Methods of using waste from steam-gas thermal power plants

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Abstract. At present, the composition of steam and condensate in periodic motion during 45кthe continuous operation of thermal power plants is getting worse and worse. Great importance is attached to the prevention of industrial wastewater pollution. In industry, water is used as a raw material and energy source, as a coolant or heater, as a solvent and extractant, and it is purified in wastewater treatment plants and discharged back into water bodies. Therefore, it is important to further improve the engineering work of wastewater treatment in water conservation. Water is the main technological raw material for obtaining steam in thermal power plants. It is the most widely used product in the continuous operation of the plant.

1 Introduction

The analysis of the energy strategy of the developed countries of the world shows that increasing energy efficiency in various sectors of the economy and saving traditional energy resources are defined as important directions. According to the data of the Commission of the European Economic Community, more than 75 percent of heat energy in agriculture is used for heating greenhouses. In this case, the share of energy costs in the cost of greenhouse products is 40-60 percent. Therefore, it is important to diversify the fuel-energy balance due to the development of renewable energy sources and to introduce innovative energy-saving technologies in order to heat water, which is considered a source of heating in the world [1, 2].

In the world, scientific research aimed at improving the heat supply systems of greenhouse complexes, increasing energy efficiency and reducing the consumption of traditional energy resources by using renewable energy sources and optimizing heat-technical parameters is being carried out. In this direction, priority is given to research on the development of energy-efficient heat supply systems, reduction of energy consumption and improvement of energy efficiency of technological processes in greenhouse facilities based on the effective use of solar energy.

During the years of independence, many tasks and issues related to reducing the costs of production, transmission and distribution of electricity, and providing uninterrupted supply of electricity to consumers by introducing high-efficiency and modern technologies into production were honorably justified. Also, at the next stage, promising projects and programs

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https://doi.org/10.1051/e3sconf/202452503007

aimed at modernization, technical and technological renewal and development of modern energy sources have begun to be implemented. The construction and modernization of new facilities served to form a strong national energy system not only in the Navoi oasis, but also in our country.

Therefore, special attention is being paid to the creation of waste heat energy utilization devices for steam-gas thermal power plants (TPP) and the justification of their main thermal technical parameters [3,4].

2 Materials and methods

There are two types of condensation methods: physical condensation and chemical condensation.

Physical condensation method. One of the methods of physical condensation is the method of sending solid vapor into the dispersion medium. Mercury, selenium, sulfur, phosphorus compounds are obtained by this method. Russian scientists A. I. Shalnikov and S. Z. The Roginskys developed a method of forming colloidal solutions by condensing substance vapor on a strongly cooled surface. Using this method, they were able to obtain colloidal solutions of many metals and nonmetals in water and organic media. In this way, these scientists created hydrosols of Hg, Cd, Se, P, S, organoparticles of Hg, Cd, K, Rb, Cs, Na.

A rotating solid substance (for example, sodium) is taken into part a of the device, a dispersion medium (for example, benzene) into part b, and liquid air into part c. When parts a and b of the device are heated, Na and benzene evaporate and condense on the surface of the container filled with liquid air. After the liquid air is removed (evaporated), the colloidal solution formed as a result of condensation is collected in part g of the structure.

Physical condensation methods include the solvent exchange method. We will show the essence of this method in the following example. It is known that some organic acids are well soluble in ethyl alcohol, but poorly soluble in water. To form colloidal solutions of such acids in water, first the acid is dissolved in alcohol, and then it is diluted by gradually adding water to the resulting solution. Since water can mix with alcohol in any ratio, the solubility of organic acid dissolved in alcohol decreases in aqueous alcohol, and its colloidal solution in water is formed. In this way, for example, by adding water to a solution of sulfur in alcohol, a white colloidal solution of sulfur can be formed.

Chemical condensation method. Chemical condensation methods are based on the formation of hard-to-dissolve precipitates as a result of chemical reactions. To them:

1) return,
2) oxidation,
3) exchange,
4) includes methods based on hydrolysis and other reactions.

In the reduction method, the dispersed phase is reduced in pure solution using a reducing agent.

It is also possible to convert sulfur into a colloidal state by reducing hydrogen sulfide with sulfite anhydride:

$$2H_2S + SO_2 = 3S + 2H_2O \tag{1}$$

The exchange method is based on exchange reactions in which insoluble substances are formed. By this method, for example, silver chloride hydrosol is formed:

$$AgNO_3 + NaCl = AgCl + NaNO_3 \tag{2}$$

Arsenic (III) sulfide hydrosol is also obtained by this method:

$$2H_3AsO_3 + 3H_2S \rightarrow As_2S_3 + 6H_2O \tag{3}$$

The size of the colloidal particles formed by the exchange method depends on the concentrations of the reacting solutions. As an example:

$$4FeCl_3 + 3K_4[Fe(CN)_6] = Fe_4[Fe(CN)_6]_3 + 12KCl \quad (4)$$

Let's take the Berlin blue colloidal solution formed on the basis of the reaction (these were determined experimentally):

