E3S Web of Conferences **390**, 05010 (2023) https://doi.org/10.1051/e3sconf/202339005010
AGRITECH-VIII 2023

Improving the efficiency of the water treatment system at the thermal station

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Abstract. The solution of the problems of increasing energy efficiency at the enterprises of the energy industry is largely due to the competent organization of modern methods of water treatment, which are one of the main units in the technological chain in the production of thermal and electrical energy. Improvement of water treatment technology can be considered as one of the directions of implementation of energy-saving measures at energy facilities. An important task is the introduction of energy-efficient methods of water treatment at thermal stations, including the method of desalination of water. There are the methods of water treatment using instant boiling evaporators, which make it possible to obtain desalinated water for steam boilers in this paper. The efficiency of the proposed water treatment system at a thermal station is shown.

1 Introduction

The feed water heat desalination plant currently used at the Kazan TPP (thermal power plant) has a significant drawback: at the first stage, surface evaporators are used in which water boils, and therefore the heating surface is polluted with salt deposits. Soft water is used as the feed water of the evaporation plant to reduce deposits. And only at the second stage, a flash distiller is used [1-4].

This paper presents the results of a study of the use of modern flash distiller (FD) to obtain desalinated water.

Flash distillers are used for evaporative cooling and heating of liquids, obtaining deep-desalinated water.

The device consists of an evaporation chamber and a heat exchange surface with a distillate collector. Several evaporative stages with condensers, which are connected in series, by counterflow through heated and cooled media, are more often used in flash distillers [5-7]. This design allows to increase the thermal efficiency of the installation and reduce its metal consumption. The number of stages is determined by the available temperature difference at one stage according to the conditions of vaporization and the required amount of distillate.

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The use of FD has the following advantages:

- an insignificant amount of chemical reagents used to correct the water and chemical regime of protection against scale deposit and corrosion and, as a result, minimal discharge of salts with waste;
- the use of various sources of thermal energy, including cheap waste heat,
- multipurpose use for obtaining desalinated water and heating process media, waste water treatment [8,9].

2 Materials and methods

The use of heat recovery in flash distillers can significantly reduce energy costs and the amount of purging wastewater. Separation of boiling processes in the apparatus allows to reduce scale deposit formation and corrosion. The intensification of heat exchange through the use of special profiles of heat exchange pipes reduces the metal consumption and the cost of equipment.

The degree of heat recovery in installations is determined by the cooling conditions, that is, the temperature of the cooling (heated) medium and the required/permissible temperature of the heated medium. Capital costs for the construction of installations depend on their capacity, placement conditions and material performance of equipment according to corrosion resistance conditions [10-13].

The experience of using multi-stage FD for cooling and heat recovery of liquids containing a significant amount of various solid impurities shows their high efficiency and reliability [14-16]. For example, this technology is used in the production of soda to recycle the heat of hot waste water, which contains a large amount of gypsum sludge and ammonia. Similar installations are effectively used in coke production for cooling waste water with a high content of harmful gases (ammonia, cyanides, etc.), which additionally allows to solve environmental issues of reducing harmful gas emissions and waste water into the environment.

As it follows from the technologies, in the process of heat and mass transfer, distillate evaporation is carried out in flash distillers, that allows using this equipment for concentrating various solutions, evaporation of waste water, distillation of volatile substances. The optimal concentration limit in FD is up to 10%, but it can be increased in combination with other methods.

3 Results

Multi stage evaporative plants (MEP) with I-600 apparatus and auxiliary equipment (mechanical and sodium-cationite filters for the preparation of MEP feed water, an atmospheric deaerator, deaerated water heaters, feed and condensate pumps) were installed and put into operation at the Kazan TPP [17-20]. The filter hall of the unit consists of mechanical Na-cation filters of the first and second stages. The source water is prepared to power the evaporators in this hall.

The first series of evaporators of a multi-stage evaporation plant (MEP) was put into operation in 1996. It consists of six evaporators (I-600 type) with a total capacity of 120 t/h.

The second series of MEP evaporators, that was put into operation in 1999, also consists of six evaporators (I-600 type) with a total capacity of 120 t/h [21-22].

The heating steam of the MEP is a steam 13 atm. In the process of distillate production, an excess steam of low parameters in the amount of 15 to 25 t/h is formed behind the last stage, which currently cannot be fully used, which reduces the productivity and efficiency of the installation.

 https://doi.org/10.1051/e3sconf/202339005010

To solve this problem, technical proposals were developed for the introduction of a thermal desalting complex based on MEP with newly installed flash distillers FD-50-16 (two evaporators with a capacity of 50 t/h each).

Flash distillers are a two-body structure with 16 expansion stages. There are 8 evaporation stages in each case.

The heating steam of the FD-50 is the secondary steam of the MEP, and the heat of the steam of the last FD is used to heat the source water. Both sodium-cated and lime-coagulated water can serve as a feed water for FD.

