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RASKHOD-R CAD SYSTEM FOR COMPUTER AIDED CALCULATION AND DESIGN OF FLOWMETERS FOR FLUID ENERGY CARRIERS

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Abstract: *This paper deals with "Raskhod-RU" CAD interactive system for calculation and design of flowmeters based on pressure differential devices according to the requirements of new standards (ISO 5167.1,2,3,4-2003 and GOST 8.586.1,2,3,4,5-2005). The main features, capabilities and prospects for this computer program are described. It is shown that application of "Raskhod-RU" CAD provides improvement of accuracy of energy carrier metering.*
Key words: *Measurement, energy carrier, flowmeter, CAD*

1. INTRODUCTION

Economical consumption and saving of energy can be provided only if metering of energy carriers is carried out with high accuracy and on every step and branch of supply. The accuracy of such a metering is defined by technical base of metering, normative base and metrological base of metering (Fedoryshyn et al., 2008). In order to control consumption of fluid energy carriers (natural gas, hot water, overheated steam etc.) the pressure differential method is applied. This method is used for measurement of energy carrier flowrate and volume in pipes with internal diameter of 50 mm and more.

2. NORMATIVE BASE OF FLOW MEASUREMENT

Metering of fluid energy carriers by means of pressure differential devices in Europe is carried out according to the requirements of ISO 5167.1,2,3,4-2003. In CIS countries new Interstate Standard GOST 8.586.1,2,3,4,5-2005 is in force. The first four parts of this Interstate Standard were developed as modified versions of ISO 5167.1,2,3,4-2003 and the fifth part of GOST 8.586.5-2005 covers the requirements of CIS laws on measurement of energy carrier flowrate and volume and normalizes the procedure for measurements.

It should be mentioned that the new standards in force (ISO 5167.1,2,3,4-2003 and GOST 8.586.1,2,3,4,5-2005) differ from previous standards considerably. The most significant distinctions are new limitations for application of the pressure differential method, new mathematical dependences for main coefficients of flowrate equation, new requirements to pipe straight lengths and fittings, new requirements to application of flow straighteners and flow conditioners and finally new methodology for assessment of uncertainty of results of flowrate and volume measurement. The detailed contrastive analysis of various normative documents on fluid flowrate measurement by means of the pressure differential method is given in (Pistun & Lesovoi, 2006).

Naturally such significant distinctions between the new standards and the previous ones cause considerable difficulties during implementation of the first. In particular, for every flowmeter the following tasks should be accomplished: verification of conditions (constraints) for application of the pressure differential method according to the requirements of new standards; calculation of parameters of primary device, pipe straight lengths and flowmeter in general according to the requirements of new standards; calculation of uncertainty of results of fluid flowrate and volume measurement.

When accomplishing these tasks it is very important to carry out design of flowmeter (and of whole unit of energy carrier metering) optimal as to the measuring accuracy i.e. flowmeter providing minimum uncertainty of energy carrier flowrate and volume measurement.

The methodology of the mentioned above verifications, calculations and design of pressure differential flowmeters was not formalized even for previous standards. Such methodology is developed by us according to new standards.

3. "RASKHOD-RU" CAD

In order to simplify accomplishment of the mentioned above tasks and implementation of new standards (ISO 5167.1,2,3,4-2003 and GOST 8.586.1,2,3,4,5-2005) we propose to realize the developed methodology of calculations and design of flowmeters in the form of a specialized computer program: system for computer aided calculation and design of pressure differential flowmeters.

Such a system with the name of "Raskhod-RU" CAD (Pistun et al. 2007) is developed in Institute of Energy Audit and Energy Carrier Accounting (www.ieoe.com.ua). By means of this computer program all the mentioned above tasks of verifications, calculations and design of flowmeters can be accomplished. "Raskhod-RU" CAD meets the requirements of new standards and this computer program is certified in Ukraine and in Russian Federation.

"Raskhod-RU" CAD is intended for design of flowmeters for 48 fluids including the following: natural gas, humid oil gas, overheated steam, dry saturated steam, water, air, nitrogen, argon, oxygen etc. All valid procedures for calculation of expansibility factor for natural gas (NX19 mod.; GERG-91 mod.; AGA8-92DC mod.; VNIC SMV; SD 7-2005) are implemented in "Raskhod-RU" CAD.

At present "Raskhod-RU" CAD is available in Ukrainian, Russian, English and Kazakh.

"Raskhod-RU" CAD provides four different types of flowmeter parameters calculation:

- calculation of flowmeter parameters for the given upper limit of differential pressure measurement;
- calculation of flowmeter parameters for the given allowable pressure loss at primary device;
- calculation of flowmeter parameters to secure minimum uncertainty of flowrate measurement;
- calculation of flowmeter parameters for the given specifications of primary device and pipe (the so called inverse calculation of flowmeter).

