IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

5th National Conference on Science, Technology and Communication Skills – NCSTCS 2K22

Narula Institute of Technology, Agarpara, Kolkata, India

Vol. 9, Special Issue 2, September 2022

Role of Solar Energy in Desalination of Sea Water

Subarna Paul[1] and Kamalika Banerjee[2]

Student, Electrical Engineering Department, Narula Institute of Technology, Kolkata, India[1]

Assistant Professor, Electrical Engineering Department, Narula Institute of Technology, Kolkata, India[2]

Abstract: We are all quite aware about the fact that only 3% of fresh water is available on the Earth, whereas only 1.2% of it is fit for drinking. Especially in remote areas, the demand of pure drinking water is high. But due to scarcity of fruitful resources, the establishment of a low expense water treatment plant is necessary. Water treatment by photovoltaic/ solar energy process not only makes the way easier and more efficient but also makes it less costly than other water treatment processes. In ruler areas, uncontaminated water is a basic requirement for irrigation of agricultural fields.

Keywords: desalination, solar insolation, distillation, reverse osmosis

I. INTRODUCTION

Water quite essential for all living organism. In manufacturing industries also, water is quite an obvious raw material.Even after having 332.5 million cubic miles of water on our planet from which the ocean, we are still in rescue of purified drinking water.The only resource that can be considered inextinguishable or infinite is the ocean. But, the excessive amount of salt in the ocean's water makes it unhealthy for drinking purposes. The promotion of an idea of desalinizing of the mentioned quantity of ocean water to meet the daily demands of the growing population will open a new era of using the oceanwater for domestic and industrial purposes. Sea water usually contains 35000-45000 ppm of salinity in the form of solid materials but according to the World Health Organization (WHO) the permissible limit of salinity in water should be 500 ppm – 1000 ppm (for some exceptional cases). The purpose of a desalinisation system installation is to eliminate the brackishness of the ocean water that causes issue in tase but also some digestion problems [1].

II. NECESSITY OF DESALINATION

Earth owns natural process of desalination of water, consists of evaporation and condensation of sea water. Desalination process has been practiced by humans since past 2000 years in the form of distillation. In 4th century B.C. when the Greek sailors were out of water in a middle of the ocean, they introduced some evaporative process to desalinate ocean water and use it.The recent history states that the discovery of oil in Arabian Gulf countries' arid regions made important contribution in developing thermal desalination plants. The mid-2007 era marks that 75% of total capacity of desalinated water was processed in Middle East countries. Having more than one way of converting seawater to fresh water, yet, all scheme uses a common overall process. The desalination method used determines each step's actual nature. The following figure shows the steps involved in the process. Figure-1 describes the diagram of desalination process [2].

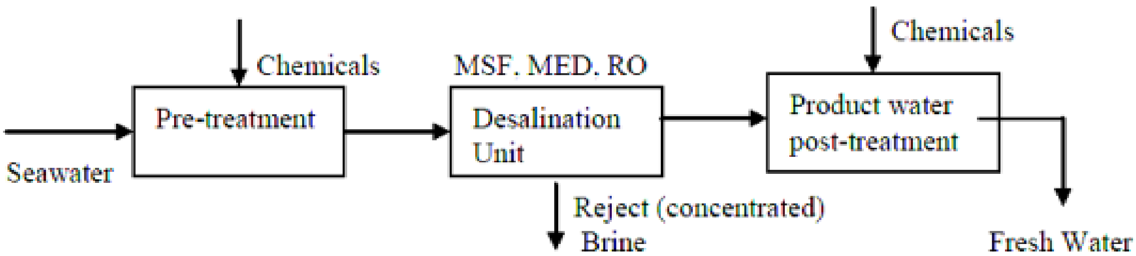

Fig. 1 Schematic diagram of a desalination process

Besides the intake system, the extent of pollution in the areas surrounding the process also determines the nature of the pre-treatment. High contents of organisms like algae and bacteria along with suspend solids are present in the water supplied by the shallow bays close to the shore. Whereas, the seawater that is obtained from the open ocean requires less pre-treatment as it is comparatively cleaner. For the preservation of the life as well as the reliability of the desalination equipment it is necessary to pre-treat the raw feed water. The product water must contain 500 ppm content of total dissolved solid (TDS) irrespective of the conversion process-based method. Table 1 gives an idea of the typical components of portable water as well as sea water [3].

