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NEW LOW-COST METHOD FOR DETERMINATION OF HEATING VALUE OF NATURAL GAS

Natural gas quality determination as primary energy resource for our country can be assigned to energy security from the point of view of its limited resources in Ukraine and the dynamics of the continuous growth of prices for natural gas. Just so, since 1999, the price for natural gas has increased at an average almost in 3 times for the population and in 10 times for enterprises.

Heat, released by the natural gas burning (heating value) is the main indicator of natural gas quality, the indicator of its application.

The heating value of natural gas can be determines in two ways:

- by the calculation method (for component composition) [1];
- by the experimental method (using the water calorimeter) [2].

Both methods for natural gas heating value determination have a number of significant drawbacks [8, 9], the main of which are:

- significant time and cost expenses for the research;
- inability of the heating value continuous measurement (in real time) directly to the consumer.

For solving the above mentioned problems new method have been developed and proved theoretically for natural gas heating value determination, which is compatible to measuring of ultrasound velocity in a gas, carbon dioxide content and to the usage of artificial neural networks as heating value nonlinear approximates as the function of the complex specified parameters. These informative parameters were selected by correlation analysis of natural gas heating value with a number of standard physical and chemical parameters of natural gas, namely: hydrocarbons content (methane, ethane, propane, butane and higher

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hydrocarbons), density, molar mass, ultrasound velocity in gas, carbon dioxide content and nitrogen content [3].

Adequacy of a new express-method for gas heating value measuring was tested with the usage of artificial neural network (SHNM) with reference values of gas physical and chemical parameters [4] and real values of natural gas parameters from the natural gas quality certificates, as defined in one of the companies of Ivano-Frankivsk region.

The purpose of this article is to conduct experimental investigation to establish the possibility of practical application of the proposed method directly to the consumers of natural gas.

The essence of experimental investigation was in the following: two identical samples of natural gas were selected simultaneously from gas network. Thereafter one of the samples was analyzed by means of specially developed experimental unit for heating value determination by the proposed method. Another gas sample was put into the chromatograph serial type KCH (industrial No. 3875) for component composition measuring and natural gas heating value calculation. After the above-mentioned investigations were performed, their results were compared. To reduce the influence of ambient temperature readings for research measuring results, the investigations were conducted simultaneously in same room.

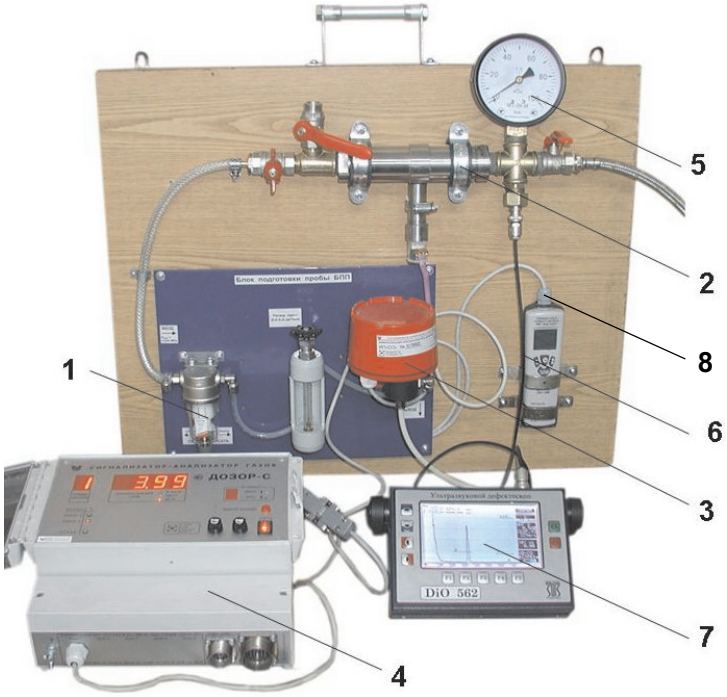

Fig. 1. Experimental unit for natural gas calorific value determination: 1 – gas preparation block, 2 – measuring chamber, 3 – CO_2 feeding for natural gas, 4 – block for measuring the sound dispersion speed in gas, 5 – pressure gauge, 6 – thermal hygrometer 7 – thermometer, 8 – ultrasound stethoscope

