Research on acid and high-mineralized wastewater neutralization and purification process of the thermal power plant (TPP) ionite water treatment plants on laboratory stand

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Abstract. This paper presents the laboratory setup model for a treatment of acid sulfate-containing wastewater after regeneration of TPP water treatment plant (WTP) H-cation exchange filters. The model is based on the principle of acid wastewater neutralizing by alkaline slurry with further calcium chloride co-precipitation, which is the main component of highly mineralized TTPs wastewater. The wastewater slurry components analysis revealed that it consists of 80% calcium carbonate.

1. Introduction
The industry is increasingly discharging wastewater with abnormal rates, which leads to penalties and additional investments in the water treatment plant. Today, one of the wastewater treatment methods is the use of sludge as a calcium-containing reagent. Sludge is a waste of the water treatment plant (WTP) of the thermal power plant (TPP). Acid waste neutralization reaction is carried out with the help of sludge, during which a solid calcium sulfate (gypsum) is formed. The remaining sulfate ions are removed by an exchange reaction with saline waste regeneration solutions, which are a solution of calcium chloride (CaCl₂). Thus, using this method, the content of sulfate-containing components can be reduced to normalized values.

2. Theoretical part
Laboratory experiments were conducted on this issue, they consisted in neutralizing model acid solutions with water treatment sludge. The goal of the experiment was to observe the kinetics of the processes and reaction products. The experiment was carried out on model solutions, prepared from chemically pure sulfuric acid and sodium sulfate. As reagents, carbonate sludge and calcium chloride were used, which were brought from pretreatment of the Nizhnekamsk (heat power plant) HPP-1 water treatment plant. Model solutions were obtained after mixing of 10 g/l solutions of acid and sodium sulfate in a ratio of 1:1. Composition of model solution: H₂SO₄ concentration – 0.051 mol/l, Na₂SO₄ – 0.035 mol/l. The kinetics of the reaction was studied by changing pH and specific electrical conductivity (SEC). SEC were translated into units of measurement for general salt content. The solution was mixed with a magnetic stirrer [1].
The disadvantage of this experiment is the complexity of conducting a neutralization and ion exchange reaction. Therefore, for the optimal and reliable result, it was decided to create a laboratory installation that will allow modeling the process of water treatment in large volumes (up to 2 liters). Installation (Fig. 1) assumes the following components: 2 liter glass cylindrical vessel; glass cover; sealing material (rubber, ferret); Hanna HI 991301 pH meter; thermometer (0-50 °C); thermocouple; stopwatch, magnetic heated stirrer Wisd Ms-MP4; solution storage tanks -3 pcs.

The lab installation is shown in figure 1.

3. Description of the experiment
The glass cover 9 is filled with distilled water and then a glass vessel 8 is placed in it, in which the neutralization reaction will take place. For ease and reliability of installation, the housing and vessel must be secured together with sealing material 10 between the casing 9 and vessel 8. Housing 9 is required to distribute the temperature more evenly according to the water bath principle. The maximum temperature in a laboratory experiment should not exceed 40 °C, this is justified by the principle of the illuminator's operation. The water before the illuminator is heated to a temperature of 30-35 °C, which allows to intensify the reaction process. Further in vessel 8 we fill a solution simulating acid spent regeneration solutions, or real wastewater with the exceeded value of sulfate ions provided by TPP. As a rule, vessel 8 is filled by 70-75% of the total volume. Further in vessel 8 we place a magnetic armature (size 40*8 mm) for uniform mixing and tightly cover with a plug 10. We assume that the system is a closed type. This will allow the most deep precipitation of sulphate-containing components from water, as carbon dioxide will acidiate the environment and the equilibrium of the reaction will be shifted. In the sealing material 10, holes for the thermometer and the electrode for measuring the pH of the medium are cut, as well as a hole for dosing solutions: highly mineralized acid drains, rigid and slurry waters. The installation is located on a magnetic heated stirrer, which will maintain the necessary temperature for the neutralization reaction. Mixing speed on a magnetic stirrer is established by an experimental way. The main criterion is the absence of strong funnel-shaped twisting. This laboratory installation provides more accurate data, with a minimal deviation from reality, which is necessary for the calculation of the industrial experiment.

We conducted an experiment on this laboratory installation. As a calcium-containing component, dried sludge was used, and as acidic sulfate-containing wastewater, a model solution prepared from sulfuric acid and sodium sulfate was used. Figure 2 shows the pH and total salt content curves.
4. Conclusion
This laboratory installation allows experiments to be carried out in conditions close to the real. As can be seen from the obtained data, reliable reproducible results are obtained. The installation simplifies the neutralization reaction of highly mineralized acid waste of ion water treatment plant.

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