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Discussion on Process Design of Zero Discharge of Wastewater in a Power Plant in Northwest China

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Abstract. This paper analyzes the water balance test report of a power plant in Northwest China, the relevant operation records and the statistical wastewater volume of various types of renovation projects. From the technical and economic point of view, the two-step process of optimizing utilization and deep treatment is proposed, and two design techniques are given. Discuss its options.

1. Introduction
In the current environmental protection requirements and water management of power plant design and actual operation, the concept and requirements of “zero emission” are often proposed, which is a change of the traditional mode of resource use and management. “Zero emission” is proposed in the situation of increasing water resources and deteriorating water environment. It is one of the means to rationally use water resources and protect the environment. It can promote the rational use of water resources by power plants, promote the recycling of wastewater, and eliminate the change of physical, chemical and biological properties of water sources caused by water discharge to the water body will maintain sustainable development, and at the same time promote the scientific and technological progress of water-saving and drainage reuse technologies[1, 2].

In 1970, the National Pollutant Discharge Removal Act (NPDES) first set clear regulations and requirements for zero discharge of wastewater. The US Electric Power Research Center (EPRI) further defined zero discharge of factory wastewater as “the power plant does not discharge any water to the surface waters. Form of water (exhausted or oozing), all water leaving the power plant is in the form of moisture or solidified in ash or slag”. For power plants, “zero discharge” of power plant wastewater means that all of the high-salt wastewater produced by industrial water after reuse is reused (more than 99%), and no waste liquid is discharged from the power plant. The salts and contaminants in the water are concentrated and crystallized and discharged as solids in a power plant to a waste treatment plant for landfill or as a useful chemical raw material. The technical means of achieving “zero emissions” include optimizing the process system, the use of cascade water, and the reuse of wastewater, which greatly reduces the water consumption and emissions of power plants. At present, there are few power plants that truly achieve zero emissions in China, and technology, investment, and operating costs are all important factors that restrict the implementation of zero emissions [3, 4].

2. Status of wastewater discharge from power plants
According to the water balance test report of the power plant and the related operation records, the amount of waste water is fully considered, and the newly-renovated various types of renovation projects
are fully considered, including: heat network renovation project, peak cooling project, desulfurization and capacity expansion project, desulfurization wastewater technology project, wet type Dust removal and other reforms, the total amount of wastewater from the whole plant is about 321 m³/h, as follows: 1. Chemical water treatment wastewater is 124 m³/h; 2. New heat network water treatment system wastewater is 22 m³/h; 3. Fine treatment system wastewater is 14 m³/h; 4, desulfurization wastewater 54 m³ / h; 5, peak cooling tower drainage 107 m³ / h, the wastewater is only produced when the summer peak cooling system is put into operation, for 5, 6, 7, 8 months.

3. Waste water zero discharge process design
Through comprehensive accounting, the current and estimated maximum wastewater volume of the whole plant is 321 m³/h. From the technical and economic point of view, the project can be divided into two steps: First, optimize the utilization project, and the chemical wastewater is transported to the desulfurization system at 146 m³/h. And the peak cooling tower drainage 107 m³ / h transported to the wet dust for comprehensive utilization; the second is the further treatment project, including the total amount of desulfurization wastewater, refined wastewater, up to 175 m³ / h (about 4200 m³ / d, with spikes The wastewater with a cooling drainage of 107 m³/h and further processing conditions is further treated.

3.1. Optimize engineering design
Optimized utilization engineering design: set up chemical wastewater buffer pool, transport the wastewater from the chemical workshop to the wastewater buffer pool through the chemical workshop, and then replenish water according to the water supply requirement of the desulfurization system through the pump. The main contents of the project are buffer pools, pumps and pipelines. No water treatment facilities are required. All equipment and facilities need to be treated with anti-corrosion treatment. The designed chemical wastewater buffer tank capacity is considered for 24 hours, and the capacity is 3500 m³ (designed as 2×1750 m³).

3.2. Advanced Processing Engineering
The advanced treatment project mainly involves the wastewater being desulfurization wastewater of 54 m³/h, the fine treatment wastewater of 14 m³/h, and the peak cooling tower discharge of 107 m³/h. The design is intended to pre-treat the desulfurization wastewater together with the sewage from the peak cooling tower. The refined wastewater and the pre-treated wastewater will continue to be desalted and concentrated. Finally, a small amount of high-concentration brine is left for evaporative crystallization to finally produce solid salt. After desalting and concentration. The fresh water produced and the steam condensate from evaporation crystallization can be used as hydration for the peak cooling tower (in summer operation) or sent to the industrial water system as hydration for the entire industrial water.

