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ScienceDirect

Procedia Computer Science 154 (2019) 549–555

Procedia Computer Science

www.elsevier.com/locate/procedia

8th International Congress of Information and Communication Technology, ICICT 2019

Research on Remote Monitoring System for Zero Discharge Treatment of External Cooling Water in Converter Valve

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Abstract

A sewage treatment remote monitoring system is designed in this paper due to long physical distance, complex process of zero discharge treatment techonology that requires monitoring. The paper firstly introduces the external cold water discharge of the valve cooling system of the converter station, and proposes the treatment measures for zero discharge of sewage in the case of phosphate, COD and salt in the discharged wastewater. The remote monitoring system is designed according to the process routes of the zero-emission scheme. The system adopts a hierarchical network control structure and mainly includes locale execution layer, harmonization layer, and remote monitoring layer. The mechanisms and functions of each layer are introduced in detail. The remote monitoring system is effective in monitoring the water treatment process and is helpful to achieve zero discharge of external cooling water in converter valve.

Keywords: remote monitoring system, hierarchical network, valve cooling system, external cold water, zero emissions;

1. Introduction

As the remote monitoring system is able to monitor industrial process in a long distance, it provides benifits to monitor the situation in different processes in the same time. When there is something inproper occurs during the process, the remote monitoring system will alarm, so it saves time to detect the problem and fix it. In the converter valve cooling system of the converter station, as the cooling tower runs for a longer period of time, the cooling water

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10.1016/j.procs.2019.06.087

is concentrated and the water quality is deteriorating. Therefore, it is necessary to continuously add fresh demineralized water to the cooling system while continuously discharging the concentrated water out of the system to maintain the water quality in the system. As the environmental protection department's standards for corporate wastewater discharge are getting higher and higher, the sewage discharge situation of power supply enterprises is gradually being concerned by people. At present, how to discharge waste water from converter station has been paid attention by various management units. However, the research on the detection, analysis and treatment method of cold water discharge from converter station has not started yet. Therefore, the research on cold water discharge from converter station is extremely urgent.

The discharge of cold water outside the converter station accounts for more than 90% of the total discharge of the converter station. Therefore, how to efficiently deal with the discharge of cold water outside the converter valve is of great significance. On the basis of summarizing relevant literature and data as well as water quality testing data of cold water outside each station, this paper puts forward the technical scheme of zero discharge of cold water outside the station [1]. Zero discharge is an ideal closed water system, without external drainage. The water in the system is constantly recycled or reused after treatment, so as to save water resources and protect the environment [2], which requires real time monitoring of the water treatment situation in different processes. A remote monitoring system is designed according to the process routes of the zero-emission scheme. The system adopts a hierarchical network control structure and mainly includes locale execution layer, harmonization layer, and remote monitoring layer [3]. The mechanisms and functions of each layer are introduced in detail. The remote monitoring system is effective in monitoring the water treatment process and is helpful to achieve zero discharge of external cooling water in converter valve.

2. Basic Situation of External Cooling Water of the Converter Valve

The high-voltage thyristor converter valve is the core equipment of HVDC transmission. The heat generated by the thyristor during operation will cause the temperature of the valve body to rise. If there is no necessary heat dissipation measures, the performance of the device will be degraded, and even the system will be shut down. . The converter valve water cooling system exchanges heat with the internal cold water system through the external cold water system to cool the valve tower thyristor device.

In the converter valve cooling system, as the cooling tower runs for a longer period of time, the external cooling water is concentrated and the water quality is deteriorating. Therefore, it is necessary to continuously add fresh demineralized water to the cooling system, and continuously discharge the concentrated water out of the system. Maintain water quality in the system. In addition, in order to prevent scaling in the cooling water pipe and inhibit the growth of algae, it is usually necessary to add a scale inhibitor, a disinfectant, a bactericide, etc., so the concentration of various pollutants in the concentrated water will continuously rise, resulting in phosphate and chemical oxygen demand. (CODcr) and salt exceeded the standard.

At present, the cold water source outside the converter stations mainly comes from tap water, lake water, reservoirs, etc. The discharge mode is mainly discharged to nearby ditches or rivers, so the direct discharge station will have a certain impact on the surrounding environment.