The water that is a product of this process cannot be consumed directly by human being and it still requires forms of post-treatment which is necessary to control sodium ions and chloride ions as well as its pH. In comparison with the natural fresh water, massive amount of energy and significant infrastructure is required in the process of Large-scale thermal desalination which increases the cost and makes it more expensive resulting in the consideration of membrane process. Lately, these processes raised the competition level against thermal desalination in the past years the reasons being that the energy required is comparatively low, maintenance is easier, requires a small area, boosts the start-up process and the cost is effective.This leads to a lower overall desalination cost over the past 10 years. Greater number of facilities uses the reverse osmosis (RO) to operate. To separate salt from water the reverse osmosis process uses semi-permeable membranes as well as intensive pressure. However, reverse osmosis process does not suit hot water as the performance of the membranes deteriorates with a certain temperature of above 40°

TABLE 1 TYPICAL CONSTITUENTS OF SEAWATER AND POTABLE WATER

Constituents	Seawater (mg/L)	Potable Water (mg/L)
Barium	0.02	1.0
Calcium	412	75
Carbonates	28	150
Chloride	19500	250
Copper	$1x10^{-4}$	1.0
Fluoride	1.3	1.5
Iron	0.002	0.3
Lead	$5x10^{-7}$	0.05
Magnesium	1290	50
Manganese	$2x10^{-4}$	0.05
Mercury	$3x10^{-5}$	0.001
Nitrates/Nitrogen	11.5	10
Phosphates	0.06	0.4
Potassium	380	10
Silica	2	7.1
Sodium	10770	200
Sulphates	905	400
Total dissolved solid	33387 (ppm)	500 (ppm)
pH	8.0	6.5 - 8.5
Turbidity	3 - 15 NTU	5 NTU

III. VARIOUS WATER DESALINATION METHODS

The most common water desalination processes adopted are Multi-stage Flash (MSF), Multiple-effect Distillation, and Reverse Osmosis (RO) .Whereas, Membrane Distillation (MD), electro-dialysis or membrane pervaporation are some of the methods which are not always commercially available. Generally, distillation processes are used in which the saline sea water is converted to water vapours by heating (evaporation) and then this vapour is further cooled by condensation to form water droplets.

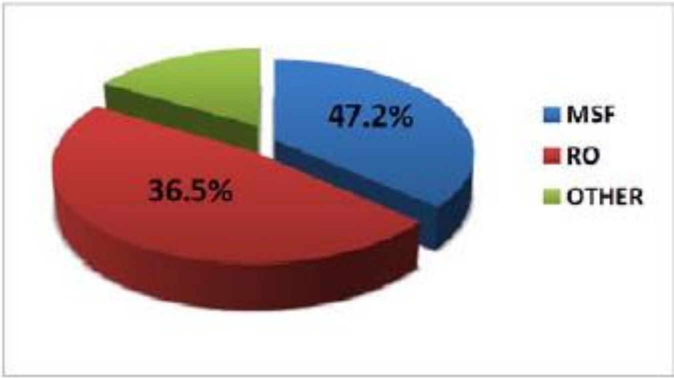

Fig. 2 Contribution of different desalination processes

Multi-stage flash distillation system (MSF)

Multistage flash distillate includes warming salty water to extreme hotness and passing it through declining pressures to produce the maximum amount of water fumes that sooner or later produces freshwater. The heat recovery is established using this distilled water as the heating source for the incoming feed and regenerative heating is utilized to flash the seawater inside each flash chamber.

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

5th National Conference on Science, Technology and Communication Skills – NCSTCS 2K22

Narula Institute of Technology, Agarpara, Kolkata, India

Vol. 9, Special Issue 2, September 2022

The latent heat of condensation released from the condensing vapor at each stage gradually raises the temperature of the incoming seawater. The seawater is fed on the tube side of the heat exchanger that is located on the upper portion of evaporator. Thus, the seawater heated by the condensing steam enters the evaporator flash chambers. The top brine temperature range is usually within 90º to 120º C. Although higher efficiency is observed by increasing TBT beyond 120º the flashed water vapor is then cooled and condensed by cold seawater flowing in tubes of the condenser to produce distillate. The distillate produced and collected in each stage is cascaded from stage to stage in parallel with the brine, and pumped into a storage tank. C, scaling and corrosion at high temperature affects the process significantly [5]. To accelerate flashing in each stage, the pressure is maintained at a lower value than that in the previous stage. Hence, the entrance of heated seawater into the flash chamber causes vigorous boiling caused by flashing at low pressure.

