Research Progress of Electrostatic Water Treatment Technology

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Abstract. In recent years, due to the increasing of environmental pressure, the complicated process of chemical treatment and the pollution caused by sewage to the water, it has become the general trend of the current development to search for the treatment technology of industrial circulating cooling water with low energy consumption, water saving and emission reduction. Physical method is simple to operate, non-toxic and pollution-free, no secondary pollution. As one of the commonly used physical water treatment technologies, the study of electrostatic water treatment technology has important significance. This paper studies and summarizes its research, hoping to further clarify the effect and mechanism of electrostatic water treatment technology on the basis of previous studies.

1. Introduction
Recirculating water system is an indispensable auxiliary equipment for large equipment to carry on heat exchange. It is widely used in industrial production and daily life. After the long-term recycling of cooling water, with the evaporation of water, the inorganic salt ions in the circulating water are constantly concentrated. Especially as the concentration of the water increases. When the concentration of scale ions in the water exceeds the saturation solubility, there will be crystals precipitated on the surface of the heat exchanger, such as calcium, magnesium, sulfate, iron carbonate, phosphate and silicate. Serious sediment attachment in the circulating cooling water system will breed a large number of microorganisms and cause corrosion of equipment. This will not only affect the effect of heat transfer, increase energy consumption, but also clog the pipeline to produce production accidents in serious cases. The circulating cooling water treatment is to solve these problems by treating the water quality[1, 2].

2. Physical water treatment technology
At present, in industrial production, in order to prevent the scaling of heat exchange equipment and its pipes, most chemical treatment methods are used, such as adding scale and corrosion inhibitor to cooling water, etc. However, the treatment method of chemical agents generally has certain limitations. For example, the discharged circulating cooling water body is easy to cause blooms and red tides in the environmental water body. In the operation process, the formula of chemical agents should be constantly adjusted according to the change of water quality, and the operation cost is also high[3]. Therefore, it is urgent to develop a simple, reliable, efficient and fast physical scale inhibition technology in the field.
of industrial circulating cooling water treatment. The so-called physical scale inhibition technology refers to the use of electric, magnetic, acoustic and other technologies to purposefully change the crystalline form of scaling ions or the motion state of water molecules in hard water and reduce the scaling amount of scaling substances on the heat exchange equipment, so as to achieve the purpose of scale inhibition[4]. Due to the advantages of low consumption, simple and convenient application and no pollution, physical scale inhibition technology has broad application prospect and commercial market.

The applied physical water treatment methods mainly include the following, electrostatic water treatment, magnetic treatment, ultrasonic and membrane treatment, etc[5,6]. There are many researches on electrostatic water treatment and magnetization treatment, and these two technologies have also been applied in other fields such as industrial and civil instruments. Electrostatic water treatment and magnetic water treatment are two kinds of physical water treatment methods, which do not need to add chemical treatment agents to water, and are environmentally friendly water treatment technologies.

3. Research status of electrostatic water treatment technology

The use of static electricity for water scale inhibition was first developed in the United States. The first electrostatic scale controller in the world was manufactured by Niigata Washington Company in the United States in the late 1960s. In the following years, there were hundreds of electrostatic scale controllers applied in enterprises in the United States, which indicated that static electricity could control the precipitation of scale. At the end of 1970s, the anti-scale technology of using static electricity in water body also appeared in Japan. Later, static resistance scale processor has been widely used in Europe, North America and other developed countries.

Water molecule is a polar molecule, which contains two asymmetric atoms, namely hydrogen atom and oxygen atom. Under the action of electrostatic field, water molecules will be oriented and arranged in a chain in the order of positive and negative electrodes, as shown in Figure 1. Shown.

![Fig.1 The arrangement of water dipoles and ions under high voltage electrostatic field](image)

Sun Jinghui et al.[7] studied the high voltage electrostatic water treatment technology. They developed an electrostatic descaling device and applied it to a condenser in a power plant. The results show that the device has the function of descaling, and the electrostatic water treatment technology can effectively reduce the corrosion of metal pipes. Liu Zhenfa et al. investigated the synergistic effect of electrostatic field and chemical agents in the circulating cooling water system. It can be proved by experiment that electrostatic field and some chemical agents have synergistic scale inhibition effect. The existence of electrostatic field makes the scale inhibition performance of chemical agents improved obviously. The two have synergistic scale inhibition effect.

Figure 2 below is the device of electrostatic water treatment commonly used in the experiment.
In the research of static resistance scale device, ion-bar water processor is only one of them. Ion bar water processor was first developed by a company in Canada and introduced into China in the 1990s, where it has been applied in circulating cooling water system and achieved satisfactory results[8]. The ion-rod electrostatic water processor consists of two parts, namely the ion-rod probe and the power box. The ion-bar probe is an aluminum electrode wrapped in Teflon and sealed with an insulating material at both ends. By connecting the cable, the high voltage is conveyed to the ion rod probe. After the ion rod is inserted into the water, the water around the ion rod probe produces a high intensity electrostatic field. It can be widely used in central air conditioning circulating water, refrigerant water, heat exchange, boiler feed water and other systems. Ye Qun et al.[9] conducted a comprehensive test on the application effect of ion-rod electrostatic water processor. They found that the ion-bar electrostatic water processor has a good effect on the treatment of industrial circulating water and low-pressure boiler water, and has obvious scale inhibition effect. In 2010, Liu Kangzhen et al.[10] used high-voltage electrostatic ion rods to conduct scale inhibition treatment on circulating cooling water. The experimental results show that the scaling phenomenon of the pipe and the equipment wall surface is obviously reduced after the treatment, and the scaling on the equipment is gradually soft and peeled off.

In recent years, the research on the mechanism of static resistance scale has also made some progress. Many scholars put forward different views on the mechanism of electrostatic field scale inhibition. Li Haihua et al.[11] studied the effect of high voltage electrostatic field on the crystallization of calcium carbonate. It can be concluded from the experiment that the high voltage electrostatic field can increase the free energy in the crystallization process of calcium carbonate scale and induce the deformation of molecules and ions in water, thus promoting the formation of stone nucleus of calcium carbonate scale. Wu Xingwu et al.[12] studied the scale inhibition mechanism of low-voltage electrostatic processor microcurrent acting on aqueous solution. They found that a small current generated by a low-voltage electrostatic processor caused the water to dissolve into more bubbles of hydrogen and oxygen. The resulting bubbles wrap around the CaCO₃ particles and inhibit the growth of CaCO₃ microcrystals to achieve the effect of scale inhibition.

4. Conclusion and prospect
The application of high voltage electrostatic water processor or ion bar high voltage electrostatic appliance in in-dustrial circulating cooling water system not only has the effect of scale inhibition, but also can kill algae and sterilize. There is synergistic effect between high voltage static electricity and environmental protection chemicals. The combination of the two provides an idea for the development of new combined water treatment technology.

The application of high voltage static electric appliance to industrial circulating cooling water system not only has the effect of scale inhibition, but also can kill algae and sterilize. In the process of scale formation, there are very complex mass and energy transfer, so it is difficult to form a unified scale inhibition mechanism. Under the action of electrostatic field, the dipole moment of water molecules is changed, which affects the crystallization of calcium carbonate scale. The effect of electrostatic field...
will also change the crystal form of calcium carbonate scale, but how the change of form will affect the
effect of electrostatic field on scale inhibition is explored all the time. It is hoped that in the future
continuous research on the electrostatic field, the scale inhibition effect and scale inhibition mechanism
of the electrostatic field can be clarified.

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