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DEVELIPING THE VUSUALIZATION PROGRAM OF MEASURING SMALL NATURAL GAS CONSUMPTION: CONTROL OF ENERGY RESOURCES: CER2 — MAIN PIPE

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Statement of the problem. The algorithm of the program "Control of Energy Resources: CER 1-gas" designed to quickly calculate the maximum permissible error of measurement by the gas meter in relative units (%) and in absolute value (m^3/h) at the current set gas flow rate for various types of meters needs to be improved.

Results. The major issues of programming physical processes for measuring low gas flow rates are discussed. A description of the program for measuring low gas flow rates is shown. A computer software and an operation algorithm "Energy Resources Control: CER2-main" have been developed that automate the calculation of the maximum permissible measurement error by the gas meter in relative units (%) and in absolute value (m^3/h) at the current specified gas flow rate, diameter, pressure for various types of counters taking into account the linear velocity of particles in the gas flow.

Conclusions. For the first time, the EMV software "Energy Resources Control: CER 2-main" has been designed aimed at quickly calculating the maximum permissible measurement error of the gas meter in relative units (%) and in absolute value (m^3/h) for the current specified gas flow rate, pipeline diameter, pressure for different types of meters, which makes it easier to check their performance during periodic verification. The results obtained meet the objectives set in the "Energy Strategy of Russia for the Period up to 2030" (No. 1715-r dated October 13, 2009) and are intended for use in the modernization of gas consumption systems and accounting for low energy costs. The studies assume the adaptation of the basic methods for assessing the reliability, risks and safety of systems in the theory of gas supply and regulation of gas consumption metering employed by regional enterprises of the gas industry.

Keywords: energy saving, energy resources, natural gas, meter.

Introduction. Heat and power calculations involve a lot of interconnected elements, in each of which complex physical processes occur. The patterns describing these processes are complex and diverse and challenging to describe mathematically. The theoretical aspects of gas

consumption metering are subject to various distribution laws, particularly when establishing the relationships between the processes occurring in gas distribution systems, among which there are unknown, and in some cases uncontrolled. The elementary components of gas distribution engineering systems in terms of their quality and functional characteristics should have a high level of reliability throughout the entire life cycle.

The reliability of energy systems including the gas supply system is a complex indicator and is determined by a set of particular parameters. The major one in relation to natural gas distribution systems is accounting for energy consumption. Difficulties multiply with a comprehensive study of the entire system. The investigation of such objects can be carried out by experimental methods as well as methods of physical and mathematical modeling.

Experimental research methods are of great importance as a basis for constructing a process and are a criterion for assessing the accuracy of knowledge about an object. However, these methods may not always serve as an effective working method for obtaining information about the properties of measuring devices. Setting up an experiment and processing experimental data is becoming more complex and costly. Experimental data cannot be used to assess the properties of the designed equipment, especially new types, since in this case a significant generalization and extrapolation of results of a specific nature is required. The method of physical (full-scale) modeling retains the features of the experiment on an actual object, but in principle requires a preliminary mathematical study to determine the conditions and the ratio of similarity. Methods of mathematical modeling using computer technology are now widely employed for a detailed study of installations for measuring gas flow rates as complex and large systems.

The objective of our work is to improve the algorithm of the program “Control of Energy Resources: CER 1-gas” designed to quickly calculate the maximum permissible measurement error of the gas meter in relative units (%) and in absolute value (m^3/h) at the current specified gas flow rate for various types of counters. Unlike the manufactured devices operating on the basis of software products that address a similar problem, this device will show the value of the permissible relative error at a given gas flow rate and its limiting absolute value and will provide additional information about the low flow rates of the measured gas medium and device sensitivity.

1. Modeling of physical processes. Physical processes taking place in thermal power plants are generally described by complex systems of nonlinear partial differential equations (equations of energy, continuity, motion, flow rate, etc.), as well as nonlinear algebraic equations. Modern mathematical apparatus does not always enable one to solve such systems analytically. The use of numerical methods makes it possible to obtain an approximate solution

with a level of accuracy sufficient for engineering practice. To obtain such a solution, it is necessary to first conduct a fairly significant amount of research on the development of sufficiently complete mathematical models suitable for implementation on computers. This work usually involves:

— elimination of a number of factors that do not have a significant impact, introduction of reasonable assumptions and simplifications;

— common use of integrative methods for solving large systems of equations that allow for convenient calculation schemes, especially in the presence of a large number of zero coefficients;

— splitting systems of large dimension into subsystems of lower dimension;

— approximation or compression of large tables of heat carrier properties, performance characteristics of units;

— development of matrices of functional relationships of the parameters of the installation (logical information) [2, 3, 6].

2. Development of programs for heat and power calculations. Solving problems on a computer requires preliminary work on designing a calculation program. To do this, it is necessary to accurately describe the algorithm of work with an indication of what actions, in what order and on what numbers they should be performed.

