

Prospect of the Seawater Desalination Technology

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Abstract: This article classifies the seawater desalination technology into four types of hot method, membrane method, electric field method and solvent method. Electric field method and solvent method still remain experimental stage, while hot method and membrane method have been realized in commercialization but are difficult to be promoted. The problem lies in high water-producing cost. It is difficult for membrane method seawater desalination technology to reduce the water-producing cost. The heat utilization efficiency is not high for the current hot method seawater desalination technology and there is large amount of heat lost with the emission of concentrated seawater. The new hot method seawater desalination technology and new solar-powered seawater desalination technology can divide the seawater into fresh water and solid salt without any emission of concentrated seawater so that the heat utilization efficiency can reach theoretical limit to multiply reduce the water-producing cost. They will become the mainstream technology for seawater desalination and can totally eliminate the global water crisis.

Key words: Seawater desalination, membrane method, hot method, solar energy.

1. Introduction

Water crisis is restricting people's social development more and more seriously, while seawater desalination technology is a necessary choice to solve the water crisis. Solar-powered seawater desalination was the origin for seawater desalination technology and it existed on the earth before human beings appeared. Earth is natural solar-powered seawater desalination plant. Seawater absorbs the solar energy and evaporates over the sea to form water vapor into entering atmosphere layer. The water vapor rises upward to condensate to rain and snow falling back to the sea or ground. It is the rain and snow falling back realizing the solar-powered seawater desalination in the natural world. These rain and snow moisten the earth and breed life so that the earth can be full of vigor. The survival and development of human beings also can not leave without the solar-powered seawater desalination of the natural world. With the increase of population and the expansion and human beings'

activities, fresh water resource tends to be in short. Acquiring fresh water by imitating the natural world's solar-powered seawater desalination became people's dream. It is a dream difficult to realize. People failed in discovering economic and suitable solar-powered seawater desalination so that they tried other means to produce cheap fresh water. Several seawater desalination technologies thus successively appeared. People invented hot method, membrane method, ion exchange method, electro-dialysis method, aquo-complex method and solvent extraction method and so on [1]. So far, only hot method and membrane method seawater desalination technologies have been realized in commercialization. Solar-powered seawater desalination technology still remains at research and small-scale testing stage [1].

The reality of seawater desalination technology not satisfying the social development demand had triggered great concern from all sectors of society to seawater desalination technologies. Early in the 16th century, the British Queen issued an order: those who invented cheap seawater desalination technologies will be endowed with a bonus of 10,000 pounds. But no one

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gets this bonus till now. British government declared the bonus that year was still valid. In 2014, British “Longitude Prize” also listed the development of low-cost sustainable seawater desalination technologies as one of the six candidate scientific problems [2].

Although the current hot method and membrane method seawater desalination technologies have been realized in commercialization, complex devices and the emission of large amount of concentrated seawater can not satisfy the requirement of low cost and sustainable development. Especially hot method seawater desalination emits hot concentrated seawater and takes away large amount of heat, which causes environmental thermal pollution. In 2014, the new hot method seawater desalination technology was invented by Chinese divided seawater into fresh water and solid salt, greatly increasing the heat utilization efficiency and totally eliminating the environmental thermal pollution [3]. On this basis, they established the performance evaluation system suitable for all hot method seawater desalination devices with the ratio of water to heat as the evaluation index [4]. New hot method seawater desalination technology can extensively utilize the industrial waste water and waste gas and the current hot method seawater desalination technology cannot realize the solid-liquid separation of seawater [5]. It can realize comprehensive utilization of the seawater resource and correspondingly reduce the fresh water cost.

Energy shortage and environmental protection pressure and so on forced people to focus on solar-powered seawater desalination technology again. The current hot method seawater desalination technology was well-reasoned to be used in the development of solar-powered seawater desalination. Just because of this, it constrained the thought of developing solar-powered seawater desalination technology that people failed to find new technological route. For example, the demonstration project for solar-powered seawater desalination built in Hainan China produced steam by solar heating to produce fresh

water through multi-effect distillation. This technology required long technological process and large quantity of equipment and is not low-cost. Chinese patent of 201710028284.5 completed solar energy collection, seawater evaporation and condensation heat recycling in a seawater-evaporation can desalinate seawater by cyclic utilization [6]. Such solar-powered seawater desalination device could be used as large-scale device and small-scale device as well. It was convenient and requires low cost. To distinguish from the current solar-powered seawater desalination technology, this patent technology was named new solar-powered seawater desalination technology. Chinese patent of 201710375895.0 utilized heat source and solar energy to collaboratively desalinate seawater, increasing the utilization efficiency of seawater desalination device by cheap heat energy [7].

New hot method seawater desalination technology was a technological leap with respect to the current hot method seawater desalination technology, confirming the competitive advantage of hot method seawater desalination technology over membrane method seawater desalination technology. New solar-powered seawater desalination technology will be extensively applied in areas sufficient with solar energy and seawater resource to produce fresh water at low cost. The dream of imitating natural world’s solar-powered seawater desalination process to produce fresh water will be realized.

