MEASURING COMPLEX FOR IDENTIFICATION AND DETERMINATION OF CONCENTRATION OF SURFACE-ACTIVE SUBSTANCES

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Abstract: The problem of identification and determination of the concentration of surface-active substances is considered. It is a part of the complex tasks of operative automated monitoring of the quality of working and technological environment of power technological equipment. The structure of the measuring complex is described, the method used to determine the composition and concentration of substances and compounds present in working environment, the structure of the database and the functions of the software. The complex can be used as part of the monitoring and chemical monitoring systems already in operation at the energy facility, as well as in the autonomous mode.

Key words: surface-active substances, power technological equipment, working environment, technological environment, quality monitoring, measuring complex, determination of concentration, identification.

Introduction

Reliability, safety and efficiency of operation of modern power technological equipment (PTE), providing heat and power supply to industrial and housing &communal consumers, is mostly determined by the quality of the working and technological environment (WTE). The task of quality control of WTE in modern conditions is solved by organizing chemical control (monitoring) of water chemical regimes (CC WCR) of power equipment. In the course of CC WCR using automated instruments or laboratory methods, the values of WTE's [1] standardized quality indicators are measured and processed, deviations (violations of WCR) are detected, and a set of water corrective measures for eliminating the violation is selected and implemented.

A very high level of requirements for the quality of working and technological environment is due, first of all, to two problems arising in the process of operation of power technological equipment: the intensive flow of corrosion processes and the formation of deposits of various nature on the functional surfaces of equipment determined by the presence of aggressive chemicals and compounds in WTE.

In modern conditions (obsolete technologies and equipment, low exploitation culture, etc.), even full compliance with the norms of WCR does not allow to achieve the estimated reliability values of the equipment operation.

The main reason for this is the shortcomings of modern monitoring systems of WCR, in particular, in the regulatory documents there is the absence of the requirements for the operational control of the concentrations of some fairly hazardous surface-active substances and compounds (SASC) in the working fluid that significantly accelerate the corrosion and sedimentation processes [2].

In addition, it is not possible to identify the composition of the SASC present, that's why it doesn't allow us to make timely effective management decisions for the selection and implementation of water-corrective measures. The mentioned shortcomings, caused by the imperfection of the applied technical means and methods of chemical control, substantially increase the operating time of the PTE in the conditions of disturbance of the WCR, causing its increased wear, reducing the efficiency and reliability of the operation of the energy complexes as a whole.

The analysis of methods and technical means of measurement and monitoring, applicable to the control of SASC concentrations (fluorimetric method, spectrography and chromatography), showed that each of them has a number of technical and (or) economic disadvantages (insufficient operability and complexity of measurements, high cost and the complexity of the equipment used, the complexity of solving the problems of identifying the present surface–active substances and compounds), which hampers their widespread use.

Thus, the development, creation and implementation of modern automated measuring instruments for the identification and determination of the concentration of SASC is included in the

monitoring complex of CC WCR as an actual task

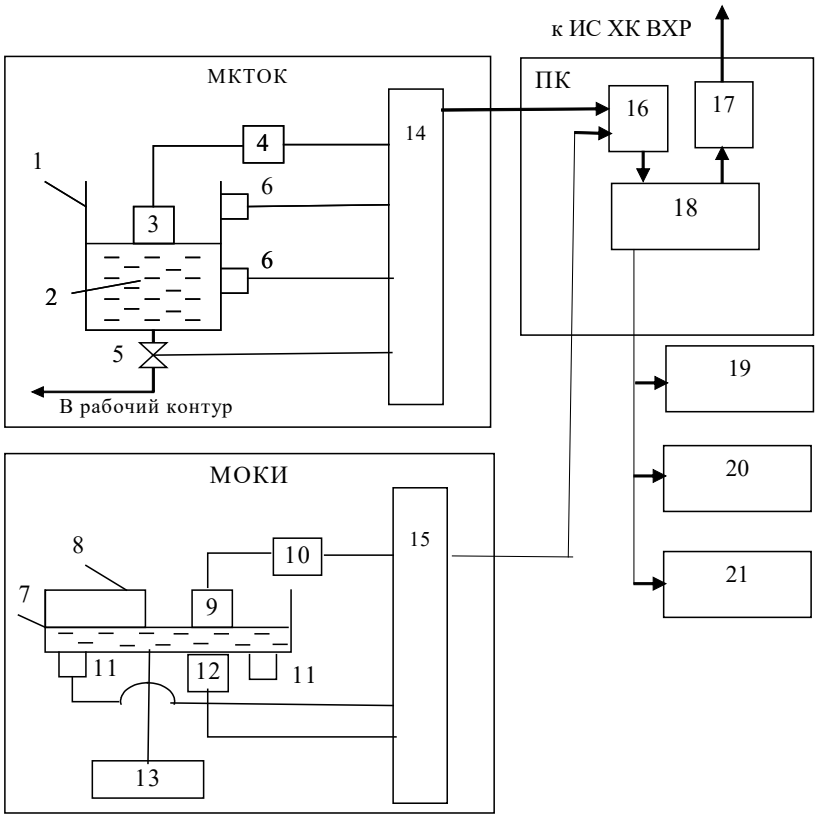
1. Functions and structure of the measuring complex

