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IMPROVING THE OPERATION PROCESS OF A THERMAL DEAERATOR DEVICE AT A THERMAL POWER PLANT

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Abstract: The article develops schemes for the targeted use of heat and condensate from the thermal deaerator of thermal power plants in the power unit. Their impact on the operation of the power unit is assessed and areas of application are based.

Keywords: thermal deaerator, evaporation, aggressive gases, heat exchanger, heat and mass transfer, separator, additional water deaerator.

Introduction. As a key component of the boiler and condensate system, the deaerator plays an important role in the steam-power cycle. Deaerators also perform the deaeration process and preheat the supply water. If the deaeration efficiency of the deaerator is low or any of the deaeration equipment is damaged, it will lead to damage, corrosion, and scale formation of heat exchange surfaces such as the screen tube system and steam transfer tubes of the boiler plant in the power unit.

The deaerator load depends on the complex effects of changing operating conditions, heating steam consumption, and consumption indicators in the pipelines. The water level changes with the change in the load, which creates hidden dangers in the operation of the boiler plant and the power plant. Therefore, mastering the dynamic characteristics of the deaerator is very important for the safe and stable operation of steam turbine units, improving the efficiency of the heat cycle, ensuring the quality of the supply water, and ultimately extending the service life of the entire steam turbine unit [1].

Currently, a number of studies are being conducted by domestic and foreign researchers on the working mechanism of the deaerator. Zhi Li, using the deaerator of a 1000 MW nuclear power plant unit as a research object, created a mathematical model of the deaerator based on the law of conservation of energy and mass, and created a water level control system in the deaerator with a PID controller [1]. In order to prevent cavitation of the water pump during the operation of thermal power plant units, Xiangxin Gu developed a transient computational model of the deaerator and proposed several anti-cavitation control schemes as optimization measures under load conditions [2]. Dr. Jackson Akpa et al. developed a deaerator model to predict the actual steam and exhaust gas velocities required for mechanical deaeration and used the continuity equation to estimate the oxygen concentration in the deaerator feed water and control the deaerator operating trend [3]. V. P. Zhukov et al. conducted extensive research on the deaerator heat and mass transfer process and proposed a mesh matrix method to calculate the deaerator transfer characteristics and studied an optimized control method based on this [4].

The deaerator is a contact heat exchanger, which is different from shell-and-tube heat exchangers. It heats the cycle condensate to the saturation temperature using superheated steam. Typically, the installation of temperature, pressure, and flow sensors inside the deaerator is very limited, and obtaining accurate values of the total and distributed operating parameters of the deaerator in real time is a very difficult process. Currently, most of the research on modeling deaerators is based on deaerators in power plants [5], [6], [7], [8].

Methodology. The main condensate from the cycle, high-pressure heater drainage water, heating boiler steam, storage valve stem vapors, and steam from the final turbine condensers enter the supply water deaerators. As a result of the fusion of the steam and condensate phases, heat and mass exchange occur, and oxygen and oxygen-containing gases that cause corrosion are separated from the condensate and discharged in the form of vapor. The amount of vapor is 1-3 kg per 1 ton of deaerated water [9].

The fact that the amount of vapor released in the process as vapor is 1-3 kg per 1 ton of deaerated water causes a waste of chemically treated water in large-capacity power plants. Due to the presence of aggressive gases in the vapor that cause oxygen corrosion, this vapor is released into the atmosphere in power units currently in operation. As a result, additional water is required to replace the water lost in the cycle.

In our research, a problem that is little studied in modern scientific research today is proposed, namely, a device for the targeted use of the evaporation condensate and heat released in the deaerator. Since increasing efficiency and reducing the waste of the working medium in the process of deaeration of the supply water of power plants is an urgent issue.