While developing programs for thermal power plants, there are two approaches. The first is preparing programs of a universal nature, i.e. suitable for almost any type of power plant. In this case, the compilation of a mathematical model of the installation is carried out automatically using a large amount of logical information. The second one is designing programs for a specific type of power plant with a simple predetermined scheme. In this case, less logical information is required as the program is simpler in structure. With the second approach, designing a program in an algorithmic language is highly efficient and does not yield great difficulties.

Use of methods of mathematical modeling with that of a computer refers mainly to verification calculations for given variations in schemes and layouts of heat and power plants. The purpose of these studies is to determine the parameters of installations (pressures, temperatures), flow rates of heat carriers, design parameters, indicators of thermal and general efficiency when various external factors and conditions change. At the same time, the main focus is on presentation of the specifics of mathematical modeling of thermal power plants on a computer.

Presently, automated control systems (ACS) are of great importance for almost all industries including the gas industry. The ACS contains information functional subsystems that perform operational control of the technological process of distribution and accounting for low gas

consumption [2, 4]. The development of new and improvement of existing software products for performing the functions of operational control, analysis of the process of measuring low gas consumption is one of the most important tasks for energy conservation and Russia's economic development [10].

The software "Control of Energy Resources: CER 1-gas" was designed to quickly calculate the maximum permissible error of measurement by the gas meter in relative units (%) and in absolute value (m^3/h) at the current set gas flow rate for various types of meters but did not take into account diameters of pipelines and pressure in the system as well as shapes of flow bodies around the sensitive element of the meter [14].

3. Purpose of the program. A new software "Control of Energy Resources: CER 2-gas" is designed to quickly calculate the maximum permissible error of measurement by the gas meter in relative units (%) and in absolute value (m^3/h) for the current set gas flow rate, pipeline diameter, pressure for various types counters [15]. This makes it easier to check the functionality of the meters during periodic verification.

Unlike the software "Control of Energy Resources: CER 1-gas" designed to quickly calculate the maximum permissible error of measurement by the gas meter in relative units (%) and in absolute value (m^3/h) at the current set gas flow rate for various types of meters, in the new software "Control of Energy Resources: KER 2-main", in addition to consumption, the pipeline diameters and pressure are taken considered.

As an example of data, gas meters manufactured by ELSTER Gazelectronika LLC were selected: BK-G 1.6 ... 100 – 10 standard sizes with a nominal capacity of 0.016 to 160 m^3/h (diaphragm-type meter).

By analogy, data on other types of meters, diameters, pressures are added to the program.

The technical requirements for software and hardware for the software are as follows: MS Windows 98 and higher; Intel Pentium IV or higher; HDD 1 MB.

The procedure for working with the program looks like this:

1. Select the type of counter.
2. Select the meter model.
3. Set the required gas flow rate and press "Calculate".

The graph will display the value of the permissible relative error at a given gas flow rate, pressure, diameter and its absolute limit value (in this case, 0.39 % and 0.02 m^3/h, respectively). If an actual gas flow rate does not exceed these values, the gas meter at the specified flow rate works properly. It is required to check on other values of the costs.

The scheme of the software "Control of Energy Resources: CER 2-main" is shown in Fig.

