

Analysis of Passive Solar Desalination Technology Route

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Abstract: Since the world's first large-scale solar desalination plant was built, there has been no breakthrough in passive solar desalination technology. The reason for this is that the problems of photothermal conversion, evaporation and condensation have not been properly solved. As a hot research topic at present, solar interface evaporation technology is only an improvement of disk solar desalination technology. The solar evaporation technology sets the heating surface, evaporation surface and condensing surface from top to bottom. It has high efficiency of photo-heat conversion, large amount of seawater evaporation and good condensation effect. Some of that heat is recycled, and it is used to heat seawater, which is a disruptive technology. We have seen the development of passive solar desalination technology that Disk solar desalination technology is the starting point, solar interface evaporation technology is the current research hotspot, and solar evaporation technology with overhead heating surface will be the end of the whole process.

Key words: Seawater desalination, solar energy, evaporation, condensation.

1. Introduction

Since the world's first large-scale solar desalination plant was built in Las Salinas, northern Chile, the technology of low-cost solar desalination has become a worldwide scientific puzzle in 1872. During this period, humans have explored and created two technical routes: passive solar desalination and active solar desalination. But there is still no satisfactory answer to the world's scientific conundrum more than 100 years later. At present, solar seawater desalination technology is still in the stage of research and development and small-scale test [1], and many scientific research institutions around the world are carrying out research on solar seawater desalination technology. In 2014, the UK Longitude Prize also listed the development of low-cost sustainable desalination technology as one of six shortlisted scientific challenges [2]. In 2020, the U.S. Department of Energy (DOE) announced a \$9 million award competition, which is the Made in America Challenge: Solar Desalination Award that it

aims to accelerate innovation in solar-thermal desalination technology.

In terms of technology, passive solar desalination technology has advantages over active solar desalination technology.

The starting point of passive solar desalination technology is disk solar desalination technology. Its heating surface is the bottom of the plate, the evaporating surface is on the water surface, and the condensing surface is the glass cover surface. This arrangement of heating surface, evaporation surface and condensation surface leads to two major disadvantages of disk solar desalination technology. Firstly, the heat absorbed by the bottom surface of the disk must warm up all the seawater in the disk that only part of the heat causes the water to evaporate at the surface. The utilization of heat is not high. Secondly, the condensing surface is above the heating surface and the evaporating surface. All of the condensation heat is emitted directly into the atmosphere that it can not be recycled. In order to overcome the first shortcoming, the solar interface evaporation technology which raises the heating surface from the bottom of the plate to the

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water surface has become a research hotspot in recent years. For the second disadvantage, solar interface evaporation technology can not overcome. Therefore, the application of solar interface evaporation technology is limited.

In 2020, the invention of setting the heating surface and evaporation surface above the water surface and the condensing surface below the heating surface and evaporation surface was applied for patent in China [3]. Two disadvantages of disk solar desalination technology have been overcome. It condenses steam quickly and part of the condensing heat is heated by uplink seawater to be recycled. In 2021, the heating surface and the evaporation surface are arranged above the water surface. The condensing surface is arranged below the heating surface and the evaporation surface. It has applied for a Chinese patent for the invention of an existing solar interface evaporative material [4]. The common technical feature of the two patents is that the heating surface, the evaporating surface and the condensing surface are arranged from top to bottom. The above technical characteristics are defined as solar evaporation technology with overhead heating surface. The existing passive solar desalination technology will be overturned and the desire of low cost solar desalination will come true finally.

2. Analysis of Passive Solar Desalination Technology Route

The perfect passive solar desalination technology solution needs to properly solve the problems of solar heat conversion, evaporation and condensation. The solution of the photothermal conversion problem mainly depends on the heating surface. The evaporation problem mainly depends on the evaporation surface. The solution of the condensation problem mainly depends on the condensation surface. If the heating surface is placed on the underside of the disk, sunlight can only reach the underside of the disk when it passes through the glass and the seawater and is converted into heat to heat the seawater. When the sea water is heated,

