

ENVIRONMENTALLY FRIENDLY WATER TREATMENT TECHNOLOGY AT THERMAL POWER PLANTS

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ABSTRACT

Water determines the quality of life and is a strategic resource, whose value has been steadily increasing every year. Water reserves are becoming unfit for consumption due to the water scarcity in many regions of the world and the pollution of the environment. Therefore, there is a strong demand for the development of new, highly-efficient and cost-effective technologies in the field of water treatment with reduced pollution to the environment. This paper describes the working principle of the highly efficient and latest equipment named IBE "ECOTECH". The technological and environmental advantages of the IBE "ECOTECH" water treatment equipment are discussed. Further suggestions are given to develop and take advantage in power engineering.

Keywords: Thermal Power Plants, water treatment, desalination, IBE "ECOTECH", thermal efficiency.

INTRODUCTION

Thermal power plants (TPPs) of Uzbekistan are powerful producers of thermal and electrical energy. At the same time, they are the largest producers of demineralized water (more than 20 million m³/year), which is required to replenish steam-water losses and conduct technological processes at TPPs. Currently, the production of demineralized water at TPPs is carried out mainly by chemical methods, which is associated with significant production costs and harmful effects on water sources due to the consumption of a large amount of chemicals and resins, which are discharged into water bodies with spent regeneration solutions. For example, during

chemical desalination, when 1 kg of salts are extracted from water, up to 2-3 kg of reagents are required, therefore, three-four times more salts are discharged into the reservoir than is extracted, which sharply increases the mineralization of reservoirs and leads to their degradation. Therefore, the tasks of reducing the cost of preparation of desalinated water and reducing the discharge of salts into water bodies for the power system are very relevant and timely.

METHODS

The reliability and efficiency of the CHP operation is largely determined by the quality of the make-up water for boiler units and district heating systems. CHP plants and many industries require the production of water for technological purposes of very high quality. The salt content in this water should be tens of thousands of times less than in the original natural water. The production of water of this quality is an expensive undertaking and has the greatest stress on water bodies.

It became possible to increase the efficiency of water treatment and significantly reduce the harmful effect on the environment due to the use of the latest equipment for flash boiling evaporators IBE "ECOTECH" - this equipment is made on the basis of modern patent solutions in the field of thermal desalination, differing from previous evaporators, compactness and high thermal efficiency.

In the recent past, thermal desalination technology was in little demand due to its high energy consumption and manufacturing costs (metal consumption, large dimensions, etc.). The developers managed to optimize technological processes, drastically reduce the energy consumption of production and significantly reduce the size of the evaporator, in contrast to those manufactured in the 80-90s.

Instant boiling evaporator "ECOTECH" with a capacity of 50 tons/hour consists of two rectangular buildings, each with a size of 6x5x1.4 m (height, length, width) and produces a very high quality of demineralized water ($\text{Na}^+ = 3-15 \mu\text{g}/\text{kg}$, $\text{SiO}_3^{2-} = 2-15 \mu\text{g}/\text{kg}$, hardness = 0,2-0,8 $\mu\text{g-eq} / \text{kg}$, electrical conductivity = 0,3-0,8 $\mu\text{S}/\text{cm}$).

With the introduction of the technology of thermal desalination based on IBE "ECOTECH":

- Firstly, undeniable environmental advantages are achieved in comparison with the most modern technologies of chemical desalination, for which, even with the consumption of reagents close to the stoichiometric content of salts in the discharged (blowdown) waters, their content will be 2 times higher than the original water, and for IBE "ECOTECH". This indicator will be close to one;

- Secondly, the costs of producing demineralized water will decrease in comparison with a traditional chemical desalination unit, only by reducing the

consumption of reagents.

Obtaining water of the highest purity at IBE "ECOTECH" consists in generating steam due to adiabatic boiling of water, and this process is carried out at low temperatures of 35 - 100 °C and in free volume, which makes it possible to work on water that has undergone simplified processing.

IBE "ECOTECH" are not very sensitive to mechanical, organic and mineral (scale- forming) impurities in the source water. This circumstance combined with the stepwise process of evaporation of the initial water in two buildings due to a sequential feeding scheme, makes it possible to replace the chemical methods of processing the initial water with correctional ones based on dosing a small amount of reagents into the initial clarified water, inhibiting the processes of scale formation and sharply reducing the intensity of iron acid deposits. The dose of reagents does not exceed 3 mg/l.

The technological and environmental advantages of the water treatment technology for power engineering at the IBE "ECOTECH" are obvious and are achieved due to:

- use of waste low-grade steam with a pressure of less than 1.2 atm as a heat source;
- generating steam under vacuum (low temperatures) in free space;
- organization of optimal processes of steam separation in conditions of low heights of evaporation chambers (0.4-0.7 m), providing steam moisture $2 \cdot 10^{-5}$ - $5 \cdot 10^{-6}$ kg/kg;
- thermal perfection of steam generation processes, residual "non-boiling" less than 0.1°C;
- optimal organization of steam streams in the evaporator condensers, providing rational washing of heat exchange tube bundles and localization of non- condensable gases;
- the use of effective antiscaling, stepwise evaporation process;
- optimal thermal scheme of IBE "ECOTECH" which ensures its switching on according to the equipotential scheme (without loss of steam potential) with the return of the used heat to the cycle of a thermal power plant or enterprise and the production of up to 10 tons of demineralized water per 1 ton of heating steam.
- service life of at least 20 years with a payback period of 2-3 years.