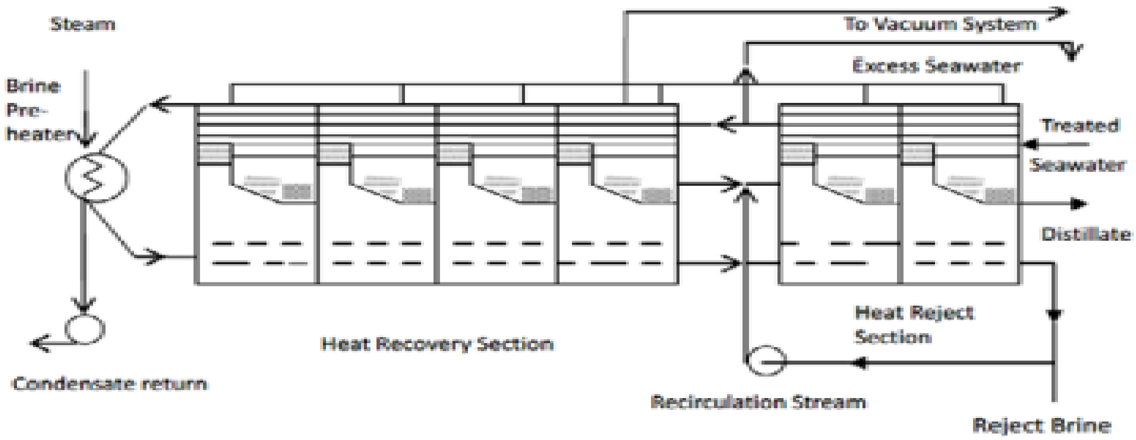

Fig. 3 MSF desalination process

Multi-effect desalination system (MED)

The Multi-effect desalination system (MED) process is the most aged but a very adept desalination plan. Instead of the term "stage", the diversified evaporators inside an MED plant are named "belongings". In this system, the water containing salt suffers angered in diversified stages outside providing supplementary heat later the first effect. The evaporators are organized either (a)horizontally [Horizontal Tube Evaporator (HTE)] accompanying dissolved water containing salt diffused outside television set while the warming energy is concentrated inside the tubes] or (b) vertically [Long Vertical Tube Evaporators (VTE)] accompanying angered water containing salt dropping film inside television set while the warming energy is shortened outside the tubes. For the first effect, the water containing salt gets preheated inside the evaporator tubes and reaches anger.

The tubes are angry outwardly by energy from a usually two-fold purpose energy-producing station. Only any of the water containing salt used to the tubes in the first effect is dissolved. The surplus feed water is augment to the second effect, place it is repeated used to a hose bundle. These tubes are in proper sequence angry for one vapour formed in the first effect. This vapour is shortened to produce new water, while giving in heat to dissolve any of the staying water containing salt feed in the next effect at a lower pressure and hotness. Figure 5 shows the diagrammatic of a MED process. Figure-4 gives a schematic diagram of the MED process [7]. The MED-specific capacity consumption is beneath 1.8 kWh/m3 of distillate, significantly inferior that of MSF, which is usually 4 kWh/m3 to improve the adeptness of the MED process, a vapour compressor is added before the exploratory to boost up energy carried for one vapour. This process is termed vapour condensation (VC). Normally, it is recommended to use diversified stages in this process, as a VC method with multiple belongings gives an increased efficiency ratio, declined power use and maximum utilization of the heating beginning. [3]

IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
5th National Conference on Science, Technology and Communication Skills – NCSTCS 2K22
Narula Institute of Technology, Agarpara, Kolkata, India
Vol. 9, Special Issue 2, September 2022