3. Feasibility Analysis

3.1.Working conditions and design requirements

Taking a converter station as an example, there are two conventional DC back-to-back converter units in the converter station involved in the project, with a rated transmission power of 1000 MW; a flexible DC back-to-back converter unit with a rated transmission power of 1000 MW. The total scale is 3000MW. According to the configuration of the converter unit, there are 4 sets of valve cooling systems in the converter station, 1 set of valve cooling system for each conventional DC back-to-back converter unit (2 sets in total), 1 flexible DC back-to-back converter unit set 2 The valve cooling system and the four valve cooling systems are all water-cooled. The sewage volume is about 600m3 per day during the high temperature season. The main pollutants in the external cold water of the converter valve include CODcr, phosphate and total dissolved solids (TDS). The test data are shown in the table below.

Table 1 Water quality test results of cold water drainage outside the converter valve

Project	Detection concentration(mg/L)
CODcr	30
Phosphate (in terms of P)	60
Total salt	2000

In this paper, the output capacity of the zero-emission system in the zero-emission design of the station is shown in the following table.

Table 2 Zero emission system design processing capacity

Project	Design concentration
Processing capacity	600m3/d，（25m3/h）
Water recovery rate	>90%（540m3/d）
Recycling water indicator	TDS<100mg/L

3.2.Technical route selection

3.2.1.Phosphate removal

Although phosphate is a kind of salt, its nature is significantly different from that of sodium chloride. In particular, it will have certain influence on the crystallization of sodium chloride during the process of crystallization separation, and it should be considered separately in the process.

Since the zero-emission system inevitably uses an evaporative crystallization unit, the presence of a large amount of phosphate component adversely affects the operation of the evaporative crystallization system (mainly crystallization process), and in severe cases, crystallization is difficult, making it difficult to separate the brine. Therefore, it should be removed in the pre-process unit. For the removal of phosphate, a coagulation and sedimentation process should be adopted. According to the content of phosphate, a certain amount of flocculant can be added to effectively remove phosphate. In order to improve the sedimentation efficiency and reduce the system footprint, the sedimentation tank adopts a high-efficiency coagulation clarifier to increase the hydraulic load, thereby effectively reducing the equipment occupation and equipment cost.

3.2.2.CODcr removal

The CODcr portion of the cold water outside the valve cooling system is formed by a phosphate type scale inhibitor, so that the phosphate can be removed by the coagulation sedimentation unit, that is, a part of the CODcr can be removed. When the concentration of CODcr in the zero-emission system reaches a certain value, CODcr will be enriched in the evaporative crystallization system (the membrane concentration system and the evaporative crystallization system have no removal effect on CODcr). When it is enriched to a certain extent, it needs to be evaporated. The concentrate is subjected to specific treatments, such as advanced oxidation or incineration, resulting in an increase in the investment and operating costs of the zero-emission system. It is more economical to remove the CODcr to the greatest extent in the previous process unit to avoid its enrichment in subsequent units. Therefore,

in the zero-emission system, in the case of uncertain use of the phosphorus-free environmental scale inhibitor and the coagulation clarification process for CODcr removal efficiency, consider adding a first-order CODcr removal unit.

The methods for removing CODcr include biochemical methods and advanced oxidation methods.

The advanced oxidation method relies on strong oxidizing agents to oxidize and decompose the reduced pollutants in the water. However, the advanced oxidation process has high operating costs and is only used when the CODcr is a non-degradable organic substance or when the land occupation is extremely limited.

The biochemical method utilizes the microbial growth and metabolism process to degrade the pollutants, and has a stable treatment effect and low operating cost, and has significant advantages. When the biochemical property of sewage is better (BOD5/CODcr>0.3), it is a very economic and reasonable way to remove CODcr by biochemical treatment.

In the biochemical method, based on the original traditional activated sludge method, combined with membrane separation technology, the membrane bioreactor MBR (Membrane Bio-Reactor) appeared. MBR is a new type of wastewater treatment system that combines membrane separation technology with biological treatment technology. The Membrane Bioreactor (MBR) replaces the secondary settling tank with a membrane module, maintains a high activated sludge concentration in the bioreactor, reduces the footprint of the wastewater treatment facility, and reduces the amount of sludge by maintaining a low sludge load. Compared with traditional biochemical water treatment technology, MBR has high processing efficiency, good effluent quality, compact equipment, small floor space, easy to realize automatic control and simple operation management. Therefore, the process has been widely used in small and medium-sized sewage treatment systems [4]. Therefore, in this paper, the MBR reactor is proposed to remove CODcr.

3.2.3.Salt removal

The removal of salt is usually through the means of membrane. Firstly, part of water is recycled to increase the concentration of concentrated phase salt. When the salt content reaches a certain concentration, the complete separation of salt and water can be achieved by means of evaporation and crystallization.

