https://doi.org/10.30857/2786-5371.2023.2.1

УДК 681.121.8: 681.122

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THE SELECTION OF TRANSMITTERS USING FUZZY LOGIC METHOD

Problems. *The main issue for solving the problem of the gas flow measurement system and its commercial accounting is to provide the metrological features required during flow measurement, as well as to create conditions for obtaining prompt, complete and reliable data.*

Methodology. *The use of mathematical models of the devices allows to correct the indicators and dynamic characteristics of the devices, taking into account the changes in the environmental parameters. In addition to hard processing and control algorithms, one of the ways to increase the efficiency of the system is to use fuzzy processing algorithms that allow considering all possible options.*

Findings. *The main aspects of choosing the optimal flowmeter for the data-measuring system for accounting and distribution of natural gas are considered using methods of solving multi-criteria problems under conditions of uncertainty. Effective methods of selecting a measuring device depending on technical and economic indicators of the flow meter are analyzed, taking into account the problems of determining priorities in terms of fuzziness, subjectivity of information provided by experts on flow meters of different manufacturers, warranty and service conditions. Provided by the manufacturer, problem-solving opportunities were studied, the appropriateness of using fuzzy selection methods, fuzzy algorithms, along with deterministic methods, when choosing devices that ensure the optimal output characteristics of data measurement systems, completeness and integrity of data, their output signals for processing is displayed.*

Originality. *Effective methods of selecting a measuring device depending on technical and economic indicators of the flow meter are analyzed, taking into account the problems of determining priorities in terms of fuzziness, subjectivity of information provided by experts on flow meters of different manufacturers, warranty and service conditions.*

Practical value. *The application of one of the methods of solving multi-criteria problems, i.e. FTOPSIS, to choose the optimal gas consumption measuring device in terms of satisfying the construction and operational characteristics presented in the development of the information measurement system, ultimately, the application of one of the methods of solving one of the alternative solutions to increase the effectiveness of the decision-making system, which opens up new opportunities in the process of choosing one of the alternative solutions can lead to simplifying (automating) the procedure of prioritizing decisions.*

Keywords: *gas consumption; transmitter; information-measurement system; fuzzy logic; selection criteria.*

Introduction. Accurate metering and distribution of natural gas during production and transportation is critical to optimizing these processes.

Therefore, considering that natural gas is used as the most environmentally friendly fuel and is an indispensable raw material for the production of chemical products such as urea – a fertilizer for plants, it has the highest environmental and thermal indicators. the rate of development of the industry, the amount of gas processing (consumption) of new tools required for measurement.

Currently, flowmeters and counters of various designs and a simple working principle are used to measure and record gas flow (quantity). The information-measurement systems to which those tools and devices are connected can be built on the basis of certain concepts. One of the important problems in the development of these systems is the selection of measuring instruments with optimal indicators and metrological properties in accordance with the manufacturer's specifications and technical tasks drawn up for the design of the system. Obviously, such a choice depends on the working principle, design parameters, metrological indicators (accuracy and error, etc.), data

reception and transmission, working temperature and pressure, type of output signal and functionality. Existing criteria and methods for the application of these devices should be based on data.

Studies show that information about devices and devices placed on websites is presented in an attractive form in most cases. Since this information is promotional in nature, it will not provide accurate results when used to select devices based on relevant criteria. As a result of the analysis, it was determined that the deterministic parameters of the devices have a certain uncertainty. These indicators and parameters include their output signal, fundamental, relative and absolute errors, and the signal processing algorithms used. On the other hand, it turns out that various manufacturers work with relevant industry standards, which in most cases focus on the design of devices to attract customers. For this reason, the use of existing deterministic methods during the selection of parametric devices that meet the specified requirements does not allow to obtain the desired result in most cases.

Therefore, improvement and development of existing selection methods based on modern information technologies is urgent and requires a systematic approach.

Statement of the question. When developing the appropriate information-measurement system, a device with characteristics that meet the requirements of technical conditions is selected and integrated into the system, the required characteristics of the system as a whole are obtained and processed. Also, the results of gas flow measurement and other parameters accompanying the gas transportation process require special attention.

As mentioned, for the application of algorithms based on the theory of fuzzy sets, which is a branch of soft computing, the output characteristics of the sensors and transducers used in the measurement of the relevant parameters, metrological indicators, and the characteristics of the sensitive element should be studied.

The problem of selecting measuring tools based on appropriate criteria for the creation of software that ensures the correct functional characteristics and dependencies of devices operating under the conditions of information uncertainty, as well as the problem of the final conversion of the measured parameter into an electrical signal and then transferring it to the digital input of the system, processing and creating the data received in the process of measurement and transformation covers issues.

To ensure the metrological and technical-economic characteristics of information-measurement systems, the joint use of deterministic and fuzzy data processing algorithms is more appropriate and allows using the advantages of both types of algorithms.

The last 25–30 years are characterized by the development and application of various information-measurement systems using microprocessor-based measuring devices using fuzzy sets and fuzzy logic, soft computing theories that automate decision-making under uncertainty [1]. The use of this approach allows obtaining optimal and more efficient results in most cases.