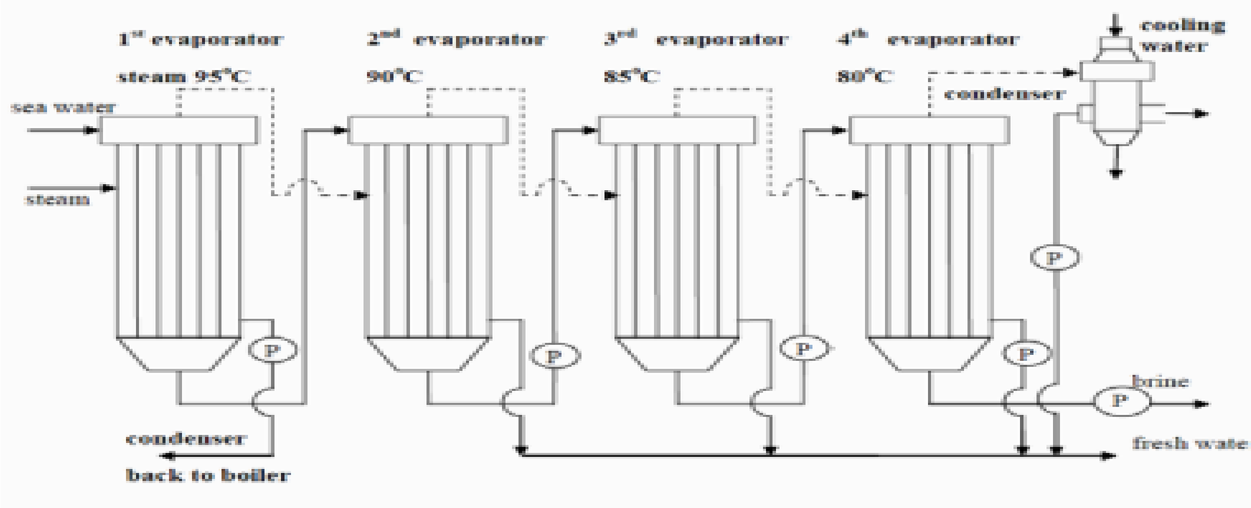

Fig. 4 MED process.

Reverse Osmosis Desalination

This membrane process does not involve phase change and the permeate passes through a hydrophilic membrane under assuredly applied pressure, that is higher than the osmotic pressure of water containing salt. Thus, water flows in the reverse direction to the unaffected flow across the sheet, leaving the dissolved salts behind accompanying an increase in salt aggregation. The major strength required for desalting is for pressurizing the water containing salt feed which is cured by pressure exchanger (PE). In the pressure exchanger the energy contained in the leftover brine is transferred hydraulically. This reduces the energy demand for the desalination process significantly and so the operating costs. The pressure necessary for separation ranges within 50 bars (water containing salt) to 20 bars (brackish water). The osmotic pressure is dependent on the feed aggregation. A typical abundant seawater RO plant consists of four important components namely a) feed water pre-treatment, b) high pressure pumps, c) membrane separation, and d) permeate post-treatment. Figure 6 shows the RO desalination structure. The RO plant energy devouring is approximately 6–8 kW h/m3 without strength recovery and accompanying an energy improvement from the high-pressure side, the energy devouring reduces to 4–5 kW h/m^3. RO has its restraints too. The important problem faced by RO plants is in the pre-situation area and the sheath sensitivity to twisting. Also, the feed temperature must not exceed 40° C to prevent thermal damage of the sheath. [8]

