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OPTIMIZATION TASK OF FLOWMETER DESIGNING IN VIEW OF ROUGHNESS OF PIPELINE INTERNAL SURFACE

The cost of natural gas is constantly increasing and trend is such that it will continue to grow. Since measurement of natural gas is carried out by the differential pressure method it is necessary to increase the accuracy of measurement of flow and quantity of this energy carrier. There is an actual task today. Improvement of accuracy can be achieved through:

- application of new mathematical models for calculating the coefficients of the equation of natural gas flow, which have the lowest value of uncertainty that is prescribed to these functional dependencies;
- application of measuring instruments with reduced consolidated value of intrinsic error;
- application of differential pressure flowmeters which provide minimal uncertainty of the outcome of measurement of natural gas flow.

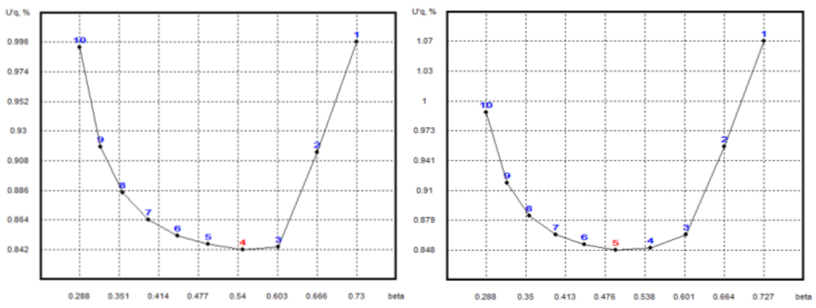
Differential pressure method is used for a long time. Therefore, this method has a highly developed methodological and metrological basis and appropriate software. Measurement of flow for this method is carried out using differential pressure flowmeters which use highly accurate measuring devices (differential pressure, pressure and temperature), which consolidated intrinsic error may reach 0.075%. Proceeding from the aforesaid, differential pressure flowmeters, which provide minimal uncertainty of the outcome of measurement of natural gas flow, should be used.

In the design of such differential pressure flowmeters the theory of optimization should be applied. For such optimization task objective function is the uncertainty of the outcome of measurement of natural gas flow, which is subjected to quantitative assessment. In addition, we possess the following resources of optimization, which we can change (diameter ratio of the orifice plate and differential pressure on the orifice plate), to solve this problem.

Formulation of the optimization task is to identify minimum of uncertainty of the outcome of measurement of natural gas flow as a function of diameter ratio of the orifice plate.

This optimization task has long been studied by scientists however in previous researches calculations have ignored the impact of roughness of the internal surface of a measuring pipeline on uncertainty of the outcome of measurement of natural gas flow.

The performed studies have shown that parameters which define roughness of the internal surface of a measuring pipeline affect the minimum value of relative expanded uncertainty as a function of diameter ratio of the orifice plate as shown in Fig. 1. Herewith diameter ratio of the orifice plate β has a unique dependence on the measuring range upper limit of differential pressure Δp_B on the orifice plate at one and the same input data.



a) b)

Fig.1. Relative expanded uncertainty of the outcome of measurement of natural gas flow as a function of diameter ratio of the orifice plate in the equivalent roughness: a) 0,1 mm; b) 0,4 mm.

As can be seen from the graphs, minimal relative expanded uncertainty of the outcome of measurement of natural gas flow at the equivalent roughness 0.1 mm (Fig.1,a) was determined for the orifice plate with diameter ratio β_a=0,54837 (calculated at Δp_{Ba}=2,5 kPa), and at equivalent roughness 0.4 mm (Fig.1,b) - for β_b=0,4923 (at Δp_{Bb}=4 kPa). It shows that the equivalent roughness affects the definition of parameters of differential pressure flowmeters which provide minimal uncertainty of the outcome of measurement of natural gas flow.

We have developed equation for calculation parameters of differential pressure flowmeters which provide minimal uncertainty of the outcome of measurement of natural gas flow, namely: the measuring range upper limit of differential pressure on the orifice plate; the diameter ratio of the orifice plate, from which is determined the diameter of the orifice plate at a temperature of medium 20 °C.