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RESEARCH ON AUTOMATED PRESSURE CALIBRATOR

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Annotation. This article presents the structure, principle of operation and study of a stand designed for the comparison and calibration of manometers. The accuracy of pressure measuring instruments is of great importance in industrial enterprises and laboratories. Therefore, it is considered appropriate to ensure the accuracy, stability and reliability of measuring instruments using a calibration stand.
Key words: manometer, calibration, comparison, pressure, standard, metrology, standard manometer, pressure adjustment, automatic pressure calibrator.

Introduction. Today, high-precision pressure measurement is of great importance in industrial production enterprises. Incorrect pressure measurement results can lead to disruption of technological processes, increased energy consumption, premature failure of equipment, and most importantly, a decrease in the level of safety in production. Therefore, manometers, as the most widely used instruments for measuring pressure, require constant monitoring of their accuracy, calibration, and comparison in a timely manner [1-2].

A manometer is a device for measuring gas or liquid pressure. The most common manometers used in all fields of technology are spring (Bourdon tube) manometers, membrane manometers, bellows manometers, differential manometers, electrical contact and digital manometers [3].

Pressure measuring instruments, manometers, are widely used in energy, chemistry, metallurgy, food and many other industries. Their measurement results are one of the main criteria for ensuring the safety and efficiency of technological processes. Therefore, the processes of periodic comparison and calibration of manometers are an important part of metrological control [4].

Calibration is the process of comparing the readings of a measuring instrument with reference (standard) values and determining the limits of error. As a result, the measured values of the instrument are determined.

Verification is a process carried out by the state metrology service to confirm the compliance of a measuring instrument with state standards.

The calibration stand allows for accurate comparison of the readings of the pressure gauge being tested using pressure standards (spring manometer, digital standard manometer). The calibration stand consists of a pressure source, a standard measuring instrument, connection blocks for the pressure gauges being compared, a pressure adjustment system, adjustment valves, a control panel, and a computer interface [5].

Fig. 1. ELEMER-AKD-12 Automatic Pressure Calibrators

1 – Touch screen; 2 – AKD-12 power button; 3 – USB port for connecting a flash drive or external devices; 4 – Four ports for connecting the current output of the pressure sensors being tested; 5 – Power button for connecting 24 V pressure sensors.

Pressure is undoubtedly one of the key parameters that must be monitored in technological processes across virtually all industries. This applies to enterprises in the fuel and energy sector, oil production and processing, mechanical engineering, metallurgy, food and medical industries, and other sectors of the national economy. The pressure sensor calibration system is designed to automate the calibration and verification of precision absolute pressure and differential pressure sensors under normal and climatic conditions. The ELEMER-AKD-12K automatic pressure calibrators are designed for precise reproduction and measurement of pressure, measurement of standardized DC current and voltage signals, relay status testing, and configuration of pressure transducers using the HART digital protocol.
The ELEMER-AKD series of calibrators are analogs of foreign-made pressure controllers, capable of quickly and accurately reproducing excess and absolute pressure, as well as negative pressure. AKD-12K-I [6] are equipped with a multifunctional measuring module and are used for automated verification and calibration of pressure transducers and electric contact pressure gauges. Functional features: color touch screen with an intuitive menu, a high-speed system of valves and equalizing tanks, 1 or 2 built-in reference modules, a barometric sensor, a built-in calibration and measuring module, support for the digital HART protocol, the function of automated sensor verification, current loop adjustment and sensor calibration, a relay testing function, galvanically isolated sensor power supply, full-featured internal software.
The basic reduced error of pressure measurement is 0.01% or 0.02% of the measurement sub-range, 4 universal measuring channels, 8 discrete inputs. External software for instrument control, data processing, printing and storing verification protocols.