2. Principle of Seawater Desalination Technology

Seawater desalination process is a physical separation process without chemical reaction heat. Characterized in water evaporation and condensation, solidification liquidation and desalination, heat absorption and release, this type of seawater desalination technology is called hot method seawater desalination technology; characterized in osmotic pressure overcoming, fresh water desalinated penetrating through semi-permeable membrane,

membrane selective penetration, this type of seawater desalination technology is called membrane method seawater desalination technology; characterized in desalinating by electrostatic force absorbing ions and the existence of electric field, this type of seawater desalination technology is called electric field seawater desalination technology; characterized in utilizing solvent to form aquo-complex or extraction and the existence of solvent, this type of seawater desalination technology is called solvent method seawater desalination technology. The four types of seawater desalination technologies independently used or mixed used form the current seawater desalination technology. Each type of the seawater desalination technology adheres to its own physical law with different working principles. For example, membrane method seawater desalination technology adheres to the physical law that osmotic pressure exists on both sides of the semi-permeable membrane; hot method seawater desalination technology adheres to the physical law of water evaporation condensation and heat convection, and its working principle is heating seawater to evaporate to condensate to form fresh water. Electric field method and solvent method seawater desalination technologies also adhere to corresponding physical laws with respective working principles. Since it is difficult for electric field method and solvent method seawater desalination technologies to be applied in practical application, we do not discuss further. Membrane method and hot method seawater desalination technologies have been put into practical application, but they adhere to different physical laws with different working principles and different development prospects.

Membrane method seawater desalination technology requires complex seawater pre-treatment device with semi-permeable membrane and high-pressure pump; while hot method seawater desalination technology requires simple seawater pre-treatment device with heating surface, evaporation surface, condensation and heat exchange surface, latent heat recycling device.

The performance of semi-permeable membrane is restricted by the osmotic pressure and intensity of the membrane. It is impossible to greatly increase the pumping pressure of the high-pressure pump with high requirement of seawater pre-treatment. The current membrane seawater desalination technology has well given consideration to the performance of the semi-permeable membrane, pumping pressure and seawater quality with mature technology. This is to say, there is limited development space for the current membrane method seawater desalination technology. The current hot method seawater desalination technology is not mature at all, mainly reflected in the following: (1) the emission of hot concentrated seawater pollutes the environment; (2) it is not reasonable for the heat surface and evaporation surface, especially the heat surface and evaporation surface of the multi-effect distillation are easy to coincide, which can easily lead to scale formation; (3) the latent heat recycling device can not totally recycle the latent heat; (4) it fails to utilize low-temperature heat source to desalinate seawater so that the heat of large amount of industrial hot waste water and waste gas cannot be utilized; (5) it fails to highly utilize the solar energy to desalinate seawater. The reason why the current hot method seawater desalination technology is not mature lies in its technological route being restricted by the thought pattern of regarding vapor as the heat source. To evaluate the performance of seawater desalination device by water-producing ratio invisibly solidified the technological route thought and obstructed the development of hot method seawater desalination technology. Large amount of heat dispersed with the concentrated seawater, leading to low heat utilization efficiency of the current hot method seawater desalination technology. There is no emission of hot concentrated seawater in the new hot method seawater desalination technology, and no coincidence of the heat surface and evaporation surface. The latent heat can be totally recycled, while the heat of industrial hot waste water and waste gas can also be sufficiently utilized.

It is discovered through theoretical analysis that main influencing factors for the performance of the device of the new hot method seawater desalination technology include the temperature difference between fresh water and seawater, heat loss in desalination, distillation ways, device leak-proofness and device adiabaticity [4]. The heat utilization efficiency of the new hot method seawater desalination can reach theoretical limit [4].

The new solar-powered seawater desalination technology can directly transfer the solar energy to heat evaporating seawater steam which can be condensed to produce fresh water. There is another technological route transferring the solar energy to electric energy which can drive the heat pump to evaporate seawater to produce fresh water. For example, Disc Solar Stirling Generator can be used to generate electricity, and Stirling heat pump can be driven to heat for seawater evaporation [8]. Theoretically, the efficiency of heat engine of Stirling Generator can reach about 30%, while the heat coefficient of the heat pump can reach 4. But the heat practically heating the seawater is 1.2 times of the solar energy. This does not violate the law of conservation of energy, because the heating temperature of the heat pump is far lower than the temperature of the heat source driving the Stirling Generator, which can bring more heat from the heat input terminal to the heat output terminal. However, the high cost of Stirling Generator and heat pump made it difficult in practical application. It also had no competitiveness over the new solar-powered seawater desalination technology.

