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AUTOMATED REGISTRATION OF SMALL-SCALE NATURAL GAS CONSUMPTION USING A NEW SOFTWARE PRODUCT

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Statement of the problem. A new developed software product for measuring small-scale consumption of natural gas is described.

Results and conclusions. The major parameters of the developed software for measuring small-scale consumption of natural gas are considered. The software would allow the processing and visualization of incoming data in order to determine the linear velocity of gas particles in the swirl nuclear as well as to evaluate the effect of the weighed phase on changes in the static and dynamic pressure.

The obtained results of the research and software can be applied in energy supply and energy-saving systems in gas industry and communal household services. Unlike similar mainstream devices, visualization of changes in the gas pressure in the device would allow one to get extra information on small-scale consumption of the measured gas environment and an increase in the sensitivity of the device.

Keywords: natural gas consumption, automated registration systems, registration software, energy consumption, energy saving, communal household services.

Introduction. This article looks at a new automated system of small-scale gas consumption. An application range of automated systems of commercial gas consumption is for all natural gas users. Automated systems have a centralized structure including a lower level, i.e. controlling stations, and an upper level, i.e. a central dispatcher service with a network of automatic switchboards [10].

Automated management systems encompass gas-distribution stations, gas-controlling centres in high- and medium-pressure networks, gas-regulating stations supplying circular and lateral pipelines (with the consumption of over 1000 m^3/h) and gas-regulating stations of residential areas. Automatic management systems include information functional subsystems for high-speed control of technological gas distribution.

Generally, a gas flowing in pipelines is non-stationary, which is largely due to non-stationary gas consumption.

Hydraulic processes in low-pressure pipelines should be used to describe flow distribution in an approximated quasi-stationary statement of a task. This is due to disappearing small time derivatives of a volumetric consumption [7]. Moreover, a gas distribution mode, as it is quasi-stationary, depends on the time of a system functioning based on hours of the day, week, month, etc. ordering the inclusion of various loads. Time is a parameter in this case.

1. Description of the software for small-scale natural gas consumption. For high-speed control, analysis of technological measurement of gas consumption, formation and transmission of a signal, there should be periodic measurements and control of the functioning parameters of no more than 5 sec [10].

The function of the software is to develop processing and visualization of incoming data to identify the linear speed of gas particles in a swirl nuclear as well as to evaluate the influence of the weighed phase on changes in the static and dynamic pressure.

Mathematical description of an aerodynamic swirl flow and comparison of the fields of axial and rotational velocities prove that kinematic similarity of the internal swirl flows can be determined with two major dimensionless parameters, i.e. the integral Φ^* and local $tg\phi_\omega$. It is known that these parameters are homogeneously connected. This allows this connection to be used to summarize the experimental data. The parameter Φ^* is most commonly used as a working characteristics of completely or partially swirl flows and the parameter $tg\phi_\omega$ for swirl flows adjacent to the walls and partially swirl ones along the entire length of the flows (spiral ribbing, wire swirler, etc.).

The parameter $tg\phi_\omega$ equals a limit (superficial) tangential of a swirl angle of a flow and is a ratio of superficial tangential of the friction stresses in the tangential and axial directions. The integral parameter Φ^* characterizes the ratio of the moment of the amount of movement M to an axial amount of movement K in a random normal to a section which random to a normal to an axial velocity and length of a linear-sized duct ℓ:

$$\Phi_* = M\,/\,K\ell, \tag{1}$$

where
$$M = 2\pi\int_0^R \rho\upsilon\omega_\text{в} r^2 dr\,, \qquad K = 2\pi\int_0^R \omega_\text{в}^2 r dr, \tag{2}$$

where R is an internal radius of the duct.

For small-scale gas consumption, swirl flowmeters are employed in order to increase the sensitivity of the meters that are fitted with stream swirl devices in the form of axial-tangential

swirler as nozzles at the input and output of the measuring tube respectively. The gas consumption is measured using a swirl flowmeter.

A rotating flow that is generated by the input swirl flow meter №1 has a central area that does not move forward. This area has an effect on the linearity of the output characteristics of the device, which influences changes in the physical and technical characteristics of the measured environment (e.g., viscosity, pressure, etc.). In order to mitigate this, the second swirl flow meter №2 is used that swirls the input flow in the reverse direction. This allows the effect of the viscosity on the device to be compensated for and natural pumping losses to be reduced. An effective area of the second swirl flow meter is smaller than that of the first one. Therefore as the external and internal rotating swirls are mixed, the total velocity and rotation direction are formed by the internal rotating with a greater power from the nozzle № 1. The internal swirl reflected from the nozzle № 2 hinders the rotation of the external one. It is obvious that the viscosity of the measured environment changes the velocity of the rotation of both swirls. But as a reduction in the rotation velocity of the internal swirl causes a decrease in the resulting rotating flow, its angular velocity remains constant and does not depend on the viscosity. This scheme is employed with swirl flow meters in the form of jet nozzles where gas comes tangentially to the surface of a device in mutually reverse directions from each nozzle respectively.

The software will be of interest to construction and designing institutions that are involved in the development of new measuring tools.

2. Implementation prospects. The developed software would enable the following:

— determination of the linear velocity of particles in gas in the swirl nuclear;

— determination of the pressure of a swirl outside the swirl nuclear;

— circulation of the velocity for the swirl nuclear in polar coordinates;

— determination of the geometric parameter of the axial and tangential swirl flow meter;

— determination of the growth in the intensity of swirling of the flow;

— graphical visualization of the dependence of the distribution of the axial and tangential velocities on the specified radius of the layer;

— determination of the influence of the weighed phase on changes in the static and dynamic pressure by visualizing the total changes in the pressure ΔP.

The software is designed to be employed in communal household services, gas industry, research and everyday practices. Unlike mainstream devices for the same purpose, visualization of changes in the gas pressure in the device allows one to get extra information on small-scale consumption of the gaseous environment and an increase in the sensitivity of the device.

The software will also come with a restriction as it is not designed for identifying large-scale gas consumption.

The software will be operating managed by the operating system with a graphic interface or another compatible operating system. A processor run PC, memory capacity of no less than 64 MB, hard drive capacity of no less than 10 GB. A graphic printer is necessary for printing out the results.

The developed software can be set up and used on mobile diagnostic and research setups.

The software requires no extra software packages as well as special training. One has to be a confident Windows user. Pilot use of the new software will enable them to work with the interface in the period of 5 to 10 minutes.

One of the advantages of the software product is that it can be developed and modified further for the calculation of extra parameters and compatibility with pulse wave record software.

This software is used to obtain original scientific results to enhance the involvement of educational institutions into the implementation of the national technological initiative № 13.11847.2018/11.12 "Developing Models for High-Speed Management of Urban Gas Supply Systems Using the Principle of Perturbation Record".

Conclusions

1. The article looks at the major parameters of the developed software for measuring small-scale natural gas consumption. The software will enable the development and visualization of incoming data in order to identify the linear velocity of gas particles in the swirl nuclear as well as to evaluate the effect of the weighed phase on changes of the static and dynamic pressure.

2. The feature of the developed product is that it requires no special training and software packages. Pilot testing of the new software would enable independent operation of the interface within 5 to 10 minutes. Moreover, if necessary, the software can be further developed and modified for calculating extra parameters and compatibility with pulse wave record software.

3. The obtained results of the research and the software can be applied in energy supply and energy saving systems in gas industry and communal household services. Unlike similar mainstream products, visualization of changes in the pressure of gas movement in the device would allow one to get extra information on small-scale consumption of the gas environment and an increase in the sensitivity of the device.

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