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INTELLIGENT SENSOR FOR ESTIMATING FRACTAL PROPERTIES OF GAS DISCHARGE RADIATION IMAGES OF WATER AND AQUEOUS SOLUTIONS

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Modern achievements in the field of information and measurement technologies have provided the possibility of obtaining measurement information with its processing based on the use of intelligent sensors. Today, intelligent sensors are used in various industries to monitor the state of various technological objects and processes [1, 2].

At mining and metallurgical enterprises, hydrosphere resources are used in the implementation of many technological processes. For example, water resources are used in the implementation of technological processes of extraction, transportation, and processing of minerals. At mining and metallurgical enterprises, tasks arise for monitoring the parameters of water and aqueous solutions. In such cases, the requirements for the properties, characteristics, composition of water and aqueous solutions depend on the characteristics of technological processes. The dynamics of the properties of water and aqueous solutions used in the implementation of technological processes requires the use of modern measuring instruments for monitoring.

Today, the task of developing and improving information and measuring technologies for monitoring the state of water and aqueous solutions used in technological processes of enterprises is an urgent task. In practice, various methods of physicochemical analysis of water have become widespread. They are aimed at determining the quantitative chemical composition of water or an aqueous solution in the form of an assessment of the presence of certain

components. Also, in some cases of implementing technological processes, there is an additional need for express assessment of the properties of water and aqueous solutions, which allows determining the integral properties of water or an aqueous solution. Recently, the corona gas discharge method has emerged as a promising direction in the development of methods for studying water [3, 4].

The method is based on the physical effect, which consists in the formation of a corona gas discharge around the liquid-phase object under study due to the processes of electron-optical emission. The gas discharge occurs in the active form of the experiment when the sample under study is exposed to an external pulsed electromagnetic field. To create an electromagnetic field, a system of two electrodes is required, which is part of the device for recording the image of gas-discharge radiation [5].

To enable express monitoring of the properties of water and aqueous solutions, in addition to the device for recording the image of a corona gas discharge, there is a need for automated processing and analysis of visual information in the form of an image. In order to provide such an opportunity, the development of an intelligent sensor with an assessment of the fractal dimension of the gas discharge image around the sample of the liquid under study is proposed.

The intelligent sensor with the assessment of the fractal dimension of gas discharge radiation images is a hardware-software complex, which includes a hardware part in the form of a subsystem for registering the image of a corona gas discharge, as well as a software unit for assessing the fractal dimension of a digital image.

The physical processes that occur when an external pulsed electromagnetic field acts on the liquid sample under study cause the formation of a set of gas discharges, which are radially arranged around a liquid drop and in the resulting image they form a superposition. The superposition of individual gas discharges is geometrically similar to a tree-like structure with branches that intersect and can form complex patterns in the resulting image.

The peculiarities of the formation of the corona gas discharge pattern led to the choice of fractal geometry methods [6] for their computer analysis in order to compare and classify images.

Based on experimental studies using the gas discharge radiation method, the peculiarities of the formation of the corona gas discharge for different types of water and aqueous solutions were determined. Distilled water samples are used as a reference sample for comparative analysis.

For images of the corona gas discharge of distilled water, a light uniform color of the inner circle for the liquid sample is characteristic, around which separate, indistinct gas discharges are formed, which have almost no intersection zones and can be separated from each other.

For aqueous solutions containing a large number of impurities in the form of solid particles, the uneven coloring of the inner circle of the image is characteristic. In this case, gas discharges around a drop of a liquid-phase object, as a rule, are characterized by a small length and insignificant branching.

Experimental studies of various types of water from natural sources have revealed the following patterns: around the inner circle of radiation, a dense picture is formed from the superposition of a large number of gas discharges, which are characterized by a large length and significant branching. However, these characteristic features are qualitative in nature and are formed on the basis of expert information.

To ensure the possibility of using an intelligent sensor as part of an automated express monitoring system, the application software includes the calculation of quantitative indicators that characterize the geometric features of corona gas discharge images, in particular fractal dimension.

During the experimental studies, samples of 30-50 corona discharge images were obtained for each type of water. For each of the image samples, the arithmetic mean value of the fractal dimension was calculated: for a distilled water sample – 0.94973; for a natural water sample with a concentration of dissolved impurities of 700 mg/l, the average value of the fractal dimension was 1.3127; for a natural water sample with a concentration of dissolved impurities of 1060 mg/l, the average value of the fractal dimension was 1.5062.

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