It is known that the natural gas extracted from the fields contains both mechanical impurities and other aggressive substances, which lead to rapid wear of the devices connected to measure gas flow directly into the well and at the outlet of the complex gas cleaning and drying unit. This fact imposes additional constraints on the selection of a suitable cost measure and further increases the size of the multi-criteria optimal selection problem. Therefore, one of the main issues that must be solved during the development and improvement of the IOS is the selection of the most suitable device for measuring the consumption of natural gas with a given composition and minimizing costs. However, studies show that it is not possible to develop universal gas flowmeters, which, in turn, allow to improve the scheme of the measuring tract and the system as a whole. These details require a differential approach to the selection of a consumer and a suitable converter that fully meets the process requirements and provides the required efficiency and quality indicators of such systems, depending on the gas composition.

As with any technical device consisting of many elements and parts and electronic circuits, the technical and operational characteristics of existing types of flowmeters are different. Therefore, they should be selected according to technical indicators, advantages and disadvantages. This choice is also affected by the unique features of the issue and process. In this case, when choosing, it is necessary to take into account the optimal ratio of price and functionality, which in some cases is important to minimize the costs of creating and maintaining the system.

Flowmeters provide a direct measurement method based on the formation of Coriolis forces when the measured flow passes through a specific device. Incorporating a microprocessor-based transducer with a suitable sensor into the flow meter provides real-time measurement of gas flow, density, temperature, and volume flow calculation. Coriolis counters have no moving parts. This ensures high accuracy and reliability of measurement results, as well as low operating costs. In addition, their installation is simpler than other flow meters, since no special equipment (such as a membrane) is required.

Despite their high sensitivity to excitation, Vortex flowmeters are widely used in industry to monitor the flow of various liquids and gases. Vortex meters use special coefficients to reduce and compensate for effects such as fluctuations in measured flow temperature, changes in pipe diameter, and flow turbulence to improve accuracy of measurement results.

Modern electromagnetic flowmeters are not used to measure gas consumption, although built-in microcontrollers allow to reduce the effect of noise and disturbances, and to expand the diagnosis of faults.

A flowmeter consisting of a differential pressure sensor and a main transducer based on variable pressure methods is the most versatile measurement method. However, this requires the installation of a shrink device.

Thus, there are currently a large number of flow meters, which in turn requires selection criteria for such flow meters.

Problem solving. Studies show that in addition to the analyzed technical and operational indicators, it is necessary to take into account the availability of the appropriate production base and service for choosing the optimal measuring device.

The necessity of choosing any decision, in this case a device characterized by a large number of indicators, requires the identification of contradictions and the search for compromises in the decision-making process. There are various methods for analyzing and solving this kind of multi-criteria problem, for example VIKOR, ELECTRE, TOPSIS [2]. The main difference between these methods is in the evaluation of comparable alternatives.

Since the issue of choosing the most optimal device for measuring gas consumption in terms of its technical and economic indicators is multi-criteria, a number of multi-criteria methods such as TOPSIS and FTOPSIS (Fuzzy Technique for Order Preference by Similarity to Ideal Solution), which allow determining the optimal alternative depending on the evaluation of the distance from the ideal solution, are used, decision-making method MCDM (Multi-Criteria Decision Making) and possibilities of algorithms were investigated. The TOPSIS method, based on the calculation of the distances from the anti-ideal point to the ideal point (solution), determines the impact of uncertainties in expert assessments, and allows determining the decision-making priorities regarding the choice of a measuring device for the gas consumption measurement and accounting system. Several advantages of TOPSİS are: simplicity of the calculation process – it allows easy programming in the form of a table; the presence of a scalar price that pays both the best and the worst alternatives at the same time – facilitates evaluation [4].

FTOPSIS, which is a derivative method, is based on fuzzy sets. Using FTOPSIS with fuzzy logic is considered to be a very effective step to reduce the influence of subjectivity in expert opinions. At the same time, by setting the priorities of this or that solution, it is possible to evaluate the

proximity of the found solution to the ideal solution. As it is known the membership functions of fuzzy sets have different forms, but it is appropriate to use the triangular function because it is the simplest and has the widest application possibilities. At this time, the issue of choosing a device that meets the requirements for most parameters and indicators will consist of several steps.

The first of these is the selection of an appropriate linguistic variable to express the importance of the relevant criterion. In this regard, when choosing a flow meter, an analysis of advantages and disadvantages is carried out after compiling a general table of available flow meters.

The second stage consists of ranking individual types of flowmeters by degrees, applying degrees depending on the criteria. Currently, the following indicators can be applied as obvious advantages:

- sufficiently high accuracy;
- measurement stability;
- does not depend on the flow direction;
- ease of installation and maintenance, lack of requirements for straight parts of the pipeline;
- reliability of measurement results during pipeline vibration, temperature and pressure changes;
- long-term service;
- no periodic calibration required.