Through the verification of the quality and quantity of wastewater in the whole plant and the analysis of various zero-emission treatment methods, combined with domestic and foreign research data and relevant technical standards, the plan for the deep treatment and zero discharge of wastewater discharged from the whole plant is as follows:

The quality of the sewage in the peak cooling tower is characterized by high salt content and high hardness of the carbonate. The direct further concentration has obvious tendency to scale. It can be concentrated and desalted after softening, and the water is evaporated and crystallized after concentration. According to the water quality and water quality analysis, the wastewater is 107 m³/h, and the integrated TDS after accounting is about 6000 mg/L.

The desulfurization wastewater is unstable due to the water quality and quantity. After the first-stage desulfurization reform and implementation optimization project, the total displacement is about 54 m³/h, and the TDS is about 20000 mg/L (controlled by chloride ion 5000 mg/L). Consider the existing triple box. Although the treatment facility can handle the removal of most COD, heavy metals, fluoride ions, suspended solids, etc., it is not possible to soften the water. At the same time, the direct evaporation of
the wastewater to the evaporator is preferably stable at 50,000 mg/L or more. Smaller, so the desulfurization wastewater can be pretreated and further concentrated together with other high-salt wastewater to achieve a more stable salt concentration and ensure stable and controllable system operation.

The desulfurization wastewater (54 m^3/h) and the peak cooling tower sewage (107 m^3/h) were respectively introduced into the buffer tank of the pretreatment system. The salt content of the integrated wastewater was about TDS=10696 mg/L and the water volume was 161 m^3/h. After the treatment, it is again desalted and concentrated together with the refined wastewater, and the concentrated brine finally enters the evaporation crystallization system. The pretreatment system and desalination system solution throughput is calculated at 125%, the pretreatment output is about 200 m^3/h, and the peak cooling system operation time is 5, 6, 7, 8 (4 months in total), design pretreatment Desalination is considered as a two-column 100 m^3/h system. During the period when the peak cooling tower is not put into operation, only one column is used for pretreatment of the desulfurization wastewater.

Considering the thorough mixing of wastewater and the short-term storage of the failure period of the wastewater system, two integrated wastewater buffer tanks are designed with a design capacity of 2×2000 m^3; the design capacity of the precision treatment wastewater buffer tank is 350 m^3.

According to the above analysis and the characteristics of various treatment processes, the following two processes are proposed:

Scheme 1: 1. Optimize the utilization of 146 m^3/h chemical wastewater; 2. Further treat 175 m^3/h wastewater; 3. Process: lime sodium carbonate softening + reverse osmosis concentration + evaporation crystallization.

Scheme 2: 1. Optimize the utilization of 146 m^3/h chemical wastewater; 2. Further treat 175 m^3/h wastewater; 3. Process: lime sodium carbonate softening + reverse osmosis concentration + high pressure flat membrane + evaporation crystallization.

4. Conclusions and discussion

The project can fundamentally solve the effluent discharge of power plants and achieve zero discharge of wastewater from the whole plant. It can save a lot of fresh water and is a resource project with outstanding social benefits (the treated water is used for peak cooling or industrial water system). It meets the requirements of national and local water conservancy, water resources planning and water resources protection. The implementation of the project, its social and environmental benefits are very obvious, is an environmental protection project for the benefit of future generations.

At present, the zero discharge of power plant wastewater can be referred to as a rare example. The project that has been put into operation and relatively stable in operation is mainly configured as a pretreatment plus desalting evaporation crystallization process. The scheme gives priority to the optimal utilization of wastewater and the feasibility of the final treatment process. The specific summary is as follows:

Scheme 1, covering an area of 6,000 m^2, with a static investment of 1,218.86 million yuan, a dynamic investment of 1,242.66 million yuan, and an annual operating cost of 25.86 million yuan.

Scheme 2 covers an area of 6,000 m^2, with a static investment of 114.81 million yuan, a dynamic investment of 117.051 million yuan, and an annual operating cost of 21.49 million yuan.

The process and economic analysis of the two schemes are both good and implementable, and the recommended scheme 2 is the first alternative:

Scheme 2 makes full use of the high-pressure flat membrane to minimize the waste water treatment, reducing the investment of partial evaporation crystallization and the overall operating cost, and saving investment in subsequent equipment investment and operation.

This feasibility study considers the impact of the technical transformation of the power plant on the quality and quantity of wastewater in the whole plant in the next few years, and has developed a treatment plan for the sustainable endurance of the wastewater. However, as many technical transformation projects have not been fully implemented, the final impact of water quality and quantity will need to be further considered in the future. It is recommended to carry out further screening and
related water quality testing and testing after the completion of the transformation, and optimize the process parameters to make it more stable. A more economical way to achieve zero emissions targets across the plant.

At the same time, the crystalline salt produced by zero emissions should actively open up the sales route. Sodium chloride and sodium sulfate can be recycled in the vicinity of the chemical companies. If they cannot be sold, they must be commissioned or buried according to regulatory standards.

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