The developed measuring complex for identification and determination of the concentration of SASC provides the following basic functions:

- performing on the simple measuring equipment in the regime of the current chemical control of WCR automated operational measurements of the current total concentration of dangerous SASC present in the WTE;
- the formation of alarms for notification (AFN) when the concentrations of SASC are out of the permissible limits set by the operator;
- in case of emergency determination of concentrations and identification of the composition of SASC present in WTE.

The structural scheme of the measuring complex for identification and determination of the concentration of the SASC (Figure 1) includes the following main functional modules and devices:

- specialized measuring complex (MC) for automated measurement of concentration and



1 – measuring capacity; 2 - investigated WTE; 3, 9 - surface tension sensor; 4, 10 - force sensor; 5 - system of the inlet / outlet of the analyzed sample; 6 - a system of liquid level sensors; 7 - working capacity with mobile concentrator; 8 - concentrator; 11 - limit switches of the "initial" and "final" area of the working compartment; 12 - sensor of the current area of the working compartment; 13 - drive of the concentrator; 14 - MMTCC management module; 15 - the module of control of the CIM; 16 - the module for entering the measurement results; 17 - data export module; 18 - database and software; 19 - operator's AWS; 20 - AWS analyst; 21- AWS administrator.

Fig. 1. Structural diagram of a measuring complex for identification and determination of the SASC concentration

identification of SASC, including::

o the monitoring module of total current concentration (MMTCC), which provides on-line measurements of the current total concentration of SASC present in the WTE, monitoring of the excess of the permissible limit concentration set by the operator and the formation of the AFN;

o the concentration and identification module (CIM), which provides (in emergency cases, identified by MMTCC) the implementation of algorithms for identifying the substances and compounds present, as well as determining the concentration of components;

• the personal computer (PC), which includes the following specialized modules and software:

o the module for entering measurement results that provides information interaction with measuring modules and input into the database of measured values of the current concentration, the facts of exceeding the permissible concentration limits, and identification results;

o the data export module that provides interaction with the top-level information system of the CC WCR hierarchy;

o the database and software package that provide automation and information support for solving problems of identification and determination of the concentration of SASC present in WTE;

• automated workstations (AWS) of the personnel of the monitoring system, including:

o Operator's AWS, which provide: control of operating modes of measuring modules, as well as protocols of information interaction when receiving / transmitting information; automation of maintenance of monitoring protocols and recording of emergency cases; informational support of solving problems of identification and determination of the concentration of SASC present;

o Expert's AWS providing automation and information support for the creation of a database of reference kinetic dependencies and calibration curves (the work is performed when the monitoring system is adapted to use at a particular facility), as well as solving problems of identification and determination of concentration in certain complex cases;

o Administrator's AWS providing management of user rights for access to information and settings of monitoring system software, as well as system software.

The construction of measuring modules, taking into account the main characteristic feature of the analyzed class of substances and compounds - the properties of surface activity, made it possible to significantly simplify the design, automate the measurement process, reduce the complexity and financial costs of operating the modules. Features of constructive execution of modules, based on the principles of tensiometry, are considered in [3]. Measurement of the current concentration of the SASC is carried out by the "break-away" method using a surface tension sensor made in the form of a Wilhelmy plate, further converting the measured peel force into an electrical signal, processing it, and transferring it to a PC.