3. Prospect of the Seawater Desalination Technology

In consideration of the development history of the seawater desalination technology, the hot method, membrane method, electric field method and solvent method seawater desalination technologies appeared with the technological progress in relevant fields. It is relatively mature for the hot method and membrane

method seawater desalination technologies, both of which are competitive now. In the predictable future, it is very difficult for the electric field method and solvent method seawater desalination technologies to shake the advantageous status of the hot method and membrane method seawater desalination technologies. Regarding to the membrane method seawater desalination technology, there will be hardly any breakthrough for the high-pressure pumping technology and energy recycling technology. The progress of the membrane method seawater desalination technology mainly depends on increasing the performance of semi-permeable membrane. It is said that graphene is a good semi-permeable membrane. For the hot method seawater desalination technology, high energy consumption and thermal pollution are two barriers restricting the progress of the current hot method seawater desalination technology. The new hot method seawater desalination technology desalinates the seawater by extensively using industrial waste water and gas including steel industry, electricity generation industry and glass industry, dispersing the heat into the fresh water to eliminate the thermal pollution by the industrial waste heat to the environment [5]. The new solar-powered seawater desalination technology only requires solar energy and seawater to produce fresh water. Therefore, the new hot method seawater desalination technology and the new solar-powered seawater desalination technology will be the mainstream direction for the development of the seawater desalination technology.

In coastal areas, seawater desalination by industrial waste heat and solar energy can guarantee the urban fresh water supply and solve the problem of water shortage in coastal cities. The new hot method seawater desalination technology can utilize the emitted heat from the current power stations and steel enterprises and so on for seawater desalination to acquire cheap stable water source. If still not satisfying the demand, the new solar-powered seawater desalination can utilize solar energy for seawater

desalination or utilize solar energy to cooperate with seawater desalination. The device for the new solar-powered seawater desalination not absorbing sunlight by the side is only 30 cm to 50 cm. The device can be supported overhead with shelf so that the space below can still be fully utilized. For example, a set of device was established for the new solar-powered seawater desalination on the sea-beach of a coastal swimming pool. The space below can be used as leisure field, while the fresh water can serve people. The east sides and west sides of the roof can be used to absorb sunlight for the new solar-powered seawater desalination, desalinating the seawater as well as cooling the buildings. The current bay-salt field can be covered by the new solar-powered seawater desalination device to realize the seawater solid-liquid separation and acquire large amount of fresh water without influencing the salt production.

In islands, the new solar-powered seawater desalination device is a reliable water source. If the new solar-powered seawater desalination device is equipped in the islands in South China Sea to form a fresh water supply net covering South China Sea, which will be the place with the most sufficient water source in the world. It is very low for the manufacturing cost and operation expense of the new solar-powered seawater desalination device. Its fresh water producing cost is even lower than that producing urban tap water.

In the northwest China, it is strong of sunlight and rich of bitter water. Like coastal areas, the new hot method seawater desalination technology and new solar-powered seawater desalination technology can solve the problem of water shortage.

In desert areas near the seashore, it can totally depend on the new solar-powered seawater desalination technology to utilize solar energy and seawater to produce fresh water. The desert can also become oasis.

The new hot method seawater desalination and new solar-powered seawater desalination technology can totally eliminate the global water crisis.

4. Conclusions

Seawater desalination technology can be technologically classified into hot method, membrane method, electric field method and solvent method. Electric field method and solvent method still remain experimental stage, while hot method and membrane method seawater desalination technologies have been realized in commercialization but are difficult to promote. The difficulty lies in high cost of water production. It is very mature for the membrane method seawater desalination technology, but it is very difficult to greatly reduce the water-producing cost. It is not mature for the current hot method seawater desalination technology with low heat utilization efficiency and loss of large amount of heat with the emission of concentrated seawater. The new hot method seawater desalination technology and new solar-powered seawater desalination technology invented in recent years can separate the seawater into fresh water and solid salt without emission of concentrated seawater. The heat utilization efficiency can reach theoretical limit and the water-producing cost also got reduced for times. The new hot method seawater desalination technology can utilize the heat of industrial waste water and gas to desalinate seawater, which can reduce the water-producing cost and eliminate the thermal pollution. The new solar-powered seawater desalination technology can highly effectively utilize solar energy to desalinate seawater, and it still remains patent application stage. As long as putting into development, it will be soon for practical application. The new hot method seawater desalination technology and new solar-powered seawater desalination technology will become the mainstream technology in seawater desalination to totally eliminate the global water crisis.

References

- [1] Gao, C. J., and Ruanm G. L. 2016. *Seawater Desalination Technology and Project*. Beijing: Chemical Industry Press.
- [2] Zhao, X. X. 2014. "Britain Established Great Prize to

- Solve the Global Number One Scientific Problem.” *China Science Paper*.
- [3] Kong, L. B. 2015. A pressure-reducing distillation seawater desalination device. China Patent Gazette.
- [4] Kong, L. B. 2017. “Engineering Problems of a New Thermal Seawater Desalination Technology.” *Journal of Energy and Power Engineering* 11 (5): 295-9.
- [5] Kong, L. B. 2016. A technique and device utilizing slag heat for seawater desalination. China Patent Gazette.
- [6] Kong, L. B. 2017. A solar-powered seawater desalination device. China Patent Gazette.
- [7] Kong, L. B. 2017. A device for seawater desalination by heat energy and solar energy. China Patent Gazette.
- [8] Kong, L. B. 2014. A solar-powered seawater desalination plant. China Patent Gazette.