In addition to the basic indicators mentioned at this time, we take into account that the presence of self-diagnostics allows timely detection and elimination of faults, and in some cases their prevention, which increases the reliability of the system and the integrity of the measurement results.

After adding a large number of other metrological and technical-economic parameters and indicators to the above list, the final tables are presented to experts. They prioritize based on obvious advantages and other characteristics necessary to determine the technical and economic indicators of the selected device according to the characteristics of the technological process.

In the third and fourth steps, the parameters of the membership functions of the corresponding linguistic variables are determined to construct the fuzzy decision matrix and the normalized fuzzy decision matrix.

The most difficult but effective step in solving this problem is to build a table of alternative solutions needed to select the required measuring instrument. For this, at the fifth stage, procedures for determining fuzzy positive ideal solutions and fuzzy negative ideal solutions come into play.

In the sixth step, the distance from each alternative solution to the positive ideal and negative ideal solutions is calculated. The seventh step is to determine the similarity score for the selected devices. The obtained results ensure that the final choice is determined by prioritizing each alternative solution.

It should be noted that the efficiency of the decision taken in all cases includes both technical and economic aspects of choosing a suitable and adequate cost meter. Therefore, the indicators corresponding to these two aspects should be analyzed in advance and reflected separately for each device in the tabular information presented to specialists for selection. This efficiency is determined by the efficiency achieved during operation together with the flowmeter data-measuring system, it is planned and predictive and should not exceed the values given in the technical assignment. It is clear that in the calculations related to this, the price of the flow meter, the cost of service services, operating costs, due to the fact that it has better characteristics compared to the current flow meter, and the effect due to its low error should also be taken into account.

After choosing a measuring device, it is advisable to carry out a simulation using Simulink or other software products, the results of which will help to evaluate the reliability and integrity of the received solutions in the future.

Conclusion:

Research shows that

- the application of multi-criteria problem solving methods in the selection of measuring devices in response to the given requirements allows not only to achieve the highest possible level of durability and reliability, but also to reduce the costs of using the device as part of the system;
- in addition to all mentioned selection methods, it is advisable to apply a hybrid method using fuzzy calculation to facilitate the operation process by experts;
- thus, the application of one of the methods of solving multi-criteria problems, i.e. FTOPSIS, to choose the optimal gas consumption measuring device in terms of satisfying the construction and operational characteristics presented in the development of the information measurement system, ultimately, the application of one of the methods of solving one of the alternative solutions to increase the effectiveness of the decision-making system, which opens up new opportunities in the process of choosing one of the alternative solutions can lead to simplifying (automating) the procedure of prioritizing decisions.

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ВИБІР ПЕРЕДАВАЧІВ МЕТОДОМ НЕЧІТКОЇ ЛОГІКИ

Мета. *Основним питанням вирішення проблеми системи вимірювання витрати газу та його комерційного обліку є забезпечення метрологічних характеристик, необхідних при вимірюванні витрати, а також створення умов для отримання оперативної, повної та достовірної інформації.*

Методика*. Використання математичних моделей пристроїв дозволяє коригувати показники та динамічні характеристики пристроїв з урахуванням зміни параметрів навколишнього середовища. Окрім жорстких алгоритмів обробки та керування, одним із шляхів підвищення ефективності системи є використання нечітких алгоритмів обробки, які дозволяють розглянути всі можливі варіанти.*

Результати. *Розглянуто основні аспекти вибору оптимального витратоміра для інформаційно-вимірювальної системи обліку та розподілу природного газу за допомогою методів вирішення багатокритеріальних задач в умовах невизначеності. Проаналізовано ефективні методи вибору вимірювального приладу залежно від техніко-економічних показників витратоміра з урахуванням проблем визначення пріоритетів щодо нечіткості, суб'єктивності інформації, що надається експертами щодо витратомірів різних виробників, умов гарантійного та сервісного обслуговування. Досліджено надані виробником можливості вирішення задач, доцільність використання методів нечіткого відбору, нечітких алгоритмів, поряд з детермінованими методами, при виборі пристроїв, що забезпечують оптимальні вихідні характеристики вимірювальних систем даних, повноту та цілісність даних, їх вихід. відображаються сигнали для обробки.*

Наукова новизна. *Проаналізовано ефективні методи вибору вимірювального приладу залежно від техніко-економічних показників витратоміра з урахуванням проблем визначення пріоритетів щодо нечіткості, суб'єктивності інформації, що надається експертами щодо витратомірів різних виробників, умов гарантійного та сервісного обслуговування.*

Практична значимість. *Застосування одного з методів розв'язання багатокритеріальних задач – FTOPSIS – для вибору оптимального вимірювача витрати газу з точки зору задоволення конструктивних та експлуатаційних характеристик, представлених у розробці інформаційно-вимірювальної системи, дозволяє підвищити ефективность системи прийняття рішень і призвести до спрощення (автоматизації) процедури пріоритезації рішень.*

Ключові слова: *витрата газу; передавач; інформаційно-вимірювальна система; нечітка логіка; критерії вибору.*