To achieve the set goal, a principle diagram of a thermal deaerator device was developed and the following was based. In power plants currently in use, 1-3 kg of vapor is released to deaerate 1 ton of water (for comparison, in a 300 MW power unit, the water consumption is 1050 tons/hour, the pressure in the deaerator is 0.7 MPa, the vapor output is 5 tons/hour, usually this mass is discharged into the atmosphere). By implementing the proposed device in production, it is possible to convert vapor into condensate in an evaporative cooler, release aggressive gases into the atmosphere, and return the obtained condensate to the cycle through an additional water deaerator after analytical tests, reducing condensate losses in power plants by 25%, and also increasing the efficiency of deaeration due to additional water heating in the evaporative cooler.

Results. Figure 1 shows the schematic diagram of the thermal deaerator device, and Figure 2 shows the structure of the evaporative cooler.

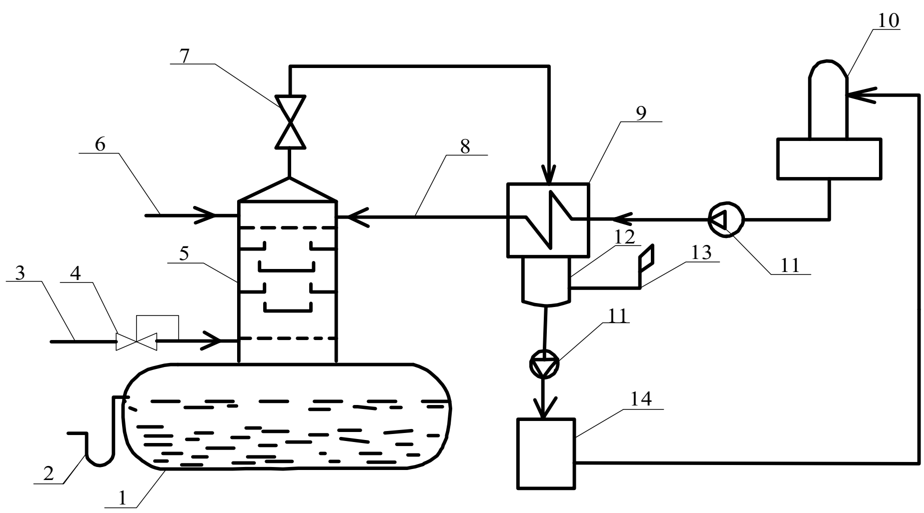

Fig. 1. Schematic diagram of a thermal deaerator device

The principle diagram of the thermal deaerator device shown in Fig. 1 consists of the following: 1-deaerator tank; 2-hydrogen trap; 3-heating steam pipe; 4-flow regulator valve; 5-deaerator column; 6-main condensate pipe; 7-evaporation valve; 8-additional water pipe; 9-evaporation cooler; 10-additional water deaerator; 11-pump; 12-separator; 13-aggressive gas outlet pipe; 14-condensate cleaning device.

