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№ 7606

A Review on Solar Desalination Techniques

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March 23, 2022

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Abstract- Desalination is most important and traditional process to get the drinkable water. Day to day the demand of fresh and drinkable water is increased, so that desalination is important which are based by solar energy. The solar desalination techniques are cost effective and also give high rate of water production. The inlet temperature of water is effects on the daily water production rate and efficiency of the system. Solar desalination techniques are not commercially used yet, but it is the emerging low cost energy can be used for water purifipositive ion in future and gained more response. Rapid decreases in the fuel storage of earth it is necessary to go with the renewable energy for the desalination process. Traditionally fuel is used which emite polutants after burning and it is harmful to environment and human also. This paper reviews the different types of desalination techniques.

Keywords- Solar energy, Desalination, Solar Techniques, Pure water, Low running cost.

I. Introduction

Water is the most important for life of all survivals. As the population of world increasing fast the demand of drinkable water is increased. According to the survey of WHO in all over world around one billion people do not get drinkable water. 41% of world population lives in water dry areas. About total Earth's surface three fourth surfaces is acquired by water out of that 97% is sea water only 3% availability of fresh water. Most of the fresh water is locked in ice and average only 1% percent of fresh water is useful for humans and animals. There for the main source of water is ocean, which having the 97% total water. And this water is impure, so that the purifipositive ion of sea water is important. We can use that pure water in day to day life. The various desalination techniques used are, multi-stage flash distillation (MSF), multi effect desalination (MED), low temperature desalination (LTD), desalination by humidifipositive ion and dehumidifipositive ion (HD), membrane distillation (MD), electrodialysis (ED), reverse osmosis (RO), mechanical vapor compression (MVC)

desalination. It is estimated that about 8.78 million tons of oil per year is required to produce soft water 1 million/m3/day of fresh water, which indicates the importance of finding suitable alternative energy resources for the desalination systems. There are various alternative renewable sources for the water purifipositive ion. Among all those solar energy have potential which gives future energy demand. Due to increase in population of developing countries need for the drinkable water is also increased. These countries cannot afford to use conventional water purifipositive ion method. So these countries can use solar energy for water purifipositive ion. These countries having higher solar radiation. For example the India the average daily solar radiation in India is 4–7 kWh/m2 compared with the global average of 2.5 kWh/m2 .Therefore, solar energy driven/assisted desalination is becoming more viable despite its high capital cost.

II. Solar Desalination Techniques

A. Solar Based MSF:

After RO the MSF is second which has largest installed desalination capacity. The production of soft water MSF consumes large thermal energy and electrical energy for the pump work is required. Fig.1 shows the MSF system connected with the solar heat source and electricity source. Power grid is connected to the thermal system by the heat engine so that it provides heat and electricity at the same time.

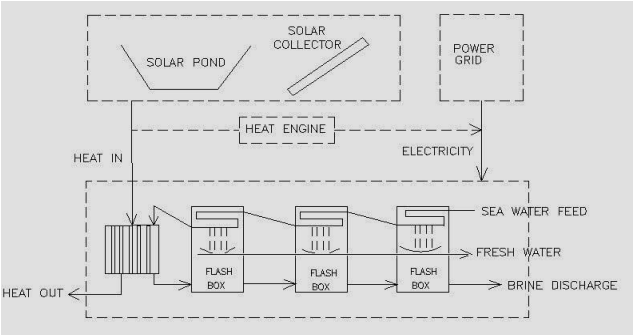

Fig.1.Solar Based MSF System

Fig.1 shows the desalination technique operated on the solar pond. Solar pond is act as a heat resorvoir for the system. Solar pond having three zone according to the concentration of salt. From the middle layer to the bottom layer the concentration of the salt is increases. Heat is collected and stored at the bottom layer. In this system the sea water is passed through the number of stages of flash box. MSF is operated in the range of 95 1105 C and solar pond operated at 35-95 0C. So that first step is to transfer liquid to liquid heat trough heat exchanger. There are also other solar methods for MSF desalination such as collector power MSF system, pv based MSF system etc.

B. Solar Based MED:

It is similar to the solar based MSF system; it also required both thermal energy and mechanical energy. There are three configuration of MED system namely;

forward feed, backward feed and parallel feed. Fig.2 shows the schematic diagram of solar based MED system with parallel feed. In this system the sea water is delivered to the effects which are the low pressure vessels with a successively sequence. The heat from source is supplied to the first effect and generated vapor of previous effect supplies its latent heat of condensation to the next effect. The MED system normally required 2-14 numbers of effects.