Evaporative crystallization system, as the last process of zero emission, plays an important role in the realization of zero emission system.

Currently the main Evaporation technologies are the Mechanical Vapor re-compression technique MVR (Mechanical Vapor Recompression), the Multiple effect Evaporation Devices MED, and the Natural Surface Evaporation system NSE (Natural Surface Evaporation).

MVR is the use of the secondary steam evaporation system itself and the energy, the low grade of steam by the compressor mechanical work promoted to steam heat source of high quality, then returned to the evaporator, compressed steam for heating the material to the evaporation, so in this system, the steam is used again and again under the action of the compressor cycle. Thus, the consumption of fresh steam in the system can be reduced to achieve the purpose of energy saving [5].

The working principle of MED is to take the steam generated by the upper evaporator as the heat source of the lower evaporator, and heat the materials to be evaporated at the lower level to make them evaporate, so as to realize the cascade utilization of energy and achieve the purpose of energy saving.

The NSE system realizes and strengthens the natural evaporation system in industrial products, and improves the heat grade released by the condensing system in the system through the heat pump system, so as to provide the heat needed to be absorbed in the evaporation system, so as to realize the energy recycling in the system and achieve the purpose of energy saving. In the natural evaporation system, the wall-type heat transfer mode between the MVR and MED evaporation systems is changed to direct heat transfer by air and water, so as to improve the heat transfer efficiency and effectively avoid scaling problems.

Scaling risk is an important index for evaluating the evaporation system, which is directly related to the normal operation of the evaporator. The cross section becomes narrow and even blocks the passage. Accelerated equipment corrosion (corrosion under scale); Increase equipment maintenance workload; Reduced equipment efficiency, resulting in increased operating costs. Therefore, scaling risk assessment is the first priority in selecting evaporation system.

Traditional evaporative forms all adopt inter-wall heat transfer, that is, the heat medium and the medium to be

heated are located on both sides of the heat transfer material, and the heat is transferred to the other side through the material. On the side of the medium to be heated, the medium close to the nearest position of the material first absorbs the heat and begins to vaporize and evaporate. Therefore, the material close to the surface of the material has a high concentration and is easy to crystallize. Crystalline particles are easy to adhere to the surface of the material, thus forming scale formation (as shown in the right figure).

NSE system is not the traditional inter-wall heat transfer, but adopts the direct heat transfer of air and water, so the risk of scaling can be effectively avoided.

In the NSE system, surface evaporation principle is adopted. Air and water contact directly and exchange heat. Gasification and crystallization occur on the surface of liquid film.

In addition, the NSE system can use a single electric energy as the energy source of the system, while the MVR and MED systems both need steam as the main or auxiliary energy source of the system. Therefore, in the converter station, NSE system has obvious advantages in energy supply compared with MVR and MED systems. In addition, NSE also has obvious differences from other two evaporation systems in terms of scale prevention, investment and operating costs.

3.3.Zero emission system process

Through the above analysis of the types of pollutants and the selection of removal processes, the following process flow is proposed as the main process of the zero emission system.

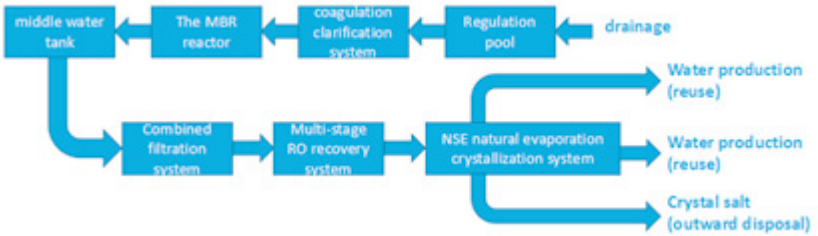

Fig. 1. The main process of the zero emission system.

3.3.1.Regulation pool

The regulating pool is used as a storage and storage measure for the system to temporarily store the wastewater, and at the same time, balance the water quality and the amount of water to ensure the stable operation of the subsequent system. The valve cooling system (normally straight part) with more phosphate and CODcr indicators can be discharged into the conditioning tank and enter the subsequent high-efficiency coagulation clarification system for pretreatment.

3.3.2.Efficient coagulation clarification system

The high-efficiency coagulation and clarification system is based on the most advanced loading sedimentation tanks for technical optimization, chemical coagulation, mechanical mixing, loading precipitation, inclined pipe separation and other technologies conducive to solid-liquid separation for a high degree of integration. It maintains the advantages of high speed, compact loading, good effluent water quality, strong impact resistance, and saving operation cost, and at the same time, it is flexible in operation, which can realize the addition of different agents according to different water quality and application, or the flexibility of no addition.