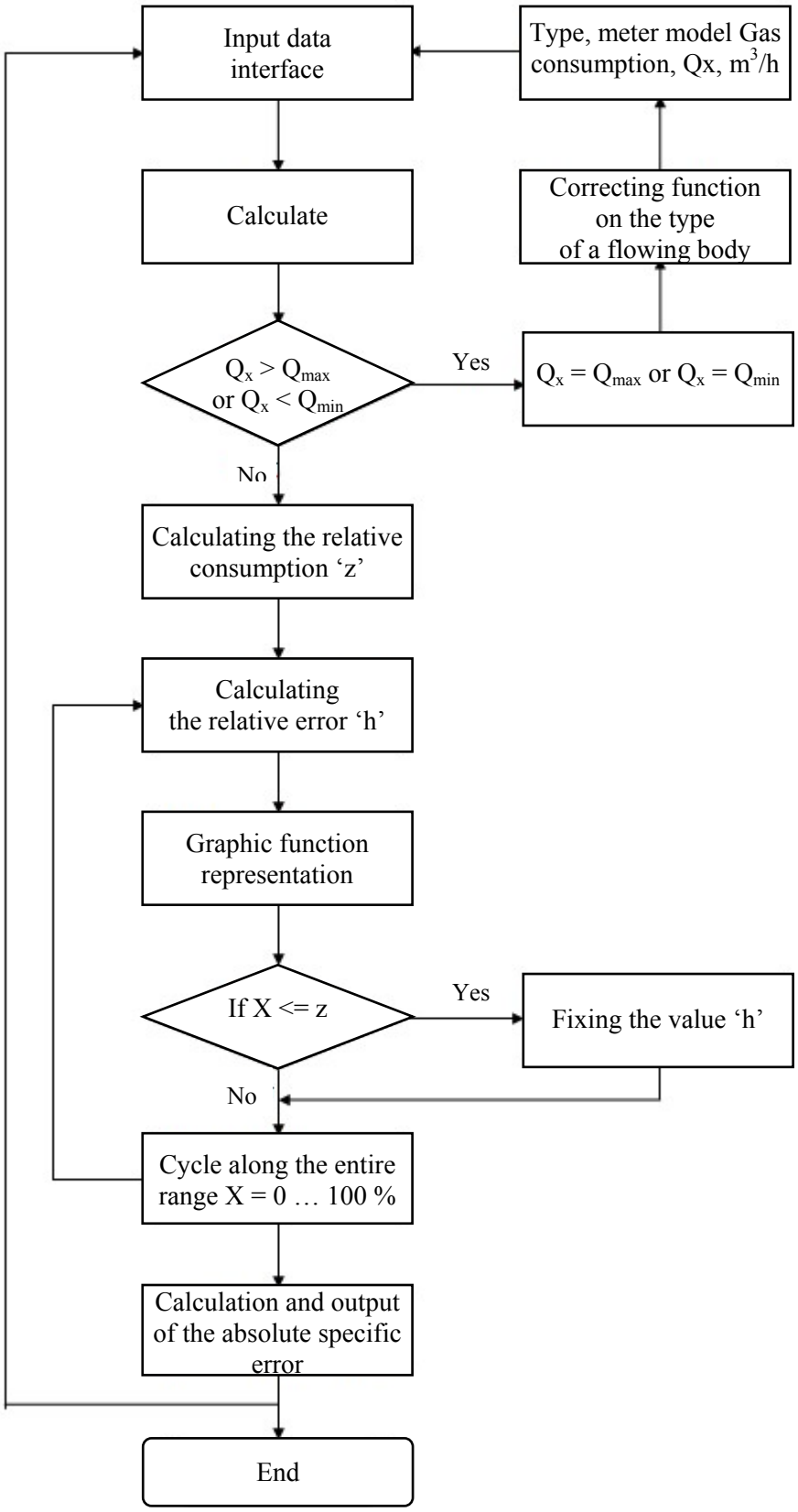

Fig. Software "Control of Energy Resources: CER 2 – main"

The research results are the second stage of the work to substantiate the adopted hypothesis on the need to improve the accuracy of gas consumption metering in gas consumption networks, to prevent its uncontrolled leaks, to automate the flow control process and organize control actions in the event of hazardous situations associated with the involuntary accumulation of free gas suspensions in apartment and in-house premises.

The solution of the tasks was performed considering the accepted conditions of the constructive, technological, production and organizational plan.

As a result the following has been achieved:

— initial data have been collected and digitized by entering into the database a visualization model of low gas flow rates in gas-consuming systems in the format of special auxiliary software for process automation;

— based on the collected initial data, a simulation model of a vortex flow meter has been developed to account for low gas flow rates;

— a mathematical model has been designed for the operational control of the functioning of the gas supply system for in-house and in-house gas consumption based on the complex accounting of the parameter of the relative error of devices and equipment of the utility network;

— the software “Control of Energy Resources: CER 2-gas" (certificate of state registration No. 2019667428) has been developed which automates the calculation of the maximum permissible error of measurement by the gas meter in relative units (%) and in absolute value (m^3/h) at the current specified gas flow rate, pipeline diameter, pressure for different types of meters;

— statistical data on the study of the functioning of gas distribution systems have been presented.

The results obtained are intended for use in accounting for low energy consumption.

The study involves the adaptation of the basic methods for assessing the reliability, risks and safety of systems in the theory of gas supply and regulation of gas flow metering.

Conclusions. A computer software and an operation algorithm “Energy Resources Control: CER 2-main” have been developed which automate the calculation of the maximum permissible measurement error by the gas meter in relative units (%) and in absolute value (m^3/h) according to the current specified gas flow rate for various types of meters, diameters, pressures.

The results obtained are intended for use in the modernization of gas consumption systems to account for low energy consumption.

The study involves the adaptation of the algorithm and software with the preparation of recommendations for use in structural and design organizations engaged in developing new measuring equipment or assessing energy consumption in the framework of energy audits.

The work has been performed within the framework of the project to obtain primary scientific results that ensure the expansion of the participation of subordinate educational organizations in the implementation of the National Technological Initiative No. 13.11847.2018 / 11.12 “Development of a Model for operational management of urban gas supply systems based on the principle of disturbance regulation" with the support of the NRU" Moscow State construction university”.

In follow-up studies, it is planned to bring the design model of the vortex flow meter to a prototype with variable models of built-in jet-swirling nozzles with a series of experiments; to design of a strain gauge sensitive element of a flow meter with an adaptively built-in software module for metering gas consumption as a dense medium with inclusions of various biotechnical impurities; to adapt the algorithm and software with the development of recommendations for use in structural and design organizations involved in developing new measuring equipment or assessing energy consumption as part of energy audits.

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