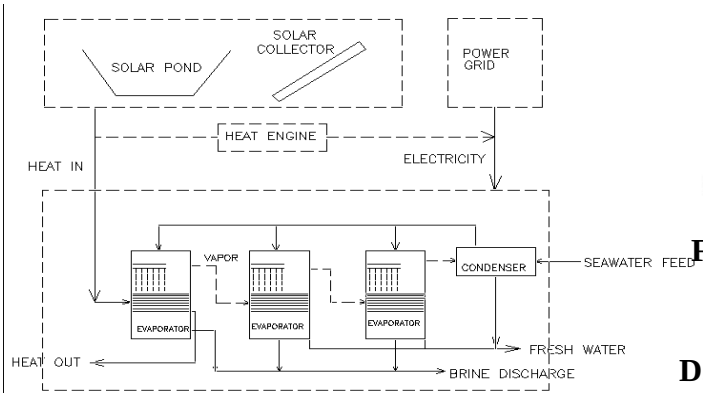

Fig.2.Schematic Diagram of Solar Based MED System

C. Solar Based Humidifipositive ion-Dehumidifipositive ion Desalination Technique:

This process is run on the same principle of the natural water cycle. Fig.3. shows the schematic diagram. The working procedure of the system is as follows. First, brackish water or sea water is heated by the solar collectors as much as possible. Then, the hot water is injected to the top of the evaporation tower. A pulverizer with a special shape is used to assure a uniform pulverisation of the hot water in all the sections of the tower. Hot and saturated air mixes with the rising air current toward the condensation tower. Then it condenses in contact with the cold condensation plates. The circulation of the air in the evaporation tower may occur in natural convection or in forced convection with two functioning modes: closed air circuit or open air circuit.

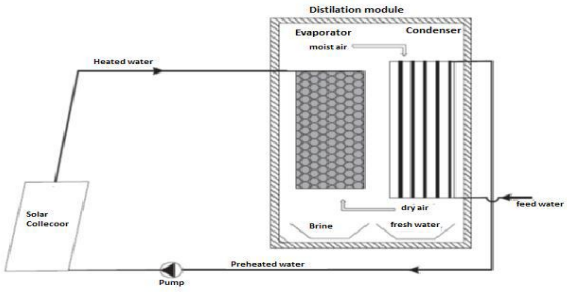

Fig.3.Schematic Diagram of HDH Water Desalination System

D. Solar Based Electrodialysis Desalinatoin Technique:

Electrodialysis is the process mostly used for the desalination of brackish or sea water. In this system the DC electric field is used for the removal of salt from the brackish or sea water. Fig. 4 shows the schematic diagram of experimental setup of electrodialysis desalination system. This system requires DC power so that system required AC to DC converters for the desalination process. So that the solar photovoltaic is most attractive alternative for conventional AC to DC converter as the solar energy is available throughout the year.

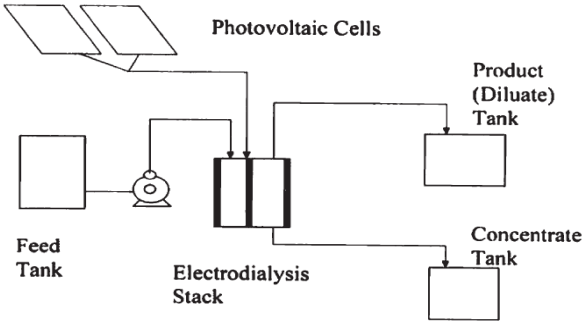

Fig.4.Solar Based Electrodialysis Desalination System

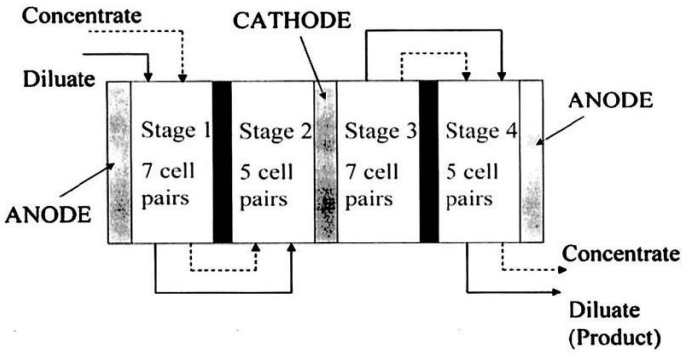

Fig.5.Electrodialysis Stack

The working principle of this system is as follows. The positive ion (positive ions) migrates from the brackish water towards the negative electrode through the positive ion membranes which allow only positive ions to pass. On the other hand, the anions migrate towards the anode through the anion membranes. In an actual process, a large number of alternating positive ion and anion membranes are stacked together, separated by flow spacers which are plastic sheets that allow the passage of water. The streams in alternating flow spacers are a sequence of diluted and concentrated water which flow in parallel to each other. The new technology called electrodialysis reversal (EDR) is used for the prevention of scaling, in which polarity of electric field is reverse for about 20 min.