3.3.3.The MBR reactor

MBR reactor adopts membrane - biological reaction technology, which is a new wastewater treatment technology combining membrane separation technology and biotechnology. The activated sludge and macromolecular organics in the biochemical reaction tank are trapped by the membrane separation equipment to avoid the secondary

sedimentation tank. Therefore, the concentration of activated sludge can be greatly improved, and the hydraulic retention time (HRT) and sludge retention time (SRT) can be controlled respectively, while the refractory substances are constantly reacted and degraded in the reactor. Therefore, membrane - bioreactor technology greatly enhances the function of bioreactor through membrane separation technology.

3.3.4.Combined filtration system

Combined filtration system is an important guarantee for the normal operation of reverse osmosis system. Including multi-media filtration system, ultrafiltration system and activated carbon filtration system. System Settings activated carbon filter, remove residual chlorine at 100% oxidizing substances such as (activated carbon filter adsorption rate was 100%) of residual chlorine in the at the same time, for some dust, impurities, organic matters, such as NOM also has certain adsorption, make into subsequent RO system of water does not contain any oxidizing substances, in order to ensure the normal use of RO membrane life.

3.3.5.Multi-stage RO recovery system

In this system, a 4-stage reverse osmosis system is designed, that is, the concentrated water of the upper level enters into the reverse osmosis treatment of the lower level, so as to further improve the TDS of concentrated phase, reduce the volume of concentrated water, and thus reduce the processing load of the evaporation system.

3.3.6.NSE natural evaporation crystallization system

Through the heat pump system, the NSE system can improve the heat grade released during the condensation process in the system and use it to absorb the heat required by evaporation, so as to realize the energy recycling in the system and achieve the purpose of energy saving. Surface evaporation is adopted in the system, and heating and evaporation are separated in the system design, which not only improves the heat transfer efficiency, but also can effectively avoid the problem of scale formation. NSE system mainly includes evaporative condensation unit, heat exchanger, heat pump unit, heat balance system, pump circulation system and salt separation system.

4. The Structure of Remote Monitoring System

According to the zero emission system process, the remote monitoring system is designed in hierarchical network control structure, which mainly includes locale execution layer, harmonization layer, and remote monitoring layer. As shown in Fig. 2, the locale execution layer includes different sensors for differnt water treatment process, such as sensors for water level, sensors for temperature and cameras. The signals of disfferent sensors are selected and sampled by A/D converter. The harmonization layer includes serial server, data processor and monitor processor. The serial server transmits the signal from locale execution layer to the remote monitoring layer, and the data processor will process the data obtained from the sensors, encode the signal. The remote monitoring layer is mainly consisted of monitor PC and internet. With the human machine interface provided by the monitor PC, the engineer could monitor the situation of differnt water treatment process, if there is an alarm signal, then the monitor PC is helpful to detect the problem of the process such as too high tempeture, too low water level.

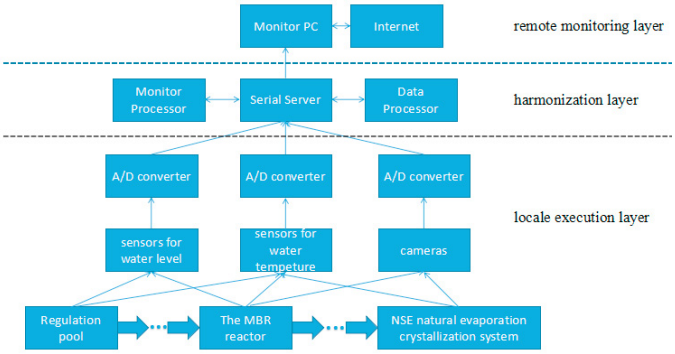

Fig. 2. Hierarchical network control structure of the remote monitoring system.

5.Conclusion

Converter station, as a large user of water and drainage, is of great significance to realize zero discharge scheme of converter station from the perspective of saving operation cost and protecting environment. This paper makes a preliminary study on the treatment measures of the cold sewage outside the valve cooling system of the converter station, and proposes technical route of the zero discharge scheme according to the actual water consumption and water quality test results of a converter station. The remote monitoring system is designed in hierarchical network control structure, mainly includes locale execution layer, harmonization layer, and remote monitoring layer. The remote monitoring system is effective in monitoring the water treatment process and is helpful to achieve zero discharge of external cooling water in converter valve.

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