The first three types of calculation are applied at initial design of pressure differential flowmeter. Here in second and third types of calculation an optimization problem is solved to

minimize pressure losses at primary device or to minimize measuring uncertainty respectively. And the fourth type of

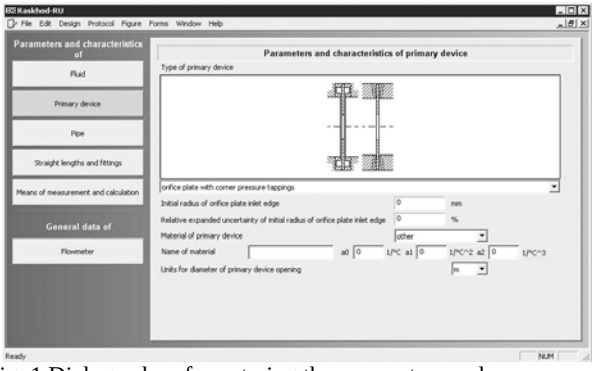


Fig. 1.Dialogue box for entering the parameters and characteristics of primary device (orifice plate)

calculation is applied to define the parameters of an existing flowmeter and the conditions of its application according to the requirements of new standards (ISO 5167.1,2,3,4-2003 and GOST 8.586.1,2,3,4,5-2005).

Besides, when designing a flowmeter the "Raskhod-RU" CAD gives the possibility to choose one of three possible configurations of the flowmeter: with separate measurement of flow parameters; with flowrate and volume calculator; with measuring complex.

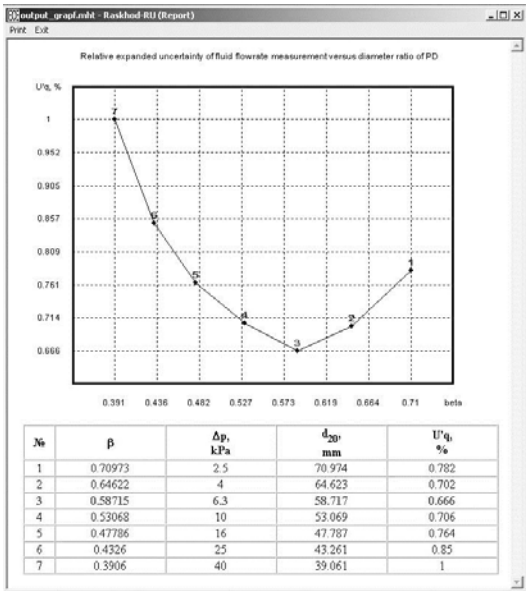
After choosing the type of the problem to be solved (type of calculation) the following input data should be entered: parameters and characteristics of fluid, primary device, pipe, straight lengths and fittings, means of measurement and calculation, flowmeter unit. Demonstrative dialogue box for entering the input data is shown on Fig. 1.

The result of "Raskhod-RU" CAD calculations is the protocol of pressure differential flowmeter calculation.

The following advantages of "Raskhod-RU" CAD should be specified:

- convenient user interface of the program providing quick and easy learning of possibilities of the program and maximum using of these possibilities which is achieved by logical and understandable distribution of input data among the dialogue boxes;
- interactive shell for data input which is especially important for pipe straight lengths, in particular there is a possibility to use flow straighteners and flow conditioners in the pipe as well as various options for mounting the thermometer;
- automatic control of dialogue boxes during entering the input data by the user which provides avoiding unforeseen mistakes;
- display of warnings about additional component errors of measurement and possible ways to eliminate these errors according to the requirements of new standards;
- high quality visualization of calculation results which simplifies the analysis and application of the results, in particular there are curves of flowrate measurement uncertainty dependence on flowrate or other parameters, drawings of primary devices, pipe straight lengths and fittings etc.

A particularly important advantage of "Raskhod-RU" CAD is the possibility to carry out design of flowmeter optimal as to the accuracy of measurement. As an example the curve of dependence of relative expanded uncertainty of fluid flowrate measurement on diameter ratio of primary device is shown on Fig. 2. There is a table under the curve with these values together with upper limits of differential pressure measurement and with diameter of primary device opening. The presented curve and table demonstrate the possibility of obtaining maximum accuracy of flowrate measurement when designing a pressure differential flowmeter. In the given example the highest accuracy is obtained for flowmeter number three.



№	β	Δp, kPa	d_{20}, mm	U'q, %
1	0.70973	2.5	70.974	0.782
2	0.64622	4	64.623	0.702
3	0.58715	6.3	58.717	0.666
4	0.53068	10	53.069	0.706
5	0.47786	16	47.787	0.764
6	0.4326	25	43.261	0.85
7	0.3906	40	39.061	1

Fig. 2.Window with results of calculation of optimal primary device as to the accuracy of measurement

4. CONCLUSION

Methodology for calculation and design of pressure differential flowmeters is developed according to the requirements of new standards (ISO 5167.1,2,3,4-2003 and GOST 8.586.1,2,3,4,5-2005). This methodology is implemented in "Raskhod-RU" CAD which enables computer aided calculation and design of pressure differential flowmeters. At the same time verification of conditions (constraints) for application of the pressure differential method according to the requirements of new standards can be carried out by this computer program which simplifies the process of implementation and application of the new standards significantly. Application of optimal flowmeters as to the accuracy of measurement, proposed by "Raskhod-RU" CAD, will provide improvement of accuracy of fluid energy carrier metering.

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