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# APPLICATION OF FUZZY LOGIC TO CONTROL TECHNOLOGICAL PARAMETERS IN THE METERING UNIT

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**Аннотация**

В статье рассматриваются вопросы создания алгоритма управления технологическими параметрами газопровода - давлением и расходом газа с помощью нечеткого ПИД-регулятора, актуальность решения задачи создания систем автоматического управления с использованием интеллектуальных технологий автоматизации управления и контроль технологических параметров. По заключению авторав, использование алгоритма управления на основе нечеткой логики позволяет лучше адаптироваться к переменному режиму работы газопровода и не требует постоянного подбора коэффициентов ПИД-регулятора.

**Ключевые слова:** нечеткая логика, газопровод, ПИД-регулятор, регулирование, давление, расход.

**Annotation**

The article discusses the issues of creating an algorithm for controlling the technological parameters of a gas pipeline - pressure and gas flow using a fuzzy PID controller, the relevance of solving the problem of creating automatic control systems using intelligent control automation technologies and monitoring technological parameters. According to the author's conclusion, the use of a control algorithm based on fuzzy logic makes it possible to better adapt to the variable operating mode of the gas pipeline and does not require constant selection of the PID controller coefficients.

**Keywords:** fuzzy logic, gas pipeline, PID controller, regulation, pressure, flow.

## Introduction

Global markets are seeing steady growth in demand for natural gas. This trend leads to accelerated development and implementation of energy saving and gas

consumption optimization programs. On the other hand, both in other countries and in Uzbekistan, the demand for gas is characterized by seasonal unevenness. The uninterrupted supply of natural gas to industrial enterprises, social and housing facilities, communal facilities is the main task in the work of gas distribution organizations. In this aspect, the tasks of optimizing gas storage in gas storages, which ensure the most efficient use of underground reservoirs in an underground gas storage (UGS), deserve attention. Ensuring the required pressure in the main gas pipeline depends on a large number of factors, among which the key role is occupied by the trouble-free and stable operation of gas reduction points (hereinafter referred to as GRP). PRG is a technological device for gas distribution and gas consumption networks, designed to reduce gas pressure and maintain it within specified limits, regardless of gas consumption [3].

To achieve the universality of control when the operating mode of the object changes (temperature and pressure of the technological process and the environment, etc.), lower values of the PID controller coefficients are often used compared to the optimal ones. This is due to the fact that under modern operating conditions of control systems, the engineer does not have enough time to perform the optimal adjustment of the controller with each change in the operation mode of the object, and the operator is not qualified to solve with such a setting [1, 2].

Currently, in gas distribution networks, classical PID controllers [4 - 6] are most widely used due to their simplicity of design and reliability in operation. During the operation of such pressure regulators, situations of their unstable operation are possible, accompanied by the following consequences: an increase in pressure at the outlet of the regulator beyond the permissible limits; increased vibration, noise; pressure pulsation at the outlet of the regulator (self-oscillations) and others [1, 7]. Field experience shows that tuning PID controllers is usually very complex and time consuming. Due to the variable operating mode of the gas pipeline, constant adjustment of the PID controller coefficients is required. All this leads to the occurrence of self-oscillations in the system, overshoot and, as a result, pressure deviation from the set value, as well as to the rapid wear of the mechanical moving parts of the regulating body (valve), such as the valve seat, seals, rods, piston, etc. [2].

For extended systems of inter-field gas transport, the non-stationarity of processes can have a significant impact. It is mainly due to the uneven nature of gas consumption, switching at complex gas treatment units, repair work and other switching in the interfield reservoir scheme. The lack of the possibility of accurate

forecasting of gas consumption processes, a large error in technological information leads to a high uncertainty of the situation when making operational decisions. The use of only stationary models in the decision-making process leads to significant errors, degrades the effectiveness of the applied solutions, and only to a small extent covers the range of tasks solved by the dispatching service. Therefore, there is a need to create simulation and optimization models for making decisions on monitoring and managing the non-stationary process of interfield gas transport.

In the case when the fluctuations in time of pressure, flow and temperature are small enough, the non-stationarity of the regime can be represented as a fuzzy state of the process and set by the corresponding membership functions. If the degree of non-stationarity of the process is large, then it becomes necessary to use the formula for the non-stationary mode of gas transport as a model of the linear section.

The need to consider the gas production system as a multi-level, multi-purpose one, as well as the presence of various types of uncertainty in the system, led to the creation of a new algorithm based on the theory of multi-level hierarchical systems and the theory of fuzzy sets.

The process of monitoring the technological parameters of the main gas pipeline gas is carried out by control valves installed at the gas metering unit, which serves to measure the flow and control pressure in the gas pipeline.

When the decision-making process for the control of a technological object is carried out by the operator, it becomes necessary to model this decision and evaluate its accuracy and efficiency. In this case, fuzzy logic is used to study and formalize the heuristic control rules used by the operator to regulate complex technological processes of natural gas production, treatment and transportation.

Modeling can be carried out using fuzzy set theory. Linguistic information can be obtained by studying the reaction of the operator in various situations, and control strategies are expressed as linguistic decision rules in the form:

If "pressure increase is large", then "partially reduce flow", otherwise, if "pressure increase is small", then "slightly reduce flow", etc.

Thus, the basic concepts are the fuzzy concepts of "increase in pressure" and "decrease in flow", and the relationship between them is represented as a compositional inference rule

If "A" THEN "B",

where A and B are fuzzy concepts that are judgments about the output and input of the object, respectively. The membership function corresponds to the fuzzy

conditional operator S, where the fuzzy subset A is defined on the domain of judgments X, and the fuzzy subset B on Y:

$$\mu s(y,x)=\min[\mu A(x), \mu B(y)], x\epsilon X, y\epsilon Y.$$

For a complex system, behavior is described by a set of such fuzzy instructions using the "OR" operations

IF “A1” THEN “B1” OR IF “A2” THEN “B2”

with membership function

$$\mu s(y,x)=\max\{\min[\mu A(x), \mu B(y)]; \min[\mu A(x), \mu B(y)]\}.$$

In this form, taking into account the principle of operation of the installation, as well as the technological regulations, a base of fuzzy logic rules will be developed that will allow regulating the pressure in the gas pipeline.

## Conclusion

Comparison of the results of direct digital control and fuzzy control, carried out in many works on the application of the theory of fuzzy sets, showed that fuzzy control is simpler and more efficient than commonly used classical methods.

Fuzzy algorithms can be used to control the non-stationary process of gas production and transportation, as well as to control the process of natural gas preparation. To control this process, the use of fuzzy algorithms is especially effective, since the absence of sensors for measuring a number of parameters, according to the value of which decisions are made (for example, on the consumption of diethylene glycol), leads to the fact that the input values are estimated using analytical sensors approximately and, in fact, are fuzzy.

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