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APPLICATION OF THE COLOUR MEASUREMENT OPTOELECTRONIC METHOD FOR QUALITY CONTROL OF NATURAL GAS

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Ціль – вимірювання кольору для контролю якості природного газу. Визначено основні положення застосування оптоелектронного методу вимірювання кольору для контролю якості природного газу. Розглянуто особливості процесу контролю параметрів газу. Запропоновано оптоелектронний метод і реалізує його пристрій. Запропонований пристрій – датчик кольору в якому використовується більше трьох фотоприймачів, що дає можливість шляхом систематичних перетворень сигналів відтворювати криву складання кольору і істотно спростити процес його налаштування.
Ключові слова: цифровий датчик, вимірювання, проникність, оптична середовище, контроль якості, природний газ.

Цель – измерение цвета для контроля качества природного газа. Определены основные положения применение оптоэлектронного метода измерения цвета для контроля качества природного газа. Рассмотрены особенности процесса контроля параметров газа. Предложен оптоэлектронный метод и реализующее его устройство. Предложенное устройство – датчик цвета в котором используется больше трех фотоприемников, что даст возможность путем систематических преобразований сигналов воспроизводить кривую сложения цвета и существенно упростить процесс его настройки.
Ключевые слова: цифровой датчик, измерение, проницаемость, оптическая среда, контроль качества, природный газ.

The purpose – measurements of color for quality control of natural gas.Defined the main provisions the use of optoelectronic method, color measurement for quality control of natural gas. The features of the process control gas parameters. The proposed optoelectronic method and implements its device. The proposed device is a color sensor which uses more than three photodetectors, which will give the opportunity through systematic transformations of the signals to reproduce the curve of the colors addition and to simplify the process of configuration.
Keywords: digital sensor, measurement, permittivity, optical media, quality control, natural gas

Control of parameters gas currently operate the only large gas consumers. The rest of the calculations use the data of the gas supplying organizations.

Up to the present time in Ukraine the quality of natural gas for the population is regulated by the State standard 5542087 (combustible natural Gases for industrial and municipal purposes), according to which the caloric value of this fuel must be at least 7600 Cal/m^3. And checked this figure, according to the same standard, should month [1].

In Ukraine, unlike most European countries, the volumes of consumed gas are charged in cubic meters.

In Europe volumes are measured in electrical units – NJ or kV, that is, the conversion of gas consumed, taking into account its calorific value.

As independently in our country to check calorific value of gas consumers can not provider the temptation is to "cheat" it volume.

All of us repeatedly noticed that when you turn on the kitchen gas burners – not always natural gas burns cleanly with a blue flame.

According to the materials of domestic and foreign researchers dealing with natural gas quality – color of light depends on many parameters [2, 3].

Bright blue color of a flame speaks about high caloric content; reddish – about impurity in gas.

Flame of obviously expressed red shade – sign of low-gas mixture with a low temperature.

Color of fire in a gas ring demonstrates the correct or wrong combustion of gas [4, 5].

If the flame has uniform blue color, then natural gas burns down completely, generating at the same time the maximum heat

If fire of the yellow, red or any other color other than blue means, to a torch the insufficient amount of air arrives. Respectively, at the same time less heat is generated [6 – 8].

On the basis of the above development of a method the express of natural gas quality control on such characteristic indicator as measurement of flame luminescence color is relevant.

In [4] modern definition methods of the general sulfur in natural gas are presented. Three definition ways of the general sulfur with use chemical luminescent detector are offered.

The method for determination of total sulfur using the same separation column as for determination of individual sulfur components in natural gas, but at maximum possible temperature values and the flow of the carrier gas, with the aim.

Fundamentals of petroleum complexes, gas systems and their features reviewed in [5].

In [6] for quality control of gas proposed structural quality management model that takes into account the peculiarities of the extraction processes, processing and transport of gas and allows to increase efficiency of gas production and gas transmission companies.

The structure of the life cycle gas quality management system which reflects some features of the extraction processes, processing and transport of gas. The stages of a quality management structural model which is based on the decomposition approach allows to determine the sequence of procedures used to determine the quality of gas.

