Discussion on the technical route of water pollution prevention and comprehensive utilization in thermal power plant

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Abstract. 91 Thermal Power Plants have investigated and the problems in water management work have analyzed in this paper, combined with the policy situation. The technical route is divided in two steps. The first step for the whole plant water quality optimization, and processing, recycling use of water resources is achieved step, realize high salt wastewater minimization; The second step for the comprehensive management of waste transformation, unable to return to the high salinity wastewater, unified with the consumption and discharged into the wastewater comprehensive treatment system, through the pretreatment of softening, concentration reduction, evaporation desalting and solid waste disposal, wastewater recycling to achieve. It provides a reference for thermal power plants to explore the prevention and control of water pollution and comprehensive utilization.

1. Introduction
With the continuous development of economic and social construction in China, water resource shortage, water quality water shortage and water environmental pollution have become important factors restricting the sustainable economic and social development. In April 2015, Water pollution prevention and control action plan clearly pointed out that we should do a good job in industrial water conservation and improve the rated standard for water consume in high water consumption industries. At the same time, as the environmental protection emission policy has become increasingly stringent, the relevant documents have been issued one after another at the national level. Develop water-saving diagnosis, water balance test and water efficiency evaluation, and strictly manage water quota. In 2016, People's Republic of China national economic and social development in the thirteenth five year plan and the Circular on the issuance of interim provisions on the Administration of sewage permits were issued one after another, We need to implement the strictest water resources management system, carry out comprehensive water-saving transformation and demonstration, encourage multi-use of one water and use it in different ways, and carry out permit management for discharging industrial waste water directly or indirectly to enterprises and institutions. It is required to control the total amount of water supply, to improve the efficiency of water use, and to carry out "licensed sewage discharge". Even in some areas there is a clear "zero discharge of waste water" requirement. Thermal power industry is facing new situation and challenge in water saving and wastewater treatment.

Based on the investigation and evaluation of 91 thermal power enterprises in china, this paper
analyzes the existing problems in the management of water resources, such as water use and drainage, and explores the technical route of comprehensive utilization of wastewater from thermal power enterprises in combination with the relevant policy requirements. It provides reference for comprehensive utilization of water resources and pollution prevention in thermal power enterprises.

2. Survey of thermal power enterprises

Of the 91 thermal power enterprises, 79 are coal-fired and 12 gas-fired, with 282 units (242 coal-fired and 40 gas-fired), involving the installed capacity of ninety four million eight hundred and thirty two thousand kilowatts. A sample of the survey is shown in table 1.

Table 1. Distribution of unit capacity.

| Target / Ten thousand kilowatt-hours | 30 | 30~60 | 60~100 | 100 and above |
|-------------------------------------|----|-------|--------|---------------|
| Number of units / unit              | 109| 109   | 56     | 8             |
| installed capacity / Ten thousand kilowatt-hours | 1566.7 | 3589.0 | 3515.5 | 812.0         |

According to the survey, the enterprises are mainly distributed in the Yangtze River, the Yellow River, the Huaihe River and the Liaohe River, accounting for 34.51%, 14.93%, 10.80% and 12.03% of the installed capacity respectively. The distribution of sample thermal power enterprises in various water systems can be found in table 2.

Table 2. Distribution of samples in water area.

| Water system area       | installed capacity / Ten thousand kilowatt-hours | Number of power plants | Number of units | Installed capacity proportion /% |
|-------------------------|--------------------------------------------------|------------------------|----------------|----------------------------------|
| Changjiang River system | 3204.7                                           | 27                     | 81             | 34.51                            |
| Yellow River system     | 1386.0                                           | 12                     | 32             | 14.93                            |
| southeast coastal water system | 522.0                                | 6                      | 17             | 5.62                             |
| Heilongjiang river system | 614.7                                      | 8                      | 35             | 6.62                             |
| Huaihe River system     | 1002.5                                           | 7                      | 27             | 10.80                            |
| Jiaodong coastal water system | 797.5                                    | 6                      | 22             | 8.59                             |
| Liaohai Haihe River system | 1116.8                                     | 13                     | 36             | 12.03                            |
| Northwest inner flow area | 292.5                                      | 5                      | 17             | 3.15                             |
| Yalu River system       | 62.4                                            | 2                      | 4              | 0.67                             |
| Pearl River system      | 286.1                                           | 5                      | 11             | 3.08                             |

According to the < 2016 China State of the Environment Bulletin >, according to the survey of power generation enterprises more concentrated water systems, such as the Yangtze River, the Yellow River, the Huaihe River and the Liaohe River, the water quality results indicators are not optimistic. The proportion of water of Class IV, class V and inferior class V is relatively high, especially in Haihe river system, and the proportion of inferior class V water is more than 40%. In the face of such a severe environmental situation, the discharge of wastewater from power generation enterprises will be further constrained.

