Experimental research of the impact of the dosing of chemical reagents on the dynamic behavior of regulation system of cycle chemistry

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Abstract. Organization of reliable chemical control for maintaining cycle chemistry is one of the most important problems to be solved at the present time the design and operation of thermal power plants. To maintain optimal parameters of cycle chemistry are used automated chemical control system and regulation system of dosing chemical reagents. Reliability and stability analyzer readings largely determine the reliability of the water cycle chemistry. Now the most common reagents are ammonia, alkali and film-forming amines. In this paper are presented the results of studies of the impact of concentration and composition of chemical reagents for readings stability of automatic analyzers and transients time of control systems for cycles chemistry. Research of the impact of chemical reagents on the dynamic behavior of regulation system for cycle chemistry was conducted at the experimental facility of the Department of thermal power stations of the Moscow Engineering Institute. This experimental facility is model of the work of regulation system for cycle chemistry close to the actual conditions on the energy facilities CHP. Analysis of results of the impact of chemical reagent on the dynamic behavior of ammonia and film forming amines dosing systems showed that the film-forming amines dosing system is more inertia. This emphasizes the transition process of the system, in which a half times longer dosing of ammonia. Results of the study can be used to improve the monitoring systems of water chemical treatment.

1. Introduction
One of the reasons of damage of an equipment on the thermal power plants (TPP) is the deviation of quality of the coolant from the established norms at the water chemical cycle used on thermal power plant. The following cycles chemistry are used at power plants: volatile treatment with dosing of ammonia in feedwater and NaOH in boiler water; water treatment with dosing of a hydrazine and ammonia in feedwater and NaOH in boiler water; phosphate treatment with dosing of ammonia or a hydrazine and ammonia in feedwater and phosphates in boiler water; with use of film-forming amines [1, 2].
One of advantages of use of film-forming amines is that on the surface of metal these reagents form a protecting film which reduces corrosion rate that is confirmed by operating experience and results of
the scientific research conducted in Russia and abroad [3,4]. Cycle chemistry monitoring of the coolant are used to maintain an optimal cycle chemistry.

Very topical issue of perfecting of systems of cycle chemistry monitoring is studying of influence of the correcting reagents on dynamics of control systems of the water chemical cycle and operation of automatic analyzers of chemical monitoring as a part of these systems. In this research influence of the complex aminocontaining reagents on operation of automatic analyzers of a control and management system for the cycle chemistry was for the first time studied. Researches on influence of dosing of the aminocontaining reagents for operation of analyzers as a part of system of chemical and technological monitoring were abroad conducted [5].

The main objective of this research consisted in studying of influence of one of actively used on heat power objects of the complex aminocontaining reagent for operation of automatic analyzers for monitoring and controlling cycle chemistry at TPPs. Researches were conducted on experimental installation of automatic dosing of the correcting reagents in the MPEI [6]. The experiment consisted of two stages: at the first stage the research of influence of complex reagent for operation of sensors of automatic analyzers of chemical control, and on the second – comparison of transition processes of systems of dispensing of ammonia and complex reagent for optimization of maintaining the water and chemical modes and increase in reliability of operation of the power equipment in general has been conducted.

2. Research the impact of chemical reagent on the operation of sensors in automatic chemical analyzers

Researches of the effect of complex amine-containing reagents were carried out on the conductometer/salt meter and pH meter electrodes. The total conductivity measurements were carried out in a contact low-frequency flow sensor, the measurement range for the specific conductivity was $0 \ldots 20 \text{[} \mu \text{S} \cdot \text{cm}^{-1}]$, the limit of permissible values of the main absolute error of the conductivity meter in the measurement $\pm (0,004 + 0,02 \cdot \varphi)$, where $\varphi$- measured value of specific conductivity, $[\mu \text{S} \cdot \text{cm}^{-1}]$. Continuous measurements of the activity index of hydrogen ions were carried out in a flow potentiometric cell. Analyzer was tuned to a measuring range $5 \ldots 10 \text{pH}$. The limit of the allowed basic error in measuring pH was $\pm 0.05$, units, pH. Before the experiment, the electrodes of the pH meter were calibrated according to the calibration procedure of the operation manual. The dependence of the pH value in the circuit on the concentration of the reagent being dosed is shown in Fig. 1.