E. Solar Based RO Desalination Technique:

Fig.6. gives the schematic diagram of the solar based RO desalination technique. If we consider the term capacity, RO is the largest desalination system in the world. This system requires of electricity from the PV panel or mechanical energy from the solar pond or from collector to run the system. Solar based RO system is more energy efficient than the phase change thermal process but it requires extensive water treatment. Osmosis is the natural phenomenon in which the salted water is passes through a membrane from less salt concentration to the more salt concentration. For the reverse flow of water the pressure required of the sea water is more than the atmospheric pressure. And it is typically of 2500 Kpa.

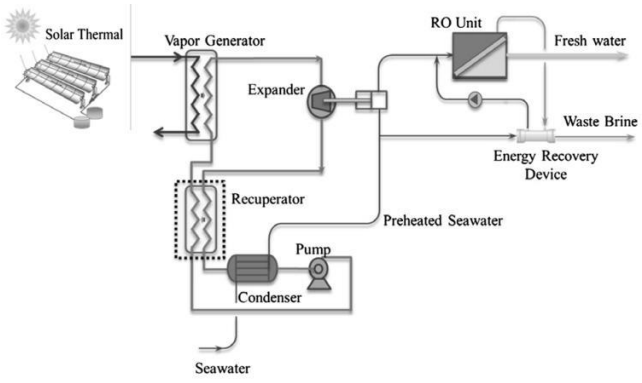

Fig.6.Solar Based RO Desalination System

Among all the process of solar based RO desalination techniques the PV based RO desalination technique is widely used, because both PV and RO are modular and easily scalable.

F. Solar Still:

Solar still is also called as the direct still. The heat collection and distillation processes occur within the same system where solar energy is used directly for distillation by means of the greenhouse effect. Water vapor rises to the transparent cover by natural convection and condenses there. A solar still output might be affected by many factors including brine depth, vapor leakage, thermal insulation, cover slope, shape material, climate The latent heat is normally wasted on the cover, therefore the system efficiency is relatively low with a daily production of about 3–4 l/m2.

G. Solar based Adsorption desalination system:

Adsorption desalination is an emerging low cost thermal desalination system [8]. Fig.8. shows the solar based adsorption desalination system

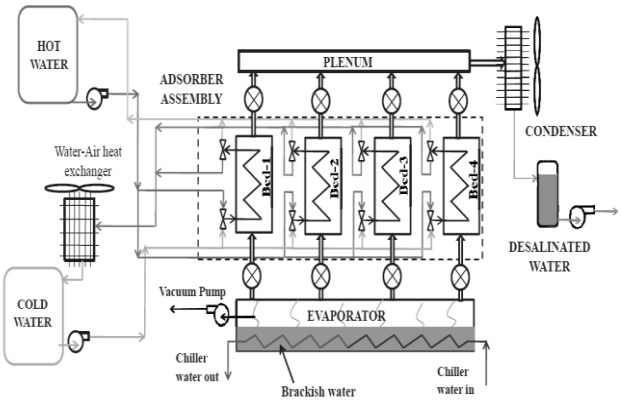

Fig.7. Solar Based Adsorption Desalination System

Working principle of adsorption desalination technique is as follows. In this system mostly silican gel is used as the absorver because it is nontoxic and eco-friendly. The sea water is evaporating in the flash evaporator. This vapor is absorbed by the absorver in absorver bed. Then the hot water from the solar heat source is passed through the absorver bed and adsorbed vapor get evaporated and going to the condenser where vapor get condensed, and forms drinkable water at the end. Again cold water is passed through the absorver bed so that bed can regain its adsorption capacity. The minimum number of absorver bed used is one. But for increasing production capacity we can increase the absorver bed so that half beds are adsorb vapor and half beds desorbs adsorb vapor. It decreases delay period hence increasing production rate of drinkable water.

