IJDIAS International Journal of Discoveries and Innovations in Applied Sciences

| e-ISSN: 2792-3983 | www.openaccessjournals.eu | Volume: 2 Issue: 11

Investigation of the Influence of Unstationary Gas Flows on the Accuracy of Flow Measurement by the Variable Pressure Differential Method

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Abstract:

The analysis of the results of studying the influence of non-stationary flows of a controlled medium on the accuracy of flow measurement by the method of variable pressure drop is performed and the tasks of increasing the accuracy of measuring the flow of liquid and gaseous media with a changing hydrodynamic structure of flows are determined.

Keywords: Flow measurement of liquid and gaseous media, variable pressure drop method, measurement accuracy, non-stationary flows.

At present, the tasks of identifying, evaluating and reducing additional components of the uncertainty of the results of measuring the flow of liquid and gaseous media remain relevant and in demand. The existing normative and theoretical literature sources do not give clear recommendations and dependencies that would allow a quantitative assessment of additional components of the undetermined flow rate due to the changing structure of the flow of the measured medium. In particular, there is a need to improve the methodology for estimating the uncertainty of the result of measuring the flow rate of liquid and gaseous media under conditions of a non-stationary flow of the medium being measured.

When applying the method of variable pressure drop to measure the flow rate of a non-stationary flow of a gaseous medium, based on the equation of the moment of the flow of the medium and the continuity of the flow, a differential equation is obtained that relates the instantaneous flow rate and pressure drop across the narrowing device [1]:

$$\Delta p = K_1 \cdot \frac{dq_m}{dt} + K_2 \cdot q_m^2. \qquad (1)$$

where Δp - pressure drop across the narrowing device; q_m - mass flow; K_1, K_2 – coefficients, the values of which depend on the design and gas-dynamic characteristics.

Considering the flow of the medium as quasi-stationary, it is assumed that the inertial term $K_1 \cdot \frac{dq_m}{dt}$ in equation (1) is zero, and the flow rate is related to the pressure drop by the following equation:

$$q_m = \sqrt{\frac{\Delta p}{K_2}}. \qquad (2)$$

Taking into account expression (2) to determine the coefficient K_2, and also, taking into account the effect of the expansion of the gaseous medium, the equation for the mass flow rate of the gaseous medium is obtained:

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$$q_m = \frac{\pi d^2}{4} \cdot C \cdot E \cdot \varepsilon \cdot \sqrt{2\rho \cdot (p_1 - p_2)}\,, \qquad (3)$$

where E is the input velocity coefficient; C - expiration coefficient; ε is the expansion coefficient of the flow; d - is the hole diameter; ρ - is the density of the measured medium under operating conditions; p_1, p_2 - are the pressure of the measured medium before and after the narrowing device, respectively.

Since when obtaining equation (3) the inertial term is not taken into account $K_1 \cdot \frac{dq_m}{dt}$ then the application of this equation to measure the flow rate of a non-stationary flow leads to the appearance of an additional component of the uncertainty of the measured flow rate.

When operating variable pressure flowmeters in unsteady flow conditions, the static pressure of the medium is usually high, and, accordingly, the relative amplitude of pressure pulsations is insignificant. The temperature of the medium being measured is an inertial parameter, so the relative amplitude of temperature fluctuations is also insignificant in most cases. Therefore, to assess the non-stationarity of the medium flow, it is advisable to consider the change in the pressure drop across the narrowing device, the relative value of which can be significant [2].

The following parameters are used to characterize unsteady flows:

- *relative deviation of the pressure drop across the orifice*-characterizes the degree of deviation of the pressure drop across the narrowing device from its average value $\overline{\Delta p}$:

$$\tilde{\Delta}(\Delta p) = \pm\frac{\Delta(\Delta p)}{\overline{\Delta p}} = \pm\frac{\dfrac{\sum_{i=1}^{n}\left|\Delta p_i - \overline{\Delta p}\right|}{n}}{\overline{\Delta p}}\,; \quad \overline{\Delta p} = \frac{\sum_{i=1}^{n}\Delta p_i}{n}\,, \qquad (4)$$

where $\Delta(\Delta p)$ - deviation of the i-th value of the pressure drop on the narrowing device, Δp_i - its average value for the measurement interval; n - is the number of pressure drop values for the measurement interval;

- *relative r.m.s. amplitude of differential pressure fluctuations*is the weighted average relative amplitude characterizing the standard deviation of the pressure drop values Δp on the narrowing device for the measurement time interval:

$$\tilde{\sigma}(\Delta p) = \frac{\sqrt{\dfrac{\sum_{i=1}^{n}(\Delta p_i - \overline{\Delta p})^2}{n}}}{\overline{\Delta p}}\,. \qquad (5)$$

The following flow regimes are distinguished as classification criteria: quasi-stationary, pulsating, variable and non-stationary. The characteristics of each of the flow modes are presented in Fig. 1.