- If 5 ml of 0.005 n yellow blood salt solution is poured into 5 ml of 0.005 n solution of ferric chloride and 50 ml of water is added to it, a clear colloidal solution of Berlin blue is formed.
- If 5 ml of 0.1 N solution of $K_4[Fe(CN)_6]$ is poured into 5 ml of 0.1 N $FeCl_3$ solution and 50 ml of water is added to it, a cloudy solution is formed and Berlin blue precipitates.
- If 5 ml of a saturated solution of $K_4[Fe(CN)_e]$ is added to 5 ml of a saturated solution of $FeCl_3$, a gel of Berlin blue is formed. By adding water and diluting it, you can make a colloidal solution of Berlin blueberry.

The natural water taken from natural water sources with the help of suction cups and sent to water treatment facilities and other branches of the power plant is called primary water (DQ_S), cleaned by chemical and thermal methods, and replaces the steam and condensate wasted in power plants. chemically pure water sent to the station (DQ_S) to cover the water that evaporates in the steam generator; called boiler water (DQ_S).

The steam turning into water in the turbine condenser is called turbine condensate (DTK). Turbine condensate makes up the main part of the supply water supplied to the steam generator in KES, and does not contain a large amount of mineral substances. The part of the water used in external consumer sources that require steam turns into steam and returns to the station is called return condensate (DKK).

Boiler water in steam generators and other steam-generating devices, water that is removed from them to keep the total salt content of water that turns into steam at the specified level, is called concentrate or pumped water (DHS). The water supplied to the turbine condenser to convert the spent steam into water is called cooling water (DSS).

The amount of lost steam and condensate when the above-mentioned equipment is working in KES is 1-3% of the amount of steam produced in the steam generator. To make up for this lost steam and condensate, additional highly purified water is continuously supplied to the plant from the water treatment plant [5-7].

Consumption of supply water sent to the steam generator in KES:

$$DTS=DTK+ DQS, \ [t\backslash h] \ or \ [kg\backslash sec] \quad (5)$$

where: DTS is the amount of supply water, t/h; DTK - amount of turbine condensate; t/h, DQS - amount of additional water, t/h.

If the amount of additional water in KES is around 1-3%, turbine condensate makes up the main part of supply water in such stations. In this case, the amount of salt in the supply water is determined by the following expression;

$$aTS=\frac{DTK}{DTS}\ aTK+ \frac{DQS}{DTS}\ aKS, \quad g\backslash t \quad (6)$$

where: DTK _ salt content of turbine condensate, g\t; DTS - salt content of supply water, g\t; DQS - salt content of additional water, g\t.

Due to the fact that the amount of additional water in condensing power plant (CPP) is slightly less than the amount of turbine condensate, the increase in the salt content of DTS mainly depends on the salt content of DTK. During the continuous operation of thermal power centers (TPC), the loss of steam and condensate occurs in both directions, i.e. inside the station and in external consumers to which steam is sent. The amount of water and condensate lost in these consumer sources depends on the technological design of steam generating devices and equipment, their reliable operation, and the amount of steam used in external consumer sources.

In TPCs, water moves along two closed circuits. In the first direction, through the turbine condenser directly to the deaerator, and in the second direction, the steam from the multi-branch turbine is sent to the deaerator after being highly purified in special devices for cleaning contaminated condensate through external production sources.

In TPCs, the consumption of supply water sent to the steam generator is expressed as follows:

$$DTS= DTK+ DQS +DQK+ DGK, [t\backslash hour] \quad (7)$$

where: DQK is the amount of condensate returning to the station every hour from external sources, t\h; DGK - the amount of steam sent to the station every hour from the steam generator expander, t\h.

In TPCs, the amount of lost steam and condensate from external and internal sources is somewhat higher than in CPP. The greater the amount of steam and condensate lost in the external sources of such plants, the greater the amount of water to be purified in water purification devices to replace it.

In the TPCs of some production enterprises, the condensate returning to the plant from external consumer sources is extremely polluted, and its level of pollution is even higher than the level of pollution of natural water. To clean such condensate at an additional water level, some complicated water treatment methods are required, and the economic funds spent on their cleaning will be a little more than the cleaning of natural waters. Therefore, high-level cleaning is not required for stations with a small water shortage.

They are cleaned in special wastewater treatment facilities and used for other purposes at the station. In this type of stations, the place of the lost condensate is mainly covered with additional water, so the main part of the supply water consists of additional water. Therefore, the change in the salt content of the supply water in TPCs does not depend only on the composition of the turbine condensate, as in the case of CPP, but mainly depends on the salt content of the additional water.

