Information system of quality assessment for liquid and gaseous medium production

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Abstract. A method and a technical solution for controlling the quality of production of liquid and gaseous media is proposed. It is also proposed to monitor harmful factors in production while ensuring safe working conditions. Initially, using the mathematical model of an ideal atmosphere, the projection to the horizontal surface of the observation trajectory is calculated. At the second stage, the horizontal projection of the observation trajectory in real conditions is measured. The quality of the medium is judged by the difference between the projections of observation trajectories. The technical result is presented in the form of a device allowing obtaining information about the quality of the medium under investigation.

1. Introduction
When managing the quality of products, special attention is paid to controlling its quality. The latter determines the efficiency of the entire production of the enterprise.

Comparison at various stages of production of the actual state of the products with established norms allows ensuring high values of quality indicators and the enterprise as a whole. The process of assessing information on the deviations of actual values from those specified for the production of liquid and gaseous media is proposed to be realized from information on their refractive properties.

For example, in [1-4], investigations were made of the refractive properties of the atmosphere and expressions were obtained which take into account its refractive properties. It is proposed to use the results of the studies described above for their practical application in manufacturing at the enterprises while monitoring the quality of the products produced, and also in ensuring the safety of personnel exposed to harmful hazards in the workplace.

2. Materials and methods
The main task of the information system at the enterprise is the speed of observation of the quality of the products (for example, water, fuel, various gaseous media, etc.) in production, as well as monitoring labor conditions while ensuring the safety of employees [5-6].

The essence of the proposed system is that initially based on the data of meteorological observations and technical conditions of sounding the environment (depending on the tasks being
solved), using the mathematical model of an ideal atmosphere, \( S_0 \) is the projection onto the horizontal surface of the observation trajectory [5-6]:
\[
S_0 = f(n_0, h_0, \psi_0)
\]
where \( n_0 = f(e, P, T) \) is the ideal refractive index, \( e \) - the partial pressure of water vapor, \( P \) - the atmospheric pressure, \( T \) - the absolute temperature in the test layer, \( h_0 \) - the height of the source of the probing optical signal; \( \psi_0 \) - the sounding angle.

**3. The study of the structure of the modified lead-tin-base bronze**

These calculations from the measurement results determine the reference channel in the proposed information system. At the second stage synchronously, under the same technical conditions, a real projection to the horizontal surface of the trajectory of the optical signal after passing through the investigated layer of the medium is measured.

The measurement data determine the measuring channel in the proposed system. The resulting difference between the calculated projection of the trajectory on the horizontal surface and the real trajectory, i.e. passed through the investigated layer of the medium, allows one to judge its quality as a medium.

The essence of the proposed information system is disclosed in figure 1.

In an ideal medium, the probing signal propagates along rectilinear trajectory 1, and its projection to the horizontal plane is \( S_0 \), respectively. The deviation of the path of the probe signal from rectilinear signal 1, fig. 1, will be due to a change in the refractive properties of the medium under study. In this case, the trajectory of the optical signal will be bent and take form 2, figure 2. Then its projection to the horizontal plane will be \( S_{\text{measured}} \).

In this case, the functional dependence will be valid:
\[
S_{\text{measured}} = f(n, h_0, \psi_0)
\]
where \( n \) is the real refractive index.

The quality of the medium under study is not difficult to determine by the relationship [6]:
\[
\Delta S = \left| S_0 - S_{\text{measured}} \right|
\]
provided that parameters \( h_0, \psi_0 \) in the process of research are constant, and \( e, P, T \) - are controlled by appropriate devices.

In the case of \( \Delta S = 0 \), the quality meets the requirements
In the case \( \Delta S \neq 0 \) there is a deviation of the parameters from the given ones.
The use of such method makes it possible to obtain continuous information about the quality of a medium of considerable length. At the same time, such information system uses standard instruments for measuring the meteorological parameters of the assessed medium.

With the technical implementation of the information system, following the approach described above, the following elements are used:

- source of radiation;
- diaphragm;
- optical focusing system on the first measuring base;
- a signal processing unit based on an amplifier and a medium control indicator on a second measuring base.

Elements of the device on the first measuring base are co-located on a single platform on the first tripod at a fixed height. This allows one to change the angle of probing the optical signal within $90^\circ$ with respect to the second measuring base.