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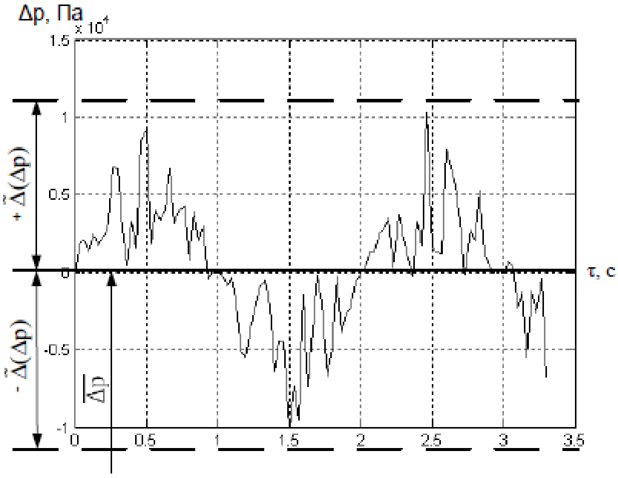
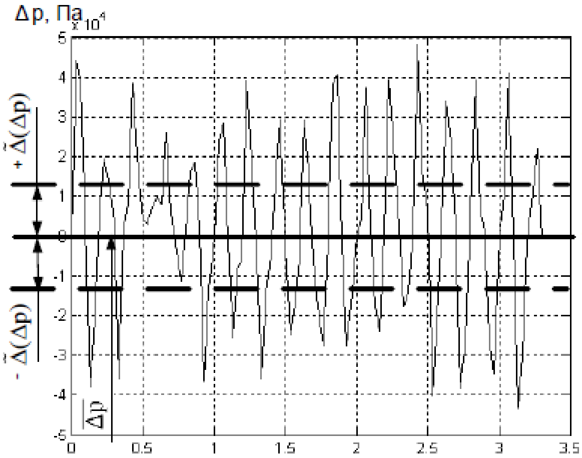
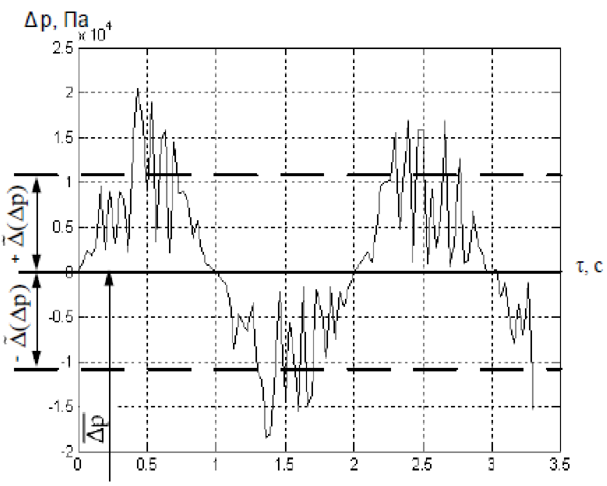


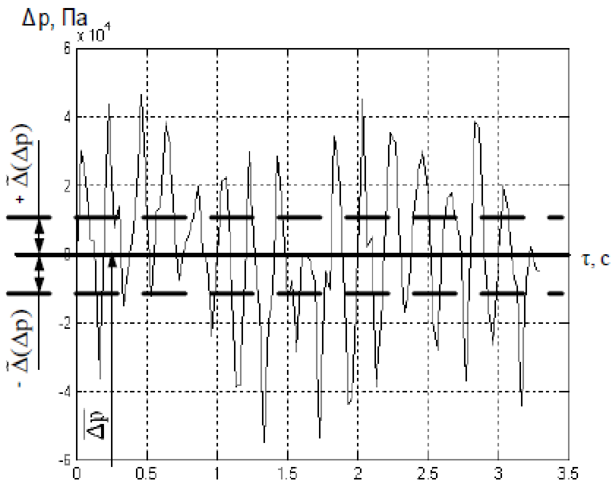
a) $\tilde{\Delta}(\Delta p) \le 0{,}14$; $\tilde{\sigma}(\Delta p) \le 0{,}1$



b) $\tilde{\Delta}(\Delta p) \le 0{,}14$; $0{,}1 < \tilde{\sigma}(\Delta p) \le 0{,}5$



in) $\tilde{\Delta}(\Delta p) > 0{,}14$; $\tilde{\sigma}(\Delta p) \le 0{,}1$



G) $\tilde{\Delta}(\Delta p) > 0{,}14$; $0{,}1 < \tilde{\sigma}(\Delta p) \le 0{,}5$

Fig.1. Flow modes of the gaseous medium flow:

a) quasi-stationary; b) pulsating; c) variable and d) non-stationary.

Based on the results of the analysis of technological modes of gas flow movement, the reasons for the appearance of an unsteady flow were identified, and their classification was introduced, according to which all the reasons are divided into two groups [3]:

- *sources of pulsations arising in the gas flow:* accumulation of condensate in gas pipelines, plugs, tees, plugged sections of the pipeline, inconsistency in geometric characteristics (welds, protrusions, recesses, bends, incompletely closed shutoff valves). These sources form non-stationary flow regimes only when gas flows in the measuring pipeline;
- *sources of pulsations arising from the operation of process equipment:* compressors, valves or incorrectly set pressure regulators, disturbances resulting from switching processes in gas networks. The sources of non-stationary flow regimes of this group are active and are capable of independently introducing disturbances into the gas flow during their operation, regardless of the medium flow regime.