Compilation of "top-down" processes of natural gas that involve the principle of gas processing, transmission and distribution, gas flow and network analysis, systems of measurements and systems of measurement and its use is presented in [7].

In [8] analyzed the tests conducted to check quality parameters of natural gas and the permissible deviation.

Physical properties and conditions of the quality control process.

Describe the process of determining the density of natural gas, etc.

The work [9] provides information about the commercial gas production facilities.

Theoretical foundations of transport, storage and distribution of natural gas.

Attention is paid to automatic control systems, widely covered the issues of gas distribution networks operation and gas storage facilities.

Considered transport, storage. the distribution and use of liquefied gas in the main production processes for household circuits and agriculture, highlights the issues of determining the liquefied gases quality and features of storage tanks operation for liquefied gases.

Established areas optimal use of liquefied gases, the efficiency increase ways of their use.

The authors propose for this purpose the optoelectronic method and implements its device (Fig. 1).

The main element of the colors recognition device is a color sensor, which each radiation puts in line three signal proportional to the color coordinates. To convert the light energy into electrical energy is used three photodetector, spectral characteristic which must be in the region of the spectrum visible portion and to reproduce one of the curves, adding the color.

Since it is difficult to find photodetectors with such characteristics, usually set in front of them the filters, selected so that the resulting characteristics of the photodetector and the optical filter $f(\lambda)$ coincides with one of the addition curves.

It is necessary to make individual adjustment of the spectral characteristics of the filter. This is a very time-consuming and laborious operation. Therefore, the authors propose a color sensor [10, 11] that uses not three but a greater number of photodetectors, makes it possible by a systematic transformation of the signals to reproduce a given addition curve of colors and to simplify the configuration process.

The principle of the color sensor, fig. 1, is that the input of the photodetector $\Phi_1, \Phi_2, \Phi_3, \Phi_4$ $b(\lambda)$ radiation is supplied.

Electrical signals from these photodetectors are received through trimming resistors R1, R2, R3 normalizing amplifiers U_1, U_2, U_3, U_4, and then on four-channel analog-to-digital converter (ADC),

microcontroller MCU through chip USB interface data transmission channel on the electronic computing machine (ECM). Introduced into the color sensor additional channel w is used to control light intensity, which reduces the measurement error at different light levels.

The input of each channel the signal can be given with different transmission coefficient, determined from the expression

$$U_{out\,j} = a_{ji} U_i = \frac{R_{oi}}{R_{ji}} U_i, \qquad (1)$$

where: U_i – the output signal of *i*-th photodetector ($i = 1...n$);

$U_{out\,j}$ – the output signal of the j-th decisive amplifier ($j = 1,2,3$);

R_{ji} – resistance of i-th resistor at the input of the j-th decisive amplifier

R_{oi} – the resistance of the feedback resistor of the j-th decisive amplifier.

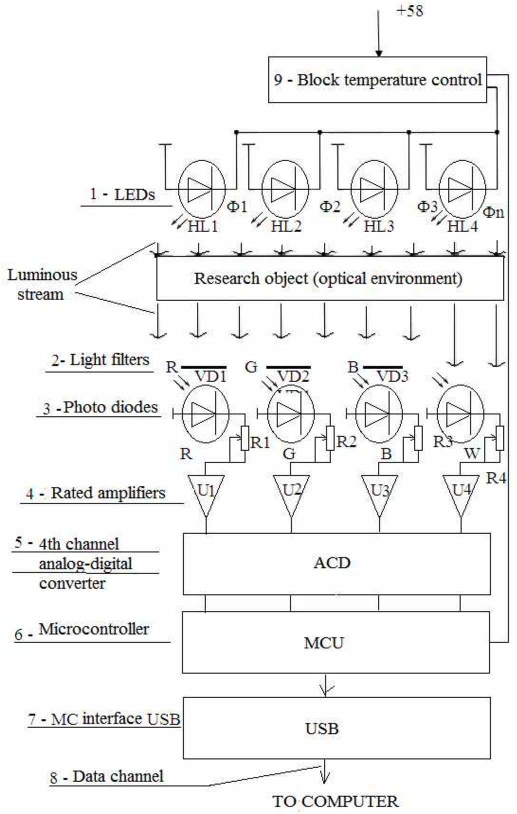

Figure 1 – Digital sensor to measure the permeability of optical materials

The electric current arising in the circuit of each solar cell under radiation effect $b(\lambda)$, can be a determinant of the expression

