark
V1, V2	Ball valve (YGT 10SH.100.00.01.NJ2)	2	Purchased
PG1, PG2	Pressure gauge (MO-11203 0-100 kgf/cm^2)	2	
R	Air reducer RV-90	1	
RV1	Relief valve GA 81806 121 3 DN 6 P=5 kgf/cm^2	1	
RV2	Relief valve GA 81806 121 3 DN 6 P=20 kgf/cm^2	1	
RV3	Relief valve GA 81806 121 3 DN 6 P=32 kgf/cm^2	1	
RV4	Relief valve GA 81806 121 3 DN 6 P=50 kgf/cm^2	1	

The test bench allows testing products with air pressure of 50 atm. Due to the use of a high-precision pressure regulator, the equipment allows for precise adjustment of the actuation pressure. Housing elements of the stand are made of stainless steel.

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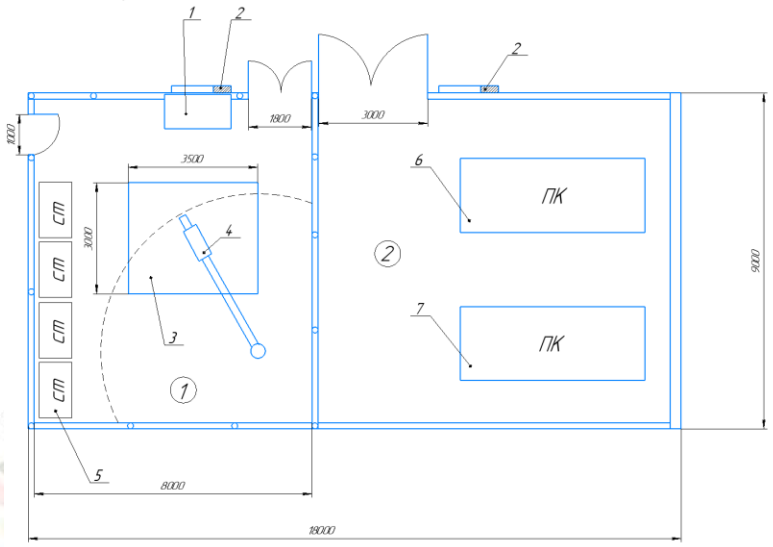

Figure 3. The figure below shows the layout of the site for a more efficient booth operation.

The pneumatic test section consists of two test boxes. The first box contains the pneumatic test bench (1) itself, a bath (3) with overall dimensions of 3 by 3.5 meters, a crane (4) with a lifting capacity of 5 tons and racks (5) for storing plugs and fixtures. The walls of the first box are made of steel plates, which are welded to support pipes.

The second box, in its turn, consists of a monoblock base, which is designed for two compressors (6,7), and one of the compressors is used to supply pressure to the stand, and the second one as a backup. Also on the doors of the boxes there are signs (2) with the inscriptions "entry prohibited high pressure".

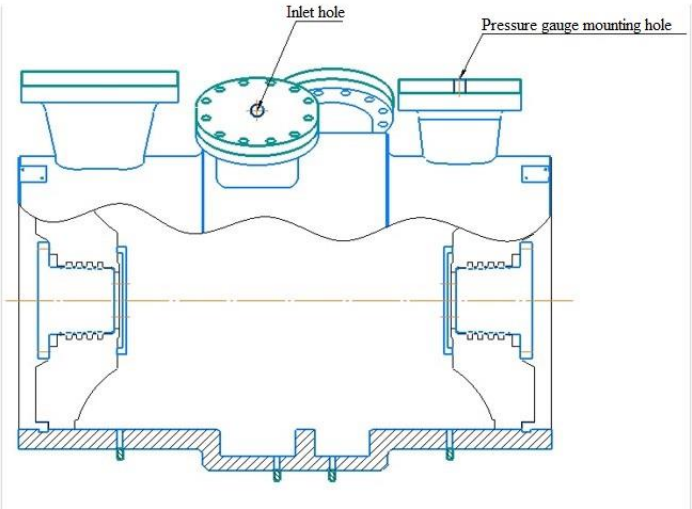

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Figure 4. This figure below shows a schematic drawing of the casing of centrifugal compressor (4GC2-115).

This case from the compressor of the vertical connector respectively on both sides has covers and they are as you can see plugged with special plugs in the form of a mushroom. The four body flanges are fitted with process plugs, fasteners and process gaskets as required by the process. The two upper plugs have one M20x1.5 threaded hole each for gas supply and pressure gauge installation. And a pressure gauge with appropriate pressure measuring limits is installed there as well. The casing also has four small holes at the bottom for condensate drainage and these should also be plugged. Then the case is immersed in bath water and the fitting of the plug is connected from the tested housing to the bench and depending on the test pressure, we supply pressurized air with the help of a compressor. As it has noticed the tightness of the casing is checked by bubble method.

Conclusion

In this article a pneumatic bench for density testing of centrifugal compressor casings with specified parameters is considered and developed:

Working gas for testing – Air;
The highest permissible pressure – 8.825 MPa.
The following was implemented:
1) Based on the identified deficiencies, the design of the pneumatic stand was modernized;
2) Assembly and detail drawings of the pneumatic bench, frame, individual pipework for each line, instrument housings, adjusting handles, as well as drawings of parts such as clamping bracket, fitting and sight glass were developed.
3) A data sheet for the modernized test bench was compiled.
4) The procedure and methodology of initial certification, requirements for testing, requirements for the test bench and test site, preparation of assemblies for hydraulic testing and the procedure for testing were developed.
The casing of the 4GC2-115 centrifugal compressor contains a shell with two inlet and outlet ports welded to it, located on different sides to the longitudinal axis of the casing. The disadvantage of such a housing is the presence of welded joints, which at high flow rates and pressures cannot provide reliability and durability of the structure. The study of strength and density of the casing by the method of hydraulic tests on the developed stand showed that the greatest stresses occur exactly in the places of welding of the cylinder with the inlet and outlet nozzles.

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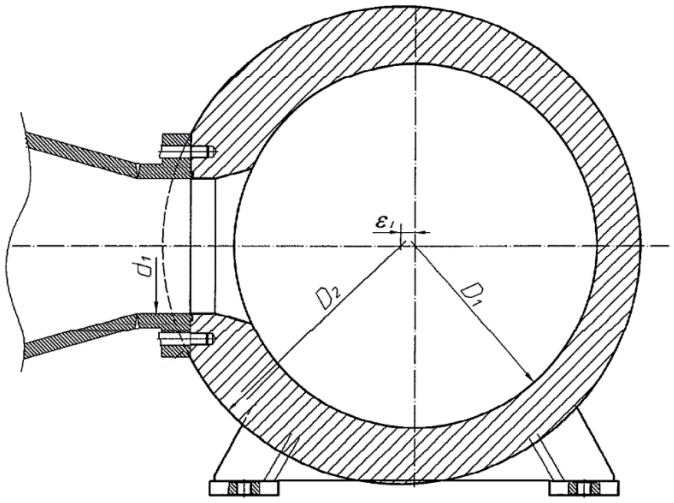

Figure 5. This figure above shows a forged steel casing with openings for compressor inlet and outlet connections.

It is recommended to make the case from steel forgings with holes for inlet and outlet spigots of the compressor, in which the end planes of inlet and outlet spigots will be formed for fixing the mating flanges of inlet and outlet pipelines. The disadvantage of the specified solution is the presence of significant pressure losses, leading to a decrease in the efficiency of the compressor, and high metal intensity.

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