![Figure 1. pH change with increasing reagent concentration.](image-url)
On the basis of the experimental data (Fig. 1), it should be noted that when the concentration of the complex reagent was varied within the operating range from 1 to 5 [mg∙L\(^{-1}\)], and the pH change was in the range 8.2...9.2 and this dependence was a nonlinear character, which corresponds to the conduct of a slightly alkaline cycle chemistry.

![Figure 2. Total conductivity change with increasing concentration of reagent.](image)

When the reagent was dosed with a concentration of 1 [µg∙L\(^{-1}\)] in the circuit, the total conductivity was 0.8 [µS·cm\(^{-1}\)]. With a further increase in the reagent concentration in the circuit to 5 [µg∙L\(^{-1}\)], the value of the total conductivity increased to 3.8 [µS·cm\(^{-1}\)] (Fig. 2). Thus, at acceptable pH values, the total electric conductivity in the circuit was much higher than the established standardized values for the quality of water and steam.

It was found that after a long dosing of the correction reagent with a concentration 1…5 [µg∙L\(^{-1}\)], the difference in the conductometer readings is within the permissible error of the devices, as a result of which the reagent does not affect the conductometer readings.

When the reagent concentrations was of more than 1 [µg∙L\(^{-1}\)], there were differences in pH meter readings above the permissible error limit of the device by 4 times, which confirms the effect of the reagent impact on the pH meter sensors.

On the basis of the data obtained, it was found that the values of the total conductivity increased with the increased in the concentration of the reacted reagent according to a linear relationship, and the dependence of the pH values was non-linear, which must be taken into account in the cycle chemistry monitoring of water chemical treatment.

3. **Comparison of transient processes of ammonia dosing systems and complex reagent.**

The next stage of the experiment was to obtain transient processes of the automatic dosing system of the film-forming amine and to evaluate its effect on the dynamics of automatic reagent dosing systems. The results are shown in Fig. 3.
Figure 3. Comparative analysis of the transient processes of automatic metering systems for a complex amine-containing reagent of pH and conductivity.

1 - transient process of the automatic dosing system of a complex amine-containing reagent according to the conductivity;
2 - transient process of the automatic dosing system of an amine-containing reagent according to the pH.

A comparative analysis of the transient processes of automatic metering systems for a complex amine-containing reagent (Fig. 3) showed that it is possible to use the pH or conductivity as a control signal. However, the use of pH is more preferable because of the finding of a dynamic error within the limits of the analyzer error and the total transient time of about 7 minutes.

Next, a study was made of the transient processes of automatic ammonia and amine-containing reagent dosing systems of pH and conductivity, which are presented in Fig. 4 and 5.

Figure 4. Transient processes of automatic dosing systems for ammonia and amine-containing reagent of pH.

1 - transient process of automatic ammonia dosing system in pH;
2 - transient process of the system of automatic dosing of amine-containing reagent in pH.

As can be seen from Fig. 4, the transient time of the automatic ammonia dosing system, which is 350 s is one and a half times less than the transient time of the automatic system for dispensing an amine-containing reagent, which was 630 s.
Figure 5. Transient processes of automatic dosing systems for ammonia and amine-containing reagent of total conductivity.

1 - transient process of automatic ammonia dosing system in total conductivity;
2 - transient process of the system of automatic dosing of amine-containing reagent in total conductivity.

The transient time of automatic ammonia dosing system making 250 with is one and a half times less than time of transition process of automatic system of dispensing of the aminocontaining reagent which has made 520 with (Fig. 5).

4. Conclusions

The analysis of dosing data for complex amine-containing reagents showed the effect of the reagent on the conductometer/salt meter sensors and pH meter electrodes used in the automatic cycle chemistry monitoring.

A comparative analysis of the transient processes of ammonia dosing systems and complex amine-containing reagents showed that, from the point of view of operational control of the cycle chemistry, it is preferable to use the automatic ammonia dosing system, since the dynamics of the automatic ammonia dosing system is 1.5 times faster.

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