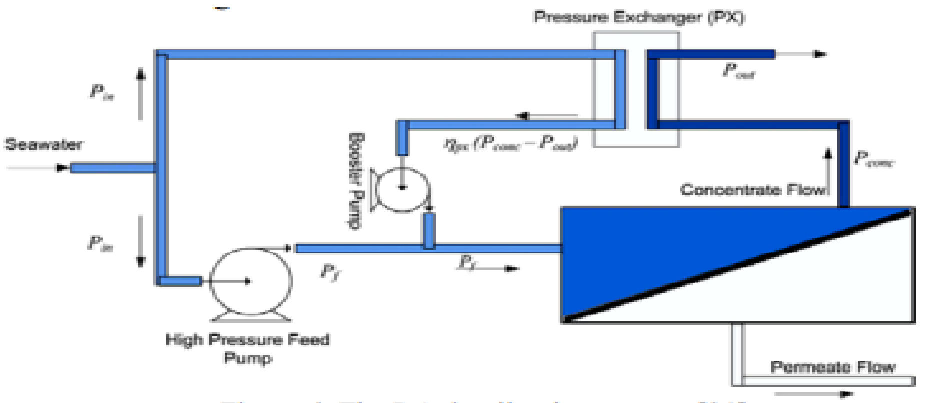

Fig. 5 RO desalination process

IV. ECONOMICS OF DESALINATION

The estimation cost of establishment of a water desalination plant is site specific and also depends on various other factors. Some of the major cost variables are specified below:

a) Quality of feed water treatment: The composition of feedwater with low concentration of Total Dissolve Solids or TDS (brackishness of water) requires lesser amount of energy compared to the treatment of feedwater containing larger concentration of TDS. Low TDS admits for higher change rates and the plant can operate accompanying less dosing of antiscalant chemical compound. The pre-treatment of surface waters to a degree tidal waters will be more harmful compared to somewhat salty groundwater because of the potential life of more contaminants in these waters.

2) Plant Capacity: Plant capability is the main design determinant. It influences the height of position wholes, furnishing, water depository capsule, and water allocation plan. Large skill plants demand the utmost primary capital investment distinguished from disadvantaged ability plants. However, on account of the frugality of scale, all result costs for abundant skill plants may be lower.

3) Site Characteristics: Site traits can affect water result cost. For example, chance of land and land condition can determine cost. The closeness of plant location to water beginning and collect discharge point is another factor. Pumping cost and costs of pipe establishment will be really reduced if the plant is situated near the water beginning and if the plant the collect is discharged to a nearby water bulk. Also, costs associated with water consumption, pretreatment and collect disposal maybe essentially reduced if the plant is a growth of an existing water situation plant as distinguished to construct a new plant [10].

V. APPLICATION SOLAR ENERGY IN WATER DESALINATION

It is distinguishable that most of the water treatment plants require thermal energy for production of the final goods. For this thermal energy requirement, the dc supplies can be replaced by solar energy driven cells. Some of the methods that are mostly applied are:

Photovoltaic Reverse Osmosis System (PVRO)

Photovoltaic Reverse Osmosis System is a variable power flow system that consists of a PV power directed DC pump. This system does not have any external intermediate battery storage. To convert the low- current and higher voltage power generated by the PV panels to a higher current and lower voltage power that a pump generally needs for working under the partial power environment a linear current booster is required. This maintains the estimated high efficiency in the system [12]. Figure-6 shows a schematic flow diagram of the Photovoltaic Reverse Osmosis System [13].

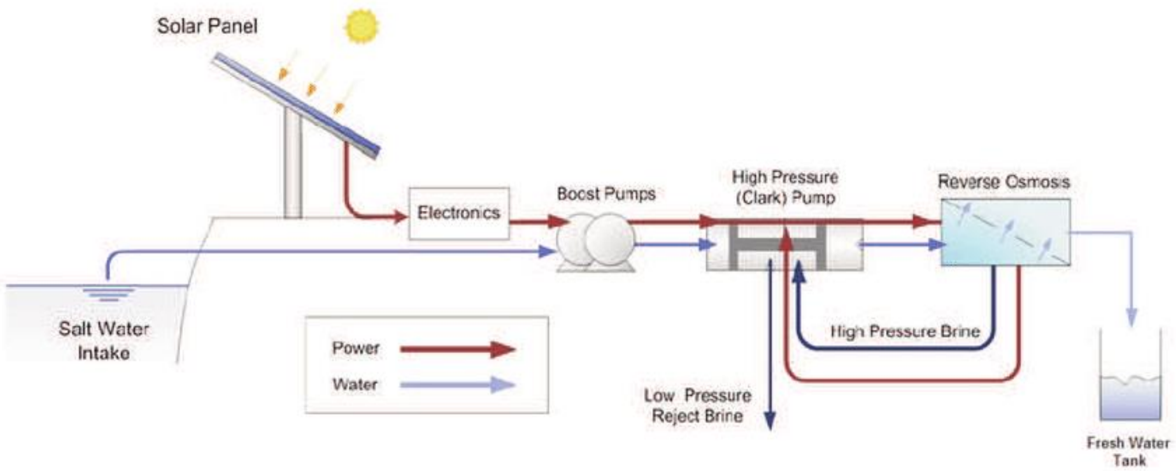

Fig. 6 Process Flow Diagram of PVRO System

Parabolic Trough in MSF

The MSF system is mainly based on the thermal distillation process, which requires a power supply. This supply demand can be met by a Parabolic Trough that concentrates the solar energy for power generation, in substitution of any conventional power sources.