The experimental unit for gas heating value determination has the following main blocks (Fig. 1): gas preparation block 1, which includes water segregator, and flow-metering tube that is designed to clean the samples of dust and moisture; sensors for measuring the sound dispersion speed in gas 2; CO_2 concentration in natural gas measuring unit, which consists of carbon dioxide sensor serial-type IP 3-CO2 (industrial No. 1 / 3002) and gas analyzer 4 „DOZOR-C (industrial No. 3002).

The specifically designed and manufactured block for measuring the sound dispersion speed in gas 2 (Figs 2, 3) is of particular interest. Block is a tight construction made of stainless steel in cylindrical form, into which the natural gas is supplied. The initial ultrasonic transducer of own production is set up in the block. Its frequency is at up to 1 MHz, which works in couple mode as emitter-receiver. At the calculated and clearly set distance of 57.7 mm upon condition of maximum energy value of reflected signal receiving, the reflector, made of stainless steel with diameter of 22 mm and a surface roughness Rz = 20, is set.

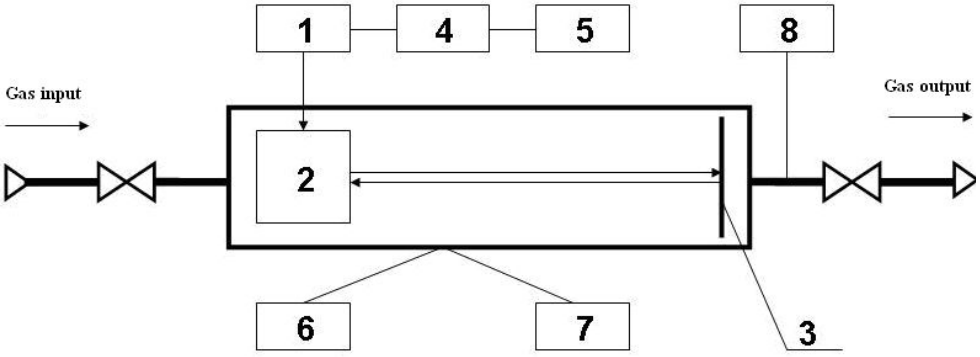

Fig. 2. Functional diagram of block for measuring the sound dispersion speed in gas: 1 – generation-receiving circuit, 2 – primary ultrasound transducer, 3 – reflector, 4 – processing results device, 5 – device output, 6 – humidity sensor, 7 – temperature sensor, 8 – pressure sensor

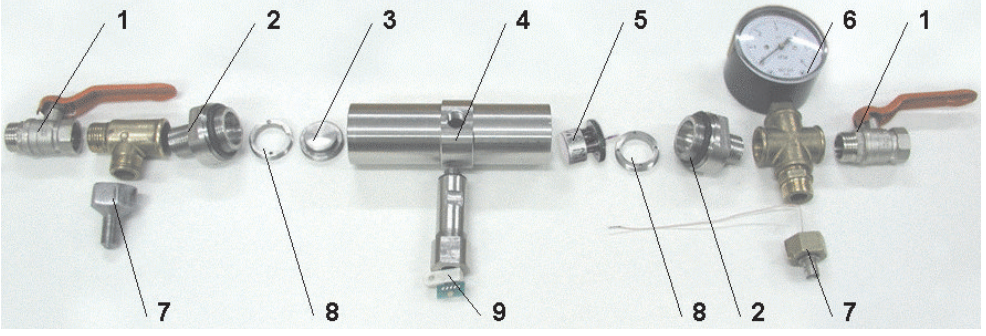

Fig. 3. Block determining velocity of sound in gas: 1 – tap, 2 – fitting, 3 – reflector, 4 – measuring chamber, 5 – piezoelectric ultrasonic transducer, 6 – pressure gauge, 7 – connector, 8 – captivating plate, 9 – temperature and humidity sensor

Also, the unit consists of 5 pressure gauges of type MT-2H (TR 33.2-33884768.001-2006) thermal hygrometer of type OVT-6-7302 (industrial No. 08,082,341); ultrasonic defectoscope DIO 562 (industrial No. 138).

