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THERMAL TREATMENT OF INDUSTRIAL WASTEWATER

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Abstract. The paper provides an overview on the major methods of thermal wastewater treatment in the power industry. Here, we present the main advantages and disadvantages of methods based on the concentration of inorganic substances (evaporation or distillation) or the burning of organic compounds (combustion neutralization). The study suggests the possible future directions for the development of thermal wastewater treatment.

1. Introduction

To date, there is a constant increase in production capacity in various sectors of world industry. This leads to more intensive environmental pollution. Nowadays, anthropogenic impact on the environment, including the hydrosphere, is not compensated by biosphere cleaning processes to the necessary extent. The problem of the rational use of water and its cleaning from various contaminants is becoming more and more urgent under modern conditions [1–3].

Wastewater contaminants are characterized by considerable variety. Moreover, the composition and concentration of such contaminants is dependent mainly on the technological process. Therefore, wastewater treatment methods vary.

The study [4] suggested that one of the major industries in Russia, which is characterized by a significant amount of wastewater discharge (about 50% of all discharges), is the power industry. Power plant wastewater contain calcium and magnesium carbonates, ash, soot, corrosive acids, sulfates, ammonia, hydrazine, arsenic, vanadium, oil, petroleum products, and etc. In particular, it is possible to remove these impurities by thermal wastewater treatment. The main arguments in favor of using thermal wastewater treatment are the ease of its implementation and high efficiency.

The aim of this paper is to analyze the current stage of the development of thermal wastewater treatment in the power industry.

2. Results and Discussion

Among the major methods of thermal wastewater treatment is the evaporation of inorganic substances. This is one of the simplest methods to implement. Also, along with its simplicity, this method is characterized by high removal efficiency, high productivity and relatively low-cost technology.

The process of evaporation is used for different purposes – desalination, the separation of mixtures, the concentration of solutions, and etc. The method involves the heating of water with

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impurities (a solution), its evaporation and subsequent condensation of purified steam, the concentration of contaminants and their removing. There are several types of modern distillation plants: evaporative, adiabatic, with an intermediate heat carrier, with boiling in a fluidized bed, and etc. [5].

Fig. 1 shows a diagram of a distillation plant for concentrating inorganic substances solutions.

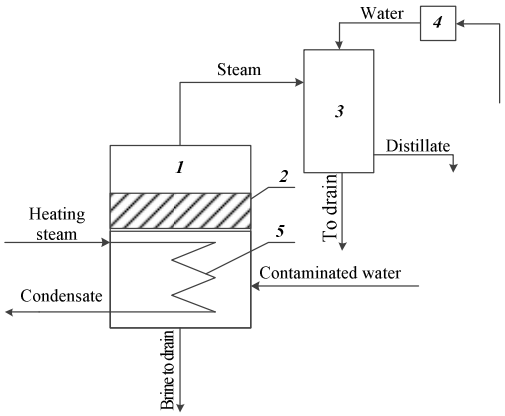

Figure 1. Diagram of a single-stage distillation plant: *1* – evaporation chamber; *2* – separator; *3* – condenser; *4* – water cooling pump; *5* – heating element.

The table below shows the comparative characteristics of different types of evaporators.

Table. Comparative characteristics of the different types of evaporators

Type of evaporator	Evaporative	Film	With an intermediate heat carrier	Contact	Adiabatic
Advantages	Simple design, high heat transfer coefficient, providing stable circulation, soft start.	High heat transfer coefficient, momentary contact of liquid with a heating surface, high specific steam capacity, small size.	The possibility of using "dirty" coolants.	High heat transfer coefficient, the possibility of using secondary energy sources, high degree of concentration, low specific heat consumption.	The possibility of using low-temperature secondary energy sources, high degree of concentration, low specific heat consumption, the possibility of placing the individual units of a plant at the considerable distance.
Disadvantages	Sensitivity to changes in conditions, high scale formation, high temperature pressure of a heating surface, large size.	The high costs of operation and maintenance, sensitivity to scaling, sensitivity to changes in operating conditions.	Large size, high material consumption, complexity of operation and automation.	Large size, design complexity, the possibility of mixing a heat transfer agent and a solution.	Large size, high material consumption, the need to maintain a vacuum in the system.

Among methods of thermal wastewater treatment from oil and other flammable substances, there is combustion neutralization [6, 7]. The method is as follows: polluted water is sprayed into the flow of combustion products at the temperature 900÷1000 ^{0}C. During the reaction, organic substances are burnt, while incombustible impurities precipitate or emit with exhaust gases. Vapor, generated as a

result of water evaporation, is removed from a combustion chamber and condenses. It should be noted that this method of treatment is also used for the neutralization of toxic wastewater.

Fig. 2 shows a diagram of a plant with heat recovery for wastewater combustion neutralization.

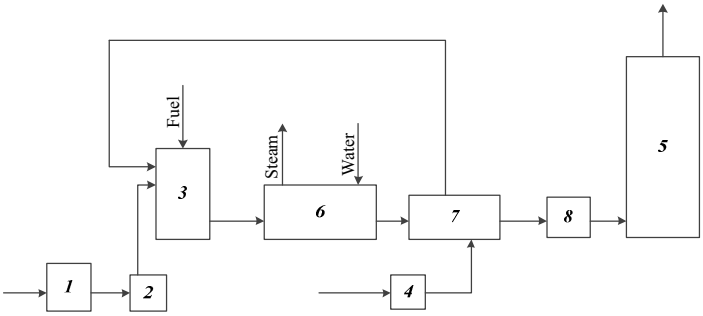

Figure 2. Diagram of a plant for wastewater combustion neutralization: *1* – wastewater collector; *2* – pump; *3* – combustion chamber; *4* – blower; *5* – chimney; *6* – waste heat recovery boiler; *7* – air heater; *8* – exhauster.

The advantages of wastewater combustion neutralization include high efficiency and the simplicity of operation. However, along with these advantages, there are some disadvantages of the method, which should be considered: the need for using additional fuel, large size installations.

Reducing costs for the implementation of evaporative and combustion wastewater treatment and for increasing their efficiency would certainly widen the scope of their application. This would allow them to replace more expensive and complicated methods of wastewater treatment. It seems appropriate to study heat and mass transfer processes, occurring at the implementation of these technologies. In particular, it is possible to conduct research using complex software and hardware systems, specialized data processing algorithms, panoramic methods and numerical models [8–10].

3. Conclusion

This work presented the overview of the major methods of thermal wastewater treatment. Results proved that there are some advantages, disadvantages and difficulties in the implementation of these methods in practice. The information about identified disadvantages may help when choosing the direction of further research to improve the effectiveness of wastewater treatment in industry.

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