III. Literature Review

S.A. El-Agouz et.al [9], conducted the experiment on the solar desalination system using spray evaporation in arid area with 1 m2 solar water collector area. They studied the effect of water inlet temperature on the various factor such as productivity, efficiency, productivity rate, Gained Output Ratio (GOR) and cost drinkable water per liter of the desalination system. They are found that as increase in inlet temperature of water is directly proportional to the productivity, efficiency, productivity rate, GOR. Maximum daily production rate is increased up to 9 l/m2. Maximum day efficiency is about 87%. And cost of drinkable water per liter is $0.029.

Saffa Riffat et.al [16], performs the experiment on the vtrough solar concentrator for water desalination applipositive ion. It is introduced as new type of collector. By experimentation they found that the water is heated up to 100 0C, and the efficiency is maximum reached up to the 38%. The new VTC is more economical in terms of cost and land requirement than the FPC and other type of collectors. Fig.11. shows the schematic diagram of the v-trough collector for desalination applipositive ion.

Xiaohua Liu et.al [10], conducted the experiment on the solar desalination system with evacuated tube collectors and use multi effect distillation system. They do the thermal and economic analysis of system and they found that,

1. With the increasing of heating steam temperature of the first effect, the area of evaporator and fresh water cost reduce the volume of storage tank increases, but fresh water production and fresh water production per unit of collector area all change slightly.
2. With the increasing of the number of effects, the volume of storage tank changes slightly, but the area of evaporator and fresh water production increase, fresh water cost reduces greatly.
3. Among the cost constitution of ETC solar desalination system, the proportion of the cost of evacuated tube collector is the largest (31%), then the cost of civil installation and auxiliary equipment and the cost of manpower is second (15%).

Mahmoud Shatat et.al [11], conducted the experiment on the small scale solar water desalination system for remote and semi-arid region. Economic study is done on the system and they had gives the conclusion that the cost of drinkable water production for this system is reduced to the 8 US$/m3 from the 11 US$/m3. The area used for the solar collector is 3 m2.

Esmail M.A. Mokheimer et.al [12], conducted experiment on the hybrid wind–solar-based reverse osmosis water desalination system for Saudi Arabia. They check the performance of the system and calculate the cost required for getting drinkable water production. And the result is the cost for the water desalination is between the range of $3.693/m3 to $3.812/m3 which is less than the all other desalination systems

Edward K. Summers et.al [14], perform the experiment on humidifipositive ion and dehumidifipositive ion desalination system using air heating solar collector. In this experiment they check the performance of the system by using different type of air heating solar collector such as use of highly trans missive polymer film, low iron glass, very absorptive absorber etc. in the collector. A collector with a double glazing, a highly roughened absorber, and a carbon black coated absorber, results in a collector efficiency of 58% at a normalized gain of 0.06 K m2 /W

Mohammad Abutayeh et.al [15], conduct the experiment on the solar flash desalination under the condition of hydrostatically sustained vacuum. They did the simulation work on this system and find the physical properties of the system. The vacuum in the system is maintained by the internal hydrostatic pressure balanced by the atmospheric pressure. The simulation results show that running the system at higher flash temperatures with a fixed flash chamber size will result in faster vacuum erosion, increased solar collection area, increased boiling point elevation, faster equilibrium attainment, shorter run time, and less production, which is leading to less overall evaporation.

Ibrahim and Dincer (2015) [16] performed an energy and exergy analysis of an evacuated solar still equipped with an air cooled condenser and operated under vacuum conditions. Higher basin area absorptivity and reduction of basin wall heat losses highly improves the performance of the system. By simulation results an increase of 87% in productivity and 152% in exergy efficiency was observed with 75% reduction of basin wall heat losses which needs experimental validation.

Conclusion

The conventional desalination techniques are energy intensive process. Solar energy could be used for purifipositive ion of water as solar energy is available in abundant, and as its technical feasibility is more. In conventional water purifipositive ion process the fuel consumption is more, so for avoid this solar energy desalination gain more response, as sources of fuel are limited in

Earth. The production rate of water by using solar energy desalination is more as compared to the conventional water purifipositive ion process. With the proper solar radiation data collection and modeling after few years the solar energy desalination is the best option for convention desalination techniques.

A. Abbreviation:

MFS - multi-stage flash desalination
MED - multi effect desalination.
RO - reverse osmosis.
HDH - humidifipositive ion-dehumidifipositive ion
GOR - gained output ratio.
VTC - V-trough collector.

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