Technology for natural gas heating value determination by means of the experimental unit is the next. Sample gas enters the measuring chamber 2, where sound dispersion velocity is determined. To measure the carbon dioxide content in natural gas, sample gas is needed to be additionally cleaned from mechanical impurities and dried with the preparing samples block. The carbon dioxide content of determined in the carbon dioxide determination block (3,4). Also the pressure, temperature and humidity of gas sample are measured.

For the new method of heating value measuring 20 samples of natural gas were selected. By means of experimental unit the following informative parameters were determined: ultrasound velocity in gas and carbon dioxide content. Table 1 presents results of informative parameters determination. Natural gas heating value was determined in Ivano-Frankivsk National Technical University of Oil and Gas.

Table 1

Results of the informative parameters measuring

Gas sample No.	Sound dispersion velocity in gas,	Carbon dioxide content, %	Gas heating value, kkal/m^3
1	398,95	0,59	9086,4
2	410,82	0,52	8931,0
3	403,67	0,47	8838,2
4	406,64	0,56	8822,3
5	395,72	0,56	8961,6
6	402,66	0,55	8873,5
7	406,91	0,51	8879,2
8	409,34	0,56	8962,8
9	408,03	0,58	8772,4
10	409,19	0,57	9071,0
11	401,85	0,6	9167,6
12	403,9	0,62	9099,1
13	406,56	0,64	9042,2
14	399,18	0,57	9108,2
15	401,64	0,59	8957,8
16	404,13	0,6	8983,3
17	394,52	0,53	8885,5
18	399,63	0,56	9174,0
19	401,65	0,56	8825,2
20	403,9	0,56	8951,7

In order to calculate the natural gas heating value by the results of measurements specially designed artificial neural networks were used. 16 sets of 20 informative parameters were selected to train the network and to test it – 4 that were not used for training. At the entrance of ANN sound dispersion velocity in gas and carbon dioxide content were given, and at the output – the natural gas heating value. ANN testing results are presented in Table 2.

Table 2

Results of the natural gas heating value determination by the developed method

Sample No.	Heating value, received by the usage of ANN, kkal/m^3	Heating value, received by the usage of gas chromatograph, kkal/m^3
1	8815,8	8822,3
2	8948,5	8961,6
3	8958,8	9071,0
4	8924,9	8957,7

As it is seen from the Table 2, the heating values, defined by gas chromatograph, are equal to the values obtained by using artificial neural network of developed method. Absolute error was 39.64 kkal/m^3 and given to the range – 4.66 %. These results can be considered acceptable, since for method control on data taken from the natural gas quality certificates, the ranges error reached to 56%.

Experimental method of new method for natural gas heating value measuring proved its adequacy and applicability.

Experimental unit required improvement, because it was necessary to take into account the effect of humidity and temperature on gas samples. For this purpose the block of sound dispersion velocity in gas velocity was updated by the including humidity and temperature sensors directly into the cylindrical measuring chamber unit. There have been improved the reflector – the previous one was replaced by the concave reflector, made of stainless steel with the diameter 20 mm and the curvature surface of 520, allowing to focus acoustic signal from the primary converter and to increase the energy value of received acoustic oscillations. In addition, the block construction of sound dispersion velocity in gas provides the possibility of distance regulation from the primary reflector to the transducer, that allows get the maximum energy value of the reflected signal due to the radiated frequency.

After corrective measures the industrial approval of proposed method of natural gas heating value determination by the above mentioned technique and results comparing with the data of gas samples chromatography analysis was conducted in SE „Ivano-Frankivskstandardmetrology" and JSC „Ivano-Frankivskgas.

The given measurement error, using the proposed method, does not exceed 4%.

Currently works on the unit industrial pattern production are performed.

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