For example, the cost of the demineralized water obtained at the ECOTECH IBE is more than two times less than the cost of demineralized water obtained by traditional technology, and the consumption of reagents can be reduced hundreds of times. The technology is equipped with a modern distributed integrated control system based on

microprocessor technology and variable drive and is 100% automated. The presence of people is minimal.

Comparative data of this equipment in comparison with the most modern foreign counterparts show its high competitiveness and superiority.

The use of IBE "ECOTECH" will significantly simplify the water treatment system, which will allow obtaining undeniable economic advantages in comparison with the use of modern reagents and technologies of reverse osmosis and chemical desalination, which, in general, will give a significant economic effect in any industry.

RESULTS

The relevance of the direction and implementation of thermal desalting complexes based on the IBE "ECOTECH" in power systems can be carried out in three directions:

The first direction is associated with increasing the thermal efficiency of autonomous multistage evaporating units (MEP). It is known that MEPs, especially in the summer, need to dispose of excess low-grade steam of the last stage and expansion tank.

This state of affairs forces the personnel of the CHP to discharge part of the steam into the atmosphere or to reduce the productivity of the MEP, which is unacceptable due to the need to maintain reserve chemical desalting plants.

The implementation of such a combined technological chain of two evaporation units, one of which operates in the temperature range of 180 - 110°C, and the second 110 - 4°C allowed increasing the production of distillate from 100 t/h to 160 t/h with almost constant consumption of heating steam at the MEP, which significantly increased the efficiency of the MEP and reduced the cost of distillate by reducing its fuel component.

"Table 1" shows that it was possible to fully use the surplus steam of the MEP and significantly reduce the costs of non-heat in the production of distillate.

Table 1

Comparison of MEP and combined evaporation plant

Part of the Equipment	Evaporation Plant Type	
	MEP-100	MEP-100 + IBE "ECOTECH"
1. Productivity, t/h	100	160
2. Heating steam consumption, t/h	22	22
3. Specific metal consumption, t/t	2,4	1,9
4. Specific output, t / t (n1: n2)	4,54	7,27
5. Excess steam, t/h	12,8	0

The reduction in fuel consumption for the production of distillate at the combined plant is ± 5.5 kg of fuel equivalent/t or 7040 t of fuel equivalent/year compared to the MEP (without IBE "ECOTECH" and the consumption of acid and alkali in the chemical plant of the CHP reduced by ± 965 t/year due to the replacement of chemically demineralized water with distillate, which had a beneficial effect on the water sources adjacent to the CHP. Thus, due to the implementation of the combined scheme, the uninterrupted operation of the MEP in the summer period was ensured at maximum performance without discharge of excess steam into the atmosphere (up to 10 t/h), which increased the reliability of the MEP operation in providing the CHP with demineralized water and made it possible to obtain additional fuel savings of ± 1200 tons of fuel equivalent/year due to the elimination of heat (and condensate) discharge into the atmosphere. With the commissioning of the CHP IBE "ECOTECH" on the second line, the total productivity of the thermal desalting complex (2xMEP + 2xIBE) amounted to 340 t/h (in summer) and 400 t/h (in winter), and the annual fuel saving is not less than 16,000 tons of fuel equivalent/year compared to the operation of the MEP, which is important in connection with the expected multiple increase in fuel prices.

The second direction is associated with the introduction of the IBE "ECOTECH" in the circuits of the heating system make-up. At CHPs with a high consumption of the heating system make-up water, it seems possible to significantly simplify the design of the IBE "ECOTECH" by reducing the number of steps from 18 to 9 and to reduce the metal consumption of the IBE "ECOTECH" by almost half. This made it

possible to develop for this CHP a compact thermal desalting unit with a capacity of 200 t/h, consisting of four rectangular columns each measuring 1.8x6.5x7.0 m (width, length, height).

Each IBE “ECOTECH” consumes steam from cogeneration extraction in the amount of 12 t/h, which is used to produce distillate in the amount of 50 - 55 t/h and heating 250 - 300 m³/h of make-up water of the heating system in front of vacuum deaerators in the last stages of IBE “ECOTECH”. Thus, all the heat of the heating steam from IBE “ECOTECH” is used in the CHP cycle. In this case, this steam heats up 1000 - 1200 m³/h of the heating system feed water and displaces high potential steam (3-6 atm) used to heat the heating network feed water in the vacuum deaerator circuit, which gives additional fuel savings of at least 10280 tons/year.

It should be noted that when replenishing the heating network in quantities of 1500 - 3500 m³/h, the flow of cooling water at IBE “ECOTECH” will always be provided in the required amount (100 - 1200 m³/h), at which 200 - 220 t/h of demineralized water will be produced.

Calculations show that the cost of the distillate obtained at the ECOTECH complexes is two times less than the demineralized water produced by the CHP plant today. The payback period will not exceed 2-3 years.

The third direction is associated with the use of autonomous IBE “ECOTECH” on the source water, which is characterized by increased mineralization.

It seems expedient to consider the possibility of obtaining desalinated water in the amount of 200 t/h for TPPs at IBE “ECOTECH”, using cheap water from the reservoir as source water. As a heat source, steam from the general station auxiliaries collector can be used, coming from the low-potential extraction of the turbines.

CONCLUSION

Thus, the introduction of thermal desalination technology in the heat power industry and at enterprises of Uzbekistan, where high-quality water is required, will significantly reduce production costs due to a multiple reduction in the consumption of chemicals, a decrease in discharges of chemically contaminated wastewater, which will significantly improve the state of the environment and adjacent water bodies for their use in the future.

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