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The reasons for the occurrence of additional uncertainties due to the unsteadiness of the medium flow are classified (Fig. 2):

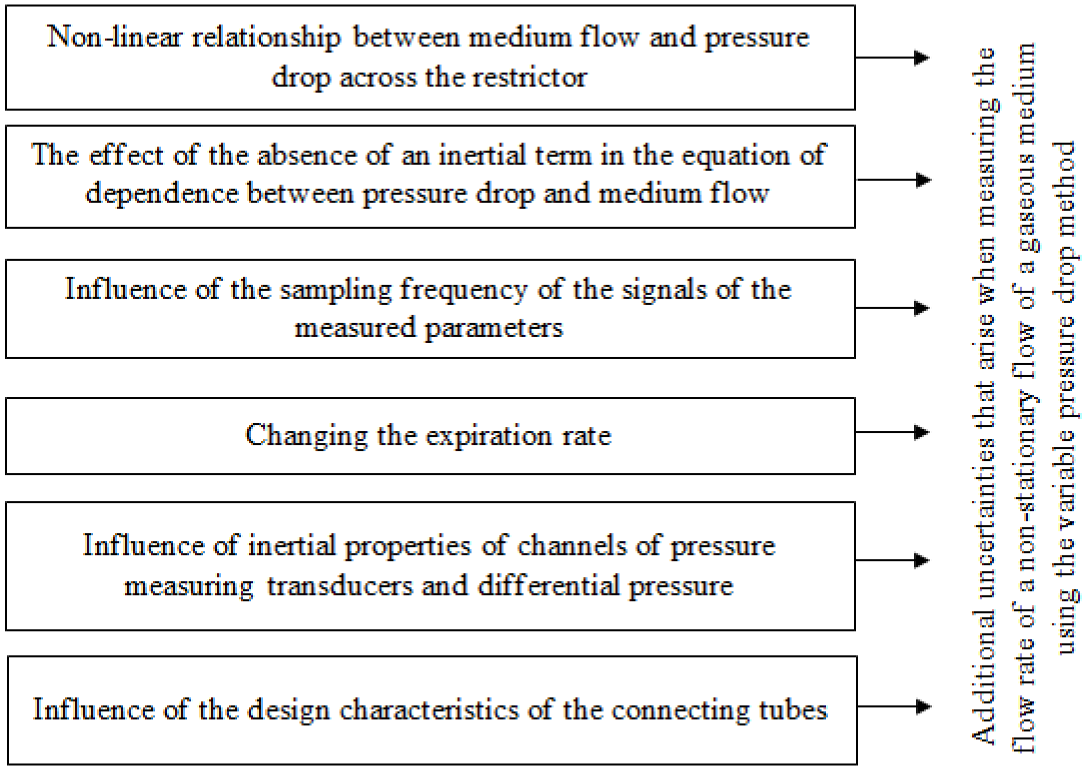

Fig.2. Classification of the reasons for the occurrence of additional uncertainties in the measurement of the flow rate of gaseous media by the method of variable pressure drop under conditions of unsteady flow.

We have performed an analysis of the current state of measuring the flow rate and the amount of liquid and gaseous media with a changing hydrodynamic structure of the flow by the method of variable pressure drop. Under the changing hydrodynamic structure of the flow, a change in the flow velocity profile is considered, which can occur due to the influence of the design parameters of the measuring transducer, as well as changes in the flow velocity profile and the parameters of the measured medium (pressure, pressure drop across the narrowing device) due to the presence of an unsteady medium flow [4].

Based on the results of the analysis, it was found that the influence of the variable hydrodynamic structure of flows on the accuracy of flow measurement can be significant and leads to additional uncertainties that can reach tens of percent, and, therefore, the study of such uncertainties is an important task, the implementation of which will allow estimating the accuracy of the measured flow rate controlled environment.

References

1. Kremlevsky P. P. Flowmeters and counters of the amount of substance: a reference book / P. P. Kremlevsky; [ch. ed. E. A. Shornikov]. – Ed. 5th. - St. Petersburg: Polytechnic, 2004. - 412 p. – ISBN 5-7325-0709-4.
2. Drobysheva N.A., Nikiforov A.N. Measurement of non-stationary costs with the help of narrowing devices // Metrolog. provide meas. M.: VNIIKI, 1984. Issue. 3. 32 p.

3. Yu.V. Ponomarev, Yu.V. Nazarenko, V.P. Borisenko. Uncertainty in measuring the main parameters of a non-stationary gas flow in the measuring pipeline of a gas measuring station // Information Processing Systems, 2009, issue 5 (79). 75-77 p.

4. N.R. Yusupbekov, Sh.M. Gulyamov, E.E. Ortiqov. Some problems of automatic control and management in conditions of uncertainty // Central Asian Research Journal For Interdisciplinary Studies (CARJIS) ISSN: 2181-2454 Volume 2 | Issue 10 |October, 2022| DOI: 10.24412/2181-2454-2022-10-65-70