V. CONCLUSION

Solar MED and MSF, though performing to be natural and inviting solutions, cannot stop living as proven technologies. More and more happenings in both solar power and desalination sciences are expected to maintain these solutions competitively distinguished from RO systems accompanying conventional power plants. Somewhere, the answer lies in combination: association of heat sources and mixture of processes. Recent developments present desalination systems containing MSF combined with reverse absorption, heat source being a warm power plant, but coupling accompanying solar resource may be imagined. The main benefit of that installation is that RO can run during night times when power costs are low and MSF works all the while during daytime with depressed running costs due to low-pressure energy.

Water storage offers an adaptable solution with strength consumption-optimized. The addition of solar energy from the start of the project (accompanying parabolic gutters) would have a low-cost impact but no GHG emissions. It can be noted that the range of potential is widely open in desalination. The need for freshwater will always show, therefore desalination electronics must be enhanced to become detergent, more efficient, and more ethical.

REFERENCES

[1] Vidya Sujitha, Manohar Biradar, Praful Koli, Rohan Kusale, Aniket Sode, Deep Gajjar, Assistant Professor, Department of Civil Engineering DYPSOET, Pune 2- UG Student, Department of Civil Engineering DYPSOET, Pune “Desalination of Seawater by Using Solar Energy” 2018 JETIR May 2018, Vol. 5 (5).

[2] Hawlader, M. N. A., “Desalination of seawater: a solution to shortage of fresh water.” Proc CAFEO 20: 20th Conf of ASEAN Fed of Eng Org, 2 – 4 Sept 2002, Phnom Penh, Cambodia.

[3] Rubina Bahar, Mohammad Nurul Alam Hawlader, Department of Mechanical Engineering, National University of Singapore. 2 Department of Mechanical Engineering, Kulliyyah of Engineering, International Islamic University Malaysia. “Desalination: Conversion of Seawater to Freshwater”, 2nd International Conference on Mechanical, Automotive and Aerospace Engineering (ICMAAE 2013), 2-4 July 2013, Kuala Lumpur

[4] IDA 2004: Desalination Business Stabilized on a High Level, Int. Desal.Water Reuse, Vol. 14 (2), pages.14–17.2004.

[5] Harris A., Seawater Chemistry and Scale Control, Desalination Technology Development and Practice, in: A. Porteous (Ed.), Applied Science Publishers, pages.31–56. London, UK, 1983.

[6] Malek, A., Hawlader, M.N.A. and Ho, J.C. Large -scale seawater desalination: a technical and economic review. ASEAN J. Sci. Technol. Development Vol. 9 No. 2. pp 41-61, 1992.

[7] Bruggen Van der B. and Vandecasteele C., Distillation vs. membrane filtration: overview of process evolutions in seawater desalination, Desalination, vol. 143, pages. 207-218,2002

[8] https://quenchwater.com/blog/what-is-reverse-osmosis-and-how-does-it-work/#:~:text=Reverse%20osmosis%20is%20a%20water,and%20dirt%20from%20drinking%20water.

[9] GhobeityA.andMitsos A., Optimal time-dependent operation of seawater reverse osmosis, Desalination,Vol 263. Pages 76–88. 2010.

[10] TamimYounos, Virginia Polytectnic Institute and State University “The Economics of Desalination”, Universities Council on Water Resources Journal of Contemporary Water Research & Education Issue 132, Pages 39-45, December 2005.

[11] https://en.wikipedia.org/wiki/Parabolic_trough

[12] https://www.usbr.gov/research/dwpr/reportpdfs/report104.pdf

[13] https://www.researchgate.net/figure/Process-flow-diagram-of-the-PV-RO-system_fig3_296873376