This scheme makes it possible to utilize up to 20 t/h of excess secondary MEP steam, while obtaining an additional 100 t/h of distillate.

The advantages of FD should include their ability to automatically self-maintain fluid levels in the expansion chambers. This circumstance eliminates the need to install electronic level regulators, which greatly simplifies the maintenance of evaporators. The principle of operation of the FD is as follows (Figure 1).

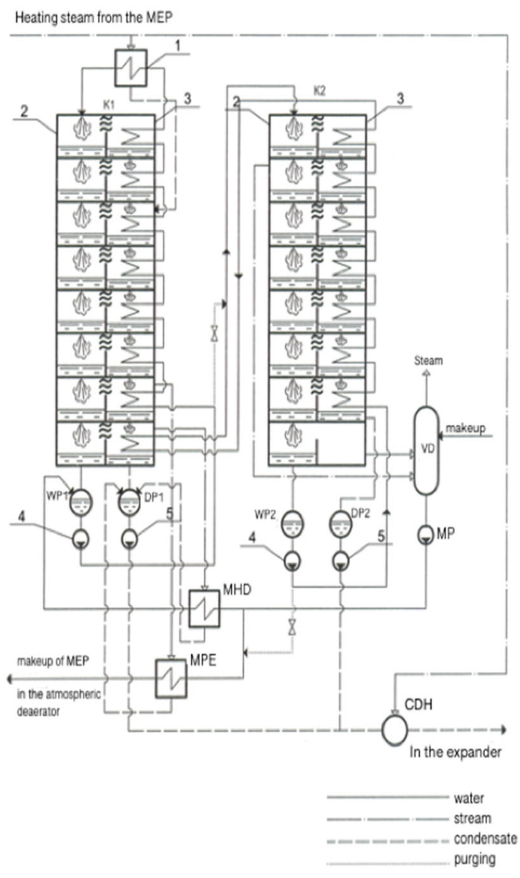

Fig. 1. Diagram of the FD of the chemical water treatment plant. The follow designations are accepted: 1 – main heater; 2 – evaporator expansion chamber; 3 – stage condenser; 4 – circulating water pump; 5 – distillate pump; K1, K2 – current columns; DV – vacuum deaerator; WT 1,2 – tanks of circulation water; DC 1,2 – distillate collectors; MP – makeup pump; MHD - makeup heater of flash distiller; MPE – makeup heater of multi-stage evaporation plant; CDH – contact distillate heater.

The circulating water of the heater 1 with a temperature of 105°C enters the expansion chambers of the evaporator 2 and then passes the remaining chambers sequentially from top to bottom. In each expansion chamber, the water boils, cooling by 3-4°C. The resulting steam condenses on the condenser tubes 3, giving heat to the circulating water. Condensate (distillate) flows down to the bottom of the condensation chamber and then through the trap from stage to stage. From the last stage of the first and second columns, the distillate is pumped by pumps 5 into the TPP cycle; (the drum boilers have 140 atmospheres, and the circulating water is supplied by pump 4 to the pipe system of the evaporator condenser. The steam of the last stage of the expander condenses on the tubes of the condenser, cooled by an outside stream of water, or is sucked off to a vacuum deaerator.

The heat desalting complex with the capacity of 340 t/h will fully cover the need for boiler makeup water in the summer. In winter, the addition of chemically desalinated water in the range of 150-250 t/h is required. The heat desalting complex (2 MEP + 2 FD) provides distillate with a temperature of 75-70°C of the following quality: the concentration of SiO_2 is no more than 20 micrograms/kg, the concentration of Na is no more than 20mcg/kg.

4 Conclusion

Flash distillers are quite easy to operate and have a number of advantages:

- the process in the FD proceeds in the temperature range of 105-40˚C;
- FD has two circuits and the maximum concentration of water occurs in the second circuit in the temperature range of 40-70˚C;
- there are no boiling processes on the water surface.

An important circumstance of the application of technology of thermal water treatment based on FD and MEP is:

- the reduction of the cost of production of thermal distillate by 2-2.5 times compared to the chemical desalination;
- the reduction of the discharge of regenerative waste water up to 50% and raw water consumption by 30%;
- the decrease of heat discharge with chemical water treatment regeneration waters;
- the simplification of the process automation diagram by 50-70%;
- the reduction of production areas for the placement of desalting plants by five times;
- the stable water and chemical regime, and, consequently, the quality of the distillate that passes the standards of the rules for technical operation;
- the reduction of acid cleaning of power boilers by 2-3 times.

This paper has been supported by the Kazan Federal University Strategic Academic Leadership Program ("PRIORITY-2030"). This study was carried out using the equipment of the Center for Collective Use “Nanomaterials and Nanotechnology” of the Kazan National Research Technological University.

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