Identification and determination of the concentration of SASC in emergency cases is carried out using the method described below.

2. A method for the rapid determination of the composition and concentration of SASC present in WTE

The method [4] developed by the authors is based on the Gibbs theory and is based on measuring the surface tension force (σ), due to the molecular mechanical properties of the surface of the water medium under study, and connected by some analytical function with the composition and concentration of substances and compounds present in the environment with surface active properties.

The known methods for measuring σ and determining the concentration are characterized by low sensitivity and accuracy, and also do not allow determining the composition of the present SASC.

The developed method [5] differs:

• by introducing the measurement regimes σ in the conditions of the dynamic interface surface area "the investigated water medium - air" using specialized tensiometers;

• by the preliminary construction of reference kinetic dependences of "compression", "spreading" and "dissolution" for model water media containing known SASC at given concentrations and creation of a specialized database;

• by removal of the experimental kinetic dependences of "compression", "spreading" and "dissolution" for the test sample of WTE;

• by comparing the parameters of the experimental dependences obtained for the WTE sample under study with the analogous parameters of the reference dependencies obtained for the model environment and the identification procedure;

• by determining the concentration of SASC

on the calibration curve, the choice of which is carried out individually according to the identification results.

The results of the experimental studies carried out and the analysis of the kinetic dependencies obtained showed that each of them is characterized by the presence of three distinct linear sections, described by the corresponding nomenclature of parameters. The obtained results confirmed the effect of the composition and concentrations of the SASC present on the main parameters of the isolated sections of the kinetic dependencies and the possibility of applying the proposed method for solving the problems of determining the composition and concentration of surface-active substances and compounds present in the WTE.

3. Database structure and software functions

The database for identification and determination of the concentration of SASC present in the WTE includes three subject sections, described below.

The section "Substances, compounds, mixtures" contains the name, basic and additional information on substances, compounds and their mixtures, for which data on experimental and reference kinetic dependencies and kinetic curves are present in the database.

The section "Database of Reference Dependencies and Calibration Curves" contains detailed data on the reference dependencies and calibration curves obtained for aqueous media in the presence of deliberately known SASC at given concentrations. The nomenclature of SASC present in the section of the database depends on the individual features of the specific monitoring object and is determined by the results of an expert survey and (if necessary) preliminary carried out at the object of additional chromatographic or spectrographic surveys allowing the selection of substances and compounds whose presence in the studied water environment is the most probable. In addition, the section stores the integral characteristics of the named reference dependencies, the use of which allows to significantly reduce the processing time and data analysis during identification procedures.

The section "Monitoring of the quality of water environment" is designed to store calendar and general data on the analysis of WTE samples, detailed data and integral characteristics on the experimental kinetic dependencies obtained during the analysis, historical data on the results of the analysis of samples.

The AWS complex provides full-featured work in the named sections of the database.

The general methodology for applying and working with the PIK at a particular monitoring facility includes the following main stages:

- creation (adaptation to the individual features of the monitoring object) of the section "Database of Reference Dependencies and Calibration Curves";
- monitoring of the current concentration of SASC and detection of emergency cases of exceeding the permissible limit concentration specified by the operator;
- handling of emergency cases - operational identification and determination of the concentration of SASC present, development of water corrective measures;
- analytical work with historical data of the analysis of water samples, the formation of justified water correction measures, forecasting the residual resource of equipment (in case of necessity).

Conclusion

Practical implementation of the described measuring complex in the operation of PTE will ensure:

- automated operative monitoring of concentrations of SASC present with the development of alarms for notification, implemented on a simple measuring equipment that can work both in stand-alone mode and as part of complex monitoring systems.
- of the nomenclature of energy facilities, where monitoring is technically and economically feasible, by reducing the cost of creating and operating the complex in comparison with currently used chromatographic and spectrographic analysis systems;
- adaptation of the complex to the specific features of the monitoring facility, which allows to increase the accuracy and reduce the cost of conducting individual measurements, and to implement monitoring in general;
- reasonable rational choice and timely adoption of appropriate corrective and preventive effects through the use of the results of procedures for identification of present SASC.

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Gratitude

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