The second measuring base is mounted on a tripod at a lower other fixed height than at the first base, vertically disposed:

- a ruler of photodetectors;
- two calculators;
- source of threshold voltage;
- source of the probe angle voltage;
- four voltage amplifiers;
- sensors monitoring the meteorological parameters of the medium.

The output of the photodetector array is connected to the first input of the first calculator, and the output of the threshold voltage source with its second input, the output of the first calculator through the first voltage amplifier is connected to the first input of the second calculator, the second input of which is connected with the voltage of the probe angle voltage, and the third, and the fifth inputs are respectively connected through their voltage amplifiers sensors of the meteorological parameters of the medium, the output of the second calculator is connected to the signal processing unit.

The functional diagram of the proposed information system is presented in figure 2.

![Figure 2. The functional diagram of the information system.](image_url)
10, a source of threshold voltage 8 and a voltage source of sounding angle 11, four voltage amplifiers 9, 13, 15 and 17 that are vertically arranged, the temperature sensors of the lower and upper boundaries of investigated near-surface atmosphere layers 14 and 12, respectively, atmospheric pressure sensor 16, a signal processing unit based on voltage amplifier 18 and medium monitoring indicator 19.

The essence of the information system, located on two bases A and B, is explained in fig. 3.

Elements of the device on the first measuring base A are co-located on a single platform on the first tripod at fixed height $H_{\text{measured}}$. That allows one to change the probe angle $\alpha$ within 90° with respect to the second measuring base.

![Figure 3. The information system, located on two bases.](image)

On the second measuring base B, the remaining elements of the device are placed on the second tripod at fixed height $h$, and $H_{\text{measured}} > h_{\text{measured}}$. The photodetector array (Pd) is positioned vertically with respect to basis AB, and the signal processing circuit is configured such that in the case of the optical beam 1 passing, a calibration light is generated on the Ph and the indicator shows the correspondence of the medium to the given parameters for any meteorological parameters and fixed sounding angle $\alpha$.

In the presence of deviations of the medium from the given parameters, the trajectory of oblique optical ray 1 curves and assumes form 2 (fig. 3).

This leads to a change in the position of the illumination of the portion of Fd line 6 and the appearance of calculator 7 at the output of calculator 7 at a given threshold voltage (block 8) at the time of calibration of certain voltage $\Delta U$, which is amplified in block 9 and at the measured values of meteorological quantities (blocks 12-17). And preset probe angle $\alpha$ (block 11) by calculator 10 is recalculated into the corresponding indications of deviation control indicator 19 (figure 2.).

The efficiency of the proposed information system was carried out in a gas environment in the enclosed space of a garage hangar. The layout of the information system includes the following elements:

- source of an optical signal with radiation wavelength $\lambda = 0.5893 \text{ nm}$ with its optical system;
- a receiver of optical signals in the form of a six-digit line of photodetectors based on a Fd-7K photodiode located in a protective blend;
- a personal computer on the basis of which the calculation was performed using mathematical models obtained in [6].

The measuring base of AB was 100 meters.

Carbon monoxide was used as a pollutant, changing the given properties of the air; the source of pollution is the working gasoline engine of the car.
Control tests of the pollution created by the working engine of the car were carried out with the help of a gas analyzer.

Meteorological measurements were carried out by advising instruments.

The experimental studies were carried out in the following sequence:

1. Synchronously measured meteorological values at the upper and lower boundaries of the investigated layer and a horizontal projection of the observation trajectory of the probing optical signal passed through this layer.

2. After starting the engine of the car with an interval of 20 minutes, synchronous measurements of meteorological values were made, a horizontal projection of the tracking trajectory of the probing optical signal, and air samples were taken by the gas analyzer.

3. The measurements of the concentration level of carbon monoxide 25-30 mg/m³ were carried out (further study with increasing concentrations are dangerous for humans).

4. With the use of mathematical models, the concentration of carbon monoxide was calculated and compared with the data obtained when sampling air with a gas analyzer.

The results obtained during the experiment confirmed the operability of the proposed information system. The error of the calculated results and the results of the measurements by the gas analyzer was 15-20%.

4. Conclusion
The proposed information system allows one to obtain quickly the information about the occurring deviations in the investigated environment using standard meteorological instruments. By the example of air pollution with carbon monoxide, the operability of the information system was confirmed. It allows one to organize, without significant financial investments, appropriate control over the quality of products, as well as to monitor labor conditions while ensuring the safety of employees of the enterprise.

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