3. The current situation of water management

3.1. Lack of a sound management system

Due to the complexity and particularity of water resource management, the power generation enterprises have not developed the water management system for the enterprise, and there is no clear comprehensive utilization plan of the water resources of the whole plant, the water-saving incentive
mechanism is not sound, the water and water-saving management work is arbitrary and large, The difficulty of water works is increased, especially for power plants with sufficient water resources and lower water intake.

3.2. Lack of basic data for water management
The water balance test cycle exceeds 5 years. In recent years, there are many revamping projects in power plants and great changes in water use system, the water balance test report is different from the field situation, and the data are not accurate, which cannot provide a reliable basis for water saving and overall optimization of water resources.

3.3. Water metering allocation is not in place
According to the actual investigation of the thermal power plant, the first-class water consumption (all kinds of water sources in the plant) and the second-class water consumption (the water used in each workshop and in the factory area) meter, the preparation rate, the qualified rate, and the detection rate basically meet the requirements, and the lack of items is small. But the third level of water (equipment and facilities water, domestic water) system table is not complete.

3.4. Lack of optimization measures for water use system
A considerable part of the power plant has not carried out the water balance test and the water-saving optimization work for a long time, the repeated utilization rate of the water is low, and the recycling and the step utilization are not achieved.

3.5. High failure rate of wastewater treatment equipment
Some waste water treatment equipment is backward in technology, low in automation, low in operation efficiency and lack of operation and maintenance, which leads to high failure rate of equipment, resulting in waste water cannot be reused, resulting in increased water consumption and drainage.

4. Utilization of water resources and prevention and control of pollution
In order to respond positively to the national plan of action for water pollution prevention and control, actively promote the comprehensive utilization of water resources and pollution prevention and control of thermal power enterprises, and carry out the work in accordance with the principles of the "The classification of waste water, the utilization of the step and the minimum of high-salinity wastewater; based on the present, taking into account the long-term and one-plant policy, and selecting the optimal process route".

The technical route is divided in two steps. The first step for the whole plant water quality optimization, and processing, recycling use of water resources is achieved step, realize high salt wastewater minimization; The second step for the comprehensive management of waste transformation, unable to return to the high salinity wastewater, unified with the consumption and discharged into the wastewater comprehensive treatment system, through the pretreatment of softening, concentration reduction, evaporation desalting and solid waste disposal, wastewater recycling to achieve.

4.1. Waste water classification, cascade utilization, minimization of high salt waste water
According to the characteristics of different wastewater quality, the wastewater is divided into four categories.

Class I waste water (produced by type I equipment): The water quality condition is better, the salt content is low, the suspended matter is low, such as the thermal system drain, the boiler discharge sewage, etc. cannot be treated or simply cooled down, then directly reuse the II, III, IV equipment.

Class II wastewater (produced by type II equipment): This kind of wastewater is of high suspended matter but low salt content or special water quality, coal-containing wastewater, oily wastewater,
domestic wastewater and backwashing water, etc., which is suitable for recycling and reuse alone or for use in type III and IV equipment.

Class III wastewater (produced by type III equipment): This type of wastewater is low in suspended matter but high in salt content, such as concentrated water in chemical workshops, acid-alkali recycled wastewater and recycled sewage, etc., which can be reused first in class IV equipment or in depth after desalination. The concentrated water is reused for class IV equipment or high salt wastewater treatment.

Class IV wastewater (produced by type IV equipment): this kind of wastewater is of high suspended matter and high salt content, such as desulphurization wastewater, which is treated only as high salt wastewater. The high salt wastewater is treated according to the relevant environmental protection policy and discharged to the standard or the zero discharge of wastewater is carried out. In principle, only class IV wastewater is allowed to be produced, and the rest of the wastewater is reused, and the specific items need to be demonstrated in detail according to the actual situation.

4.2. One factory one policy, select the best process combination scheme

4.2.1. Achieve the goal of meeting emission compliance. After step-by-step utilization and deep reuse of waste water, the class IV wastewater produced is treated by chemical reaction precipitation and discharged to the standard, or used for ash field spraying and dry ash mixing, etc. At the same time, maintain the whole plant waste water "zero discharge" transformation interface, convenient for future transformation.