The salt content of supply water in TPCs is expressed as follows:

$$\text{aTS}= \frac{\text{DTK}}{\text{DTS}}\,\text{aTK}+\frac{\text{DKS}}{\text{DTS}}\,\text{aKS}+ \frac{\text{DKK}}{\text{DTS}}\text{aQK}+\frac{\text{DKb}}{\text{DTS}}\,\text{aKB, g\textbackslash t} \quad (8)$$

where: a_{QK} is the amount of salt of the condensate returning to the station from the external consumer, g\t; a_{KB} – the amount of salt in the steam taken from the steam expander, g\t.

Thermal power plants are divided into the following according to their function:

a) Thermal power plants TPP, these are heat and electricity;
b) Condensation heat power plants – CPP, which provide only electricity.

During the continuous operation of thermal power plants (PPT), the composition of periodically moving steam and condensate deteriorates more and more, and its pollution level rises above the amount specified in the operating standards, due to this, the separation of various layers on the walls of the heat exchanger is accelerated [8].

Causes of water and steam pollution in thermal power plants (PPT) and thermal power centers (PPC):

a) absorption of cooling water in the condenser through the condenser pipes into the pipe condensate;
b) air absorption into supply water in low and high pressure heat exchangers;
c) addition of highly unpurified distillate or unpurified water to the standards required in water treatment facilities to the turbine condensate or supply water;
d) in heat supply turbines, it occurs as a result of factors such as the addition of contaminated condensate returning from external sources to the turbine condensate.

The degree to which these factors affect steam and condensate pollution depends on the types of thermal power plants (TPP) and thermal power centers (TPC) and the efficient and reliable operation of their main equipment.

In condensers, the absorption of cooling water into the condensing steam occurs mainly as a result of the pressure of the cooling water being higher than the pressure of the condensing steam and the double-rusting of the refrigerant pipes of the condenser, the formation of cracks of various sizes in the pipes. During the continuous operation of the condenser, absorption of cooling water into the turbine condensate occurs in all TPP and TPCs.

If the amount of absorbed water is not greater than 0.001-0.003% of the amount of steam being condensed, such a situation is considered a normal situation for the station. If macro-cracks are formed in condenser pipes due to corrosion, the amount of absorbed water can be 10-20 times (0.01-0.02%) more than the normal state. If one of the condenser pipes is cracked and the water passing through it is completely added to the turbine condensate, the amount of water being sucked will be 200 times (0.2) more than the normal condition. In this case, contamination of the turbine condensate due to absorbed water and air mainly depends on the composition of the cooling water [9-11].

3 Results and discussion

If mineralized spring or river water is used as cooling water in the condenser, mainly Ca and Mg compounds are added to the turbine condensate with the absorbed water. On the contrary, if highly mineralized sea or lake waters are used, the concentration of Na compounds and the amount of kalloid and organic compounds in the turbine condensate will increase.

A solution of compounds such as ammonium hydroxide (NH_4OH), NH_3, hydrazine hydrate ($N_2H_4{*}2H_2O$) or hydrazine sulfate ($N_2H_4H_2SO_4$) are added to the supply water in thermal power plants (TPP) in order to prevent the formation of various layers on the heat exchange surface of steam and water heating devices and pipes and to protect them from rusting. The added NH_4OH solution, firstly, removes CO_2 gas from the supply water, and secondly, ensures that the pH of the supply water is within the standard of technical operation, that is, the specified standard of 8.0-10.5 provides. When the pH of the supply water is 8.0-10.5, an oxide layer is formed on the inner walls of the pipes through which water flows, which protects metals from rusting, and this oxide layer slows down the rusting of metals. The reaction of combining NH_4OH with CO_2 gas in water proceeds as follows:

$$-NH_4OH+CO_2=NH_4HCO_3 \quad (9)$$

$$NH_4HCO_3+NH_4OH=(NH_4)CO_3=H_2O \quad (10)$$

The results of the pH value of treated water are shown in Figure 1.

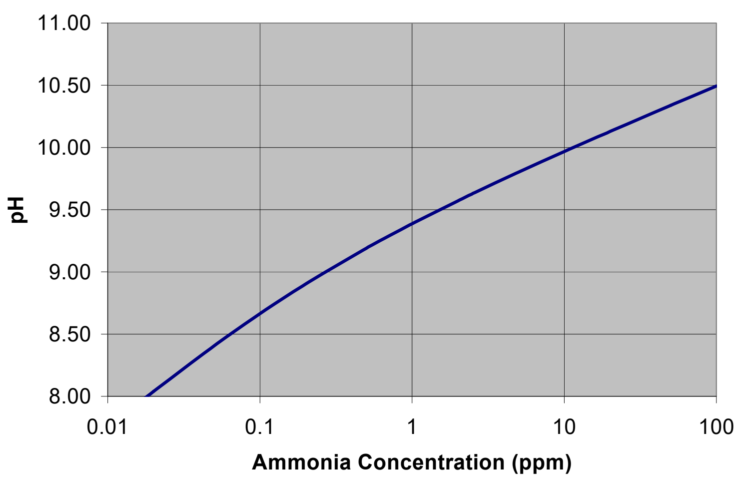

Fig. 1. pH value results of purified water.