it evaporates into steam at the water surface, which is the evaporating surface. The steam exothermally condenses on the inner surface of the glass cover. Condensation heat radiates into the atmosphere through the outer surface of the glass enclosure. The inner surface of the glass cover is the condensation surface. In order to improve the efficiency of photothermal conversion, solar interface evaporation technology was born with the heating surface raised to the water surface. Researchers from the Chinese Academy of Sciences, Massachusetts Institute of Technology, Shanghai Jiao Tong University, Nanjing University and other scientific research institutions have successfully developed a variety of new materials for solar interface evaporation. The application of these new materials has not properly solved the problems of photothermal conversion, evaporation and condensation. The fundamental reason is that solar interfacial evaporation technology is an improvement on disk solar desalination technology, rather than a disruptive innovation. Both of them have the technical characteristics that the vapor condenses upward and the condensing heat radiates directly to the atmosphere. The characteristics of solar evaporation technology with overhead heating surface are that the heating surface and evaporation surface are on top, the steam condenses down, and part of the condensing heat is heated up and the seawater is recycled. The problems of photothermal conversion, evaporation and condensation are solved. The Chinese invention patent 2020109186213 and the Chinese invention patent 2021100455488 are the concrete implementation plan of the solar evaporation technology of the overhead heating surface.

The vapor-liquid two-phase mass transfer heat transfer is realized between the photothermal plate and the condenser and between the condenser and the bottom of the seawater evaporation tank, which forms a downward channel for heat. It uses absorbent materials to build seawater channels for upward transport. The condenser has the function of water storage, which

realizes the efficient mass transfer and heat transfer and can balance the water supply in that both sunshine intensity are strong and weak [3].

The heating surface and the evaporation surface are arranged in the condenser above the sea water level. The condensing surface is the bottom and side of the condenser. The top and bottom of the condenser are transparent material, gasket, photothermal material, water absorbing material, bracket, anti-wave plate and anti-wave floating plate. The condenser is provided with a ventilation pipe, a water pump interface and a water-absorbing material that sinks into the sea water along the side. Some of condensers floating on the surface of the water are connected to the bottom. The bottom of a condenser is connected to a water pump [4].

Passive solar desalination technology has been developing. Disk solar desalination technology, solar interface evaporation technology, overhead heating surface solar evaporation technology are about the solar heat conversion, evaporation and condensation of the problem. The problem of photothermal conversion, evaporation and condensation can only be solved by optimizing the setting of heating surface, evaporation surface and condensation surface. Solar evaporation technology with overhead heating surface is the best solution.

3. Prospect of Application of Solar Evaporation Technology on Overhead Heating Surface

Solar evaporation technology with overhead heating surface has a wide application prospect in seawater desalination, sewage treatment, industrial and agricultural production and other fields.

Solar-powered desalination devices built using the technology are fixed on sand beaches or floating on the sea on islands, and the use of the technology has nothing to do with land. When the device is running, there is no energy consumption other than electricity and solar energy used to extract fresh water.

It is the island's essential fresh water supply infrastructure.

The technology can use solar energy to treat water that does not meet drinking water standards into qualified drinking water in water-scarce areas. For example, the sun shines brightly and brackish water is abundant in northwestern China. It uses solar-powered desalination technology to solve the water shortage problem. Small solar desalination devices are widely used in rural areas, and the problem of drinking water safety in rural areas will be solved.

The technical device is used in the salt pans of coastal salt farms. It obtains fresh water and increases the rate of salt water concentration. Both salt and fresh water have economic value.

If the technology is used, all kinds of sewage can be discharged or recycled after evaporation and condensation of solar energy.

The technology of solar evaporation with overhead heating surface will make great contribution to the elimination of water crisis in the world and environmental protection.

4. Conclusion

The core of passive solar desalination technology is to properly solve the problems of photothermal conversion, evaporation and condensation. Heating surface, evaporation surface, condensation surface from top to bottom is the best solution to solve the above problems. Development history of passive solar desalination technology is running. We have seen the development of passive solar desalination technology that Disk solar desalination technology is the starting point, solar interface evaporation technology is the current research hotspot, and solar evaporation technology with overhead heating surface will be the end of the whole process.

Reference

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