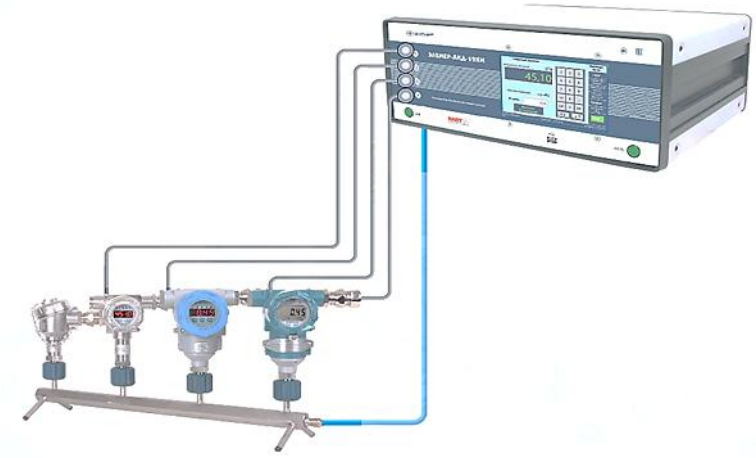

Fig. 2. Sensor connection diagram

The AKD-12 control program is designed to measure and set pressure, graphically display the progress of the regulation process, measure analog and discrete output signals of verified pressure sensors, configure and change the characteristics of pressure sensors using the HART protocol; calibrate the current output using the HART protocol, calibrate the sensor for two pressure values using the HART protocol, set verification parameters, perform verification with the formation of a verification results file and the calculation of the expanded verification uncertainty, perform automatic verification of pressure sensors with the HART protocol with the formation of a verification results file, with automatic reading of ranges, configuration and the

possibility of preliminary calibration, test the operation of the relay, and perform special adjustment procedures for the AKD-12.

Pressure monitoring is a critical parameter for ensuring the safety and efficiency of technological processes across all industries. Therefore, high-precision calibration and verification of pressure sensors is particularly important in modern manufacturing practices. The ELEMER-AKD-12K automatic pressure calibrators match their international counterparts in terms of metrological and functional characteristics, reproducing absolute, gauge, differential pressure, and vacuum. The device features extensive functionality, a user-friendly interface, and support for the HART digital protocol. This enables automated calibration and verification of pressure measuring instruments, significantly improving the quality, reliability, and safety of technological processes in various industries.

Stands designed for calibrating pressure gauges must meet the following requirements:

1. Pressure measurement range - must be appropriate for the type of pressure gauge being tested;
2. Availability of reference instruments - must be a high-precision load piston pressure gauge or a digital reference pressure gauge;
3. A compressor, hydraulic pump or gas cylinder should be used as a source of stable pressure;
4. Pressure must be adjusted with high accuracy using regulators and valves.
5. For safety reasons, equip with overpressure protection valves and quick-acting actuators.
6. Provide the ability to calibrate several pressure gauges simultaneously.

Results. In the process of comparing manometers, a pressure of a certain value is generated using a pressure generating source. This pressure is simultaneously transmitted to the standard manometer and the manometer under test, and these indicators are compared with each other and deviations are recorded. Metrological indicators such as accuracy class and measurement error are determined. The design of the stand under study is designed to operate in the pneumatic (0–1 MPa) and hydraulic (0–60 MPa) ranges.

The newly developed stand allows for the simultaneous calibration of 3–4 manometers, using a digital manometer with an accuracy class of 0.05% as a standard. The pressure adjustment is adjusted with an accuracy of ±0.01 MPa using adjusting valves, and to automate the calibration process, it is necessary to connect to a computer via a digital interface (USB/RS-485).

According to the results of the study, when comparing the indicators in the range of 0–16 MPa, the average relative error was in the range of 0.12–0.25%, and a linear increase in the error was observed with increasing pressure. The repeatability indicator did not exceed 0.08%, which fully complies with the requirements of the current UzDSt 8.586:2010. The results showed that it is possible to compare manometers with high accuracy using the stand.

Conclusion. The development of a manometer calibration and comparison stand ensures high-precision pressure measurement in industry, increases production efficiency and strengthens safety. In the future, the possibility of automating such stands based on digital technologies and analyzing measurement results using artificial intelligence is one of the current research directions. The development of a manometer calibration and comparison stand increases the reliability of pressure measuring instruments, creates the basis for safe process control, and allows for the automation of metrological control. In addition, in the future, by adding a digital data acquisition module to this stand, the calibration process will be fully automated.

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