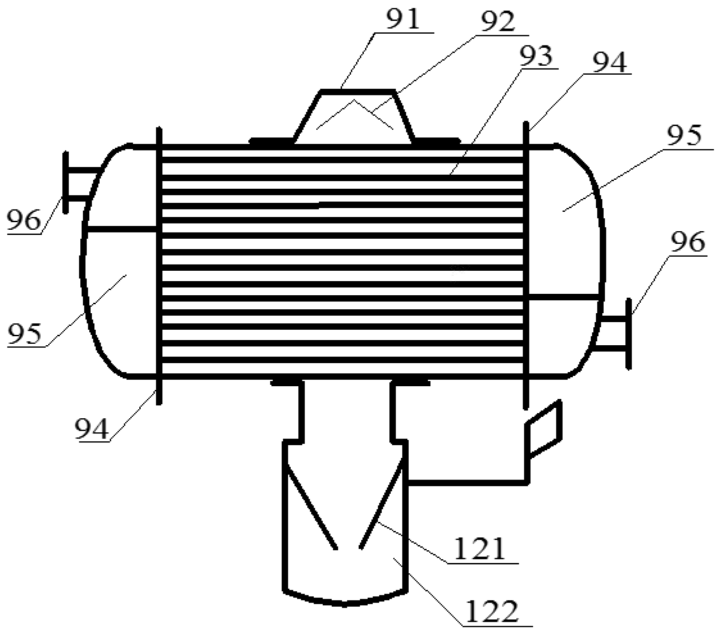

Fig. 2. Structure of an evaporative cooler in thermal deaerators

The structure of the evaporative cooler shown in Figure 2 consists of the following: 91-inlet pipe to the evaporative cooler body; 92-separator; 93-cooler pipes; 94-pipe plate; 95-water chamber; 96-inlet and outlet pipes; 121-separator funnel; 122-condensate collector.

The thermal deaerator device includes the following technological processes. The deaerator tank 1 is equipped with a hydraulic valve 2 to maintain the supply water level at a specified level, the heating steam 3 is supplied to the deaerator column 5 through a flow regulator valve 4, after the main condensate 6 is introduced from the upper part of the column, the deaeration process begins and as a result of the interaction of the heating steam with the condensate, the vapor begins to separate, the vapor is removed through the vapor valve 7 in the upper part of the column, the condensate lost in the cycle is replaced through an additional water pipe 8 attached to the column, the vapor leaving the deaerator is transferred to the evaporative cooler 9, the supply water pumped from the additional water deaerator 10 by a pump 11 is used as the cooling water in the evaporative cooler, a separator 12 device is attached to the lower part of the evaporative cooler body, where the non-condensable gases separated there are discharged into the atmosphere through the outlet pipe 13, and the condensate obtained is 11 is transferred to the condensate cleaning device 14, in turn, the condensate cleaning device is proposed to be used for the first time in the utility model, since the oxygen compounds contained in the condensate are in the form of a solution, which are considered to be corrosive to metal surfaces, after complete purification of these compounds in the condensate cleaning device 14, laboratory testing is carried out and transferred to the additional water deaerator 10, all types of thermal power plants are equipped with an additional water preparation deaerator 10 to compensate for the working fluid losses in the main cycle and for the primary purification of the incoming water from corrosive gases, in the developed scheme, it is proposed to pass the condensate discharged from the condensate cleaning device 14 through the additional water preparation deaerator 10 and use it in the cycle, in turn, the evaporative cooler 9 and the separator 12 are structurally connected elements.

The evaporator is fed into the evaporative cooler body through a conical inlet pipe 91, which is equipped with a separator 92 to ensure even distribution of the evaporator throughout the cooler body. The evaporative cooler pipes 93 are fixed on both sides to the tube sheet 94, in turn, the tube sheet separates the part of the evaporative cooler body where the pipes are located from the water chamber 95. The water chamber 95 is provided with cooling water inlet and outlet pipes 96, barriers (in Russian, peregorodka) for turning the water flow (in heat exchange devices, the walls separating the water chamber into separate chambers are called “barriers” (peregorodka)). The flow in the pipes connected to the separated part of the tube sheet, flowing in one direction, is conventionally called a “path”. The fact that the design in the proposed scheme is “multi-path” is considered a different aspect from the design of the evaporative cooler used in the analog and prototype, and the evaporator The cooler is considered to be designed as a multi-pass heat exchanger, the separator 12, which is connected to the bottom of the cooler, is equipped with a funnel 121 with a special structure (not shown in the diagram) to create a turbulent flow of condensate, the turbulent movement of the flow accelerates the separation of gas particles, the condensate collects at the bottom of the separator, therefore this part is called the condensate collector 122. It is advisable to make the elements of the evaporative cooler body - walls, pipes and tube sheet, thermal and technical properties of which are resistant to corrosion and salt deposits, for example, brass.

Conclusion. The device can be used as an energy and resource-saving system for thermal deaeration of boiler water in thermal power plants, preventing condensate loss and ensuring a high-quality deaeration process by heating additional water.

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