$$I_i = K \int_{\lambda_{i1}}^{\lambda_{i2}} b(\lambda) f_i(\lambda) d\lambda, \qquad (2)$$

where $f_i(\lambda)$ – the resulting spectral response of the i-th photodetector and the filter;

$\lambda_{i1}, \lambda_{i2}$ – the wavelengths of radiation corresponding to the beginning and end of the transmission range of i-th filter;

K – the coefficient of proportionality.

Then the voltage at the output of each photodetector is equal to

$$U_i = I_i R_{нi} = KR_{нi} \int_{\lambda_{i1}}^{\lambda_{i2}} b(\lambda) f_i(\lambda) d\lambda, \qquad (3)$$

where $R_{нi}$ – the load resistance in the circuit of the i-th photodetector.

Since the input of the normalizing amplifier serves at the same time the signals from all photodetectors, its output voltage will be determined according to the formula

$$U_{вых\,j} = \sum_{i=1}^{n} a_{ji} U_i =$$

$$\sum_{i=1}^{n} a_{ji} KR_{нi} \cdot \int_{\lambda_{i1}}^{\lambda_{i2}} b(\lambda) f_i(\lambda) d\lambda =$$

$$= KR_{нi} \cdot \int_{\lambda_1}^{\lambda_2} b(\lambda) \cdot \left(\sum_{i=1}^{n} a_{ji} f_i(\lambda) \right) d\lambda, \qquad (4)$$

where λ_1, λ_2 – lower and upper boundaries wave lengths of a light band.

From the expression (4) shows that the spectral characteristic each of the three channels passage signals determined from the relationship

$$J_i(\lambda) = \sum_{i=1}^{n} a_{ji} f_i(\lambda). \qquad (5)$$

Since the real color visible to the human eye, three meters color space is not the point character, which is associated with the presence of thresholds tutorialize.

In order for the device color recognition could classify shades of color like the human eye, i.e. taking into account thresholds of color differentiation, it should be able to automatically compare the received signal for the color of the burning gas with some benchmarks and find the maximum distance between them by the formula

$$d_{к\,\min} = \sum_{i=1}^{3} \left| [X_i] - [X_{iк}] \right|, \qquad (6)$$

where $[X_i]$ – the i-th line image of the color represented in binary code;

$X_{iк}$ – i-th line k-th standard color;

$d_к$ – a number written in binary code that specifies the distance between the test color and k-th reference.

The process of recognition is reduced to checking the inequality

$$d_{\kappa i} = \left| X_{ij} - X_{i\kappa} \right| \le d_{n_i}, \qquad (7)$$

where x_{ij} – the i- th component of the *j*-th image of the measured color;

$X_{i\kappa}$ – i-th line *k*-th standard color;

$d_{\kappa i}$ – the distance between the test color and the standard;

d_{n_i} – the threshold distance of the color and standard.

It should be noted that this means in three-dimensional space not crossed areas, each of which is allocated a point corresponding to the reference.

The sizes of the regions are defined by color differentiation thresholds and the elucidation of arbitrary radiation belonging to this region is the process of color recognition.

The signals taken with the ADC on the microcontroller analyzes (compares) the data array which contains the parameters of the impurity of the air in the gas. Indicator on the LCD (LCD) device color measurement and display indication of the air percentage in the gas depending on emission color (from blue to red) if necessary, the indicative signal can be displayed on the automated workplace of the operator or be transmitted to the SCADA system.

CONCLUSIONS

Scientific novelty lies in the fact that the quality control of natural gas proposed to use the photoelectric method of measuring color.

Thus, the developed device allows with high enough accuracy to produce rapid quality control of natural gas.

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