4.2.2. Aim to achieve zero emissions. And the waste water which cannot be recycled, consumed or discharged uniformly enters the comprehensive treatment system of the waste water. The high-salt wastewater comprehensive treatment system mainly comprises four processing units, namely a pretreatment unit, a decrement concentration unit, an evaporation and desalination unit and a solid waste processing unit. The process flow chart is shown in figure 1.

Figure 1. Comprehensive treatment system for high salinity wastewater.

- Pretreatment unit
  The salt content of high salt wastewater from thermal power plant is usually between 10000–40000mg/L, the water contains a large amount of solid suspended matter, heavy metals, silicon content and hardness are also high, pre-precipitation and softening pretreatment are needed before entering the follow-up system. In order to avoid subsequent concentration treatment system scaling. According to the quantity of high salt wastewater, water quality conditions and site conditions, lime/sodium hydroxide-sodium carbonate softening-clarifier-filter treatment process and lime/sodium hydroxide-sodium carbonate softening-tubular microfiltration membrane (TMF) process were selected. Considering the softening-filtration pretreatment unit of high salt wastewater as a whole, the desulphurization wastewater "neutralization-flocculation-precipitation" process system is no longer operated alone.

- Reduction concentration unit
  After reduction in (SWRO) process of nanofiltration (NF) seawater reverse osmosis, electrodialysis-reverse osmosis (ED-RO) [5] and dish-tube reverse osmosis (DTRO) can be used in
high salt wastewater [6,7]. Positive osmosis of (FO) and evaporation concentration of (MVC) were further concentrated. In terms of concentration effect [8], positive osmosis (FO) > electrodialysis (ED) > high voltage reverse osmosis (DTRO/STRO). High Voltage reverse Osmosis (DTRO/STRO) > Electrodialysis (ED) > positive Osmosis (FO). The effect of reducing concentration has a direct effect on the investment cost of reforming the end-end wastewater evaporation treatment system. By combining with the terminal wastewater treatment scheme, the economic and technical comparison and analysis are carried out, and the suitable reduction-concentration scheme is selected.

Thermal evaporation concentration process investment, operation costs are too high, is not recommended.

- Evaporative desalination unit
  The evaporative desalination unit was evaporated by flue atomization [9-11] and the evaporative crystallization process [12, 13]. According to the conditions of terminal water volume, flue gas parameters and flue layout space, the revamping project takes into account the investment operation cost and operation stability of each process and gives priority to the atomization and evaporation of flue before dust collector (the end wastewater quantity is small, the amount of waste water is small at the end). Second, consider the evaporation of the bypass flue in front of the air preheater (the volume of waste water at the end of the flue is small, and the flue or flue gas condition cannot meet the requirements of direct atomization evaporation). Again consider the mechanical vapor re-compression (MVR) evaporation crystallization technology (the end of the waste water is larger).

- Solid waste disposal unit
  Fixed waste mainly includes sludge of pretreatment unit and crystalline salt of evaporative desalination unit. Sludge is dewatered, compressed, discarded or landfill. Crystal salt is demonstrated according to the local sales situation, and the suitable disposal plan is considered to avoid secondary pollution.

5. Conclusion
In the face of the increasingly stringent national and local environmental protection requirements, the problems of comprehensive utilization of water resources and pollution prevention and control in thermal power enterprises have become increasingly prominent, and thermal power enterprises should give priority to the investigation of the status quo of waste water and sort out the existing problems. Pay attention to water management, optimize the allocation of water flow, improve the efficiency of water use, realize deep water saving.

The technical route of water pollution prevention and comprehensive utilization can be carried out step by step. The first step of whole plant water use optimization, and separating treatment and reuse of utilizing water resource cascade, as far as possible to reduce the amount of wastewater treatment, is the basis and premise of the comprehensive management of wastewater. The next step is the comprehensive administration of the wastewater in the whole plant. Different technical schemes are selected according to the quality and quantity of the wastewater. The second step can be carried forward according to the policy situation.

The process route of comprehensive treatment of wastewater is pretreatment softening, concentration, evaporation desalination and solid waste treatment.

In the stage of waste water concentration and reduction, according to the quality and quantity of wastewater, there are more technological schemes or combination schemes that can be chosen, and at the same time optimize the mature and reliable technological schemes with more application achievements, taking into account the economic efficiency of the transformation investment. Thermal enrichment process is not recommended.

For the evaporative desalination unit, no matter it is evaporation crystallization or flue evaporation technology, there are technical characteristics and restriction conditions. According to the principle of "one factory, one policy", the optimal scheme should be fully demonstrated and selected.
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