The amount of NH_4OH added per liter for cleaning the supply water from CO_2 gas and keeping the pH of the water in the range of 8.0-10.5 is 0.4-0.5 mg should be more than the amount used to bind CO_2 gas in the water.

The N_2H_4 solution added to the wastewater reduces the concentration of O_2 gas in the water. The reaction of N_2H_4 with O_2 proceeds as follows:

$$N_2H_4+O_2=N_2=2H_2O \tag{11}$$

The combination of hydrazine and oxygen does not increase the salt content of boiler water, because as a result of their combination, inert N_2 gas is formed.

In order to reduce the level of pollution of steam and condensate in thermal power plants, it is necessary to follow the following requirements:

- preparation of steam and condensate-passing parts of the main and additional devices of thermal power plants operating at high temperature and pressure from corrosion-resistant metals;
- timely and high-quality cleaning of the layers of condenser pipes exposed to steam and water;
- reducing the amount of absorbed water into the turbine condensate;
- that the distillate sent to the station from the devices that generate steam and receive distillate is of a quality that is always required;
- that the quality and parameters of the additional water sent to the station from the water treatment facilities are always within the specified standard;
- sending the condensate returning to the station from external sources to the station after it is cleaned to the required standard in condensate treatment facilities.

Factors such as ensuring that the salt content of the boiler water in the steam generator does not exceed the allowable increase in the process of continuous steam conversion dramatically reduce the level of water and steam pollution in the periodic circulation at the station and ensure the long-term efficiency of the equipment at the station. and ensures reliable operation.

4 Conclusion

Thus, it is necessary to achieve that energy and their benefit to people in the creation of steam-gas devices should be as light as possible, strong enough, simple in shape, easy to use, safe and fully meet the requirements of the state standard. In addition, it is now important to study steam-gas devices and increase their durability, in order to meet the needs of providing heat and electricity to the population in the national economy and agriculture.

Therefore, the task of every worker, engineer, and scientist is to create new devices that fully meet the requirements of our time, are highly productive, durable, and have a high efficiency. For this purpose, it is necessary to achieve that in the creation of energy and their steam-gas devices, which are beneficial to people, as light as possible, strong enough, simple in shape, easy to use, safe and fully meet the requirements of the state standard. In addition, the study of steam-gas devices in order to provide electricity to the population in agriculture is considered important for today.

References

1. D.N. Mukhiddinov, E.K. Matjanov, *Turbine devices of thermal power plants* (Tashkent, sharq publishing house, 2007) **3**, 120-127
2. K.A. Alimov, R.F. Mingazov, K.Kh. Akhmedov, *Boiler equipment of thermal power plants* (Tashkent, New edition, 2012) **5**, 64-71

3. D.A. Khadjibaev, Chemical journal of Uzbekistan **5**, 61-68 (2020)
4. D.A. Khadjibaev, F.I. Erkabaev, Enrichment of glaucanite minerals used in water softening, Current problems of innovative technologies in the chemical, oil and gas and food industries, collection of proceedings of a scientific and technical conference **3,** 87-88 (2020)
5. D.A. Mukhammadieva, D.A. Khadjibaev, F.I. Erkabaev, *Treatment of industrial wastewater from ions heavy metals by electrochemical method,* Innovative technologies based on local raw materials and secondary resources. Republican scientific and technical conference. Uranch **4,** 87-93 (2021)
6. Q.A. Yakubov, E.S. Boriyev, *Waste water treatment*. Textbook (T-innovation rivsh, 2020) **7**, 85-92
7. M. Akhtamova, U. Temirov, N. Khurramov, A. Shukurov, B. Karshiev, E3S Web of Conferences **434** 03016 (2023)
8. D.N. Oljaev, Z.U. Karimova, Q.Kh. Ganiev, D.N. Shermatova, Research and education scientific journal **9**, 71-75 (2023)
9. D.N. Oljaev, H.Sh. Urunova, L.A. Bozorov, M.B. Barakayev, Research and education scientific journal **9**, 269-275 (2023)
10. D.N. Oljaev, T.I. Nurmurodov, N.I. Khurramov, S.Sh. Sharipov, Obogashchenie Rud **3**, 16-22 (2023). https://www.doi.org/10.17580/or.2023.03.03
11. U. Sharafutdinov, I. Razhabboev, Z. Kadirova, A. Koldarov, M. Atamuratova, E3S Web of Conferences, **414,** 02020 (2023)