Solar Energy Driven High-Yield Low Cost Seawater Desalination for Drinking Water Production

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ABSTRACT: About four billion people face severe water scarcity every year around the globe. To provide remedy to this situation sea water desalination has proven to be one of the most effective ways. A number of proven technologies are already in existence. However, these methods take help of non-renewable energy sources and thus using up the non-renewable recourses. This article has a proposed methodology in it which would help in desalination of water without any use of non-renewable energy sources or any highly expensive material that has high maintenance costs. A simple desalination process that uses renewable sources of energy to desalinate water is proposed in this article.

KEYWORDS: Compact PFHE, Numerical study, Fanning friction factor, Colburn j factor, Nanofluid.

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1. INTRODUCTION

We know, 70% of the Earth's surface is covered with water. But out of this 70%, only 2.5% is freshwater, rest 97.5% is in the form of seawater. So in this situation where there is observed to have a big freshwater drain one after another, the only thing to save us from this standing situation is to find out new and efficient ways to convert seawater into freshwater for future use [1].

1.1 Conventional methods of seawater distillations and their drawbacks

There are several methods of sea water distillation (Fig. 1). Each method has their own advantages and disadvantages but all are useful. Some of the methods include:

1.2 Reverse Osmosis (RO)

Reverse osmosis [2] is one of the oldest and most common methods of seawater desalination. In this process a certain amount of pressure is created so as to overcome the osmotic pressure to enhance the diffusion of the particles through the semi-permeable membrane filtering and purifying the seawater.

1.3 Drawbacks

The reverse osmosis process can be only done at a small scale basis. This is mainly used in water purifiers at home, mass scale purification by this method will cost a huge sum of money and also the maintenance cost will be pretty high.

1.4 Vacuum distillation

Vacuum distillation [2] is one of the traditional methods of sea water desalination which involves heating up of sea water to stream so as to leave the impurities behind. In this method the pressure above the liquid to be distilled is lowered to the vapour pressure of the liquid, evaporating the liquid at a comparatively lowered temperature than normal.

1.5 Multi-stage flash distillation

Multi-stage flash distillation (MSF) is one of the most thermodynamically efficient methods [2] of seawater desalination in which a flash of light is passed through a patch of incoming seawater converting it into stream which is then condensed to freshwater.

The major drawback of the process is the high maintenance cost of the plant and huge amount of power that is required to the run the water purification process .Fuel and electricity is used in this process which makes it dependent on non-renewable resources.

1.6 Multiple-effect distillation

Multiple-effect distillation (MED) [2] is also one of the most thermodynamically efficient methods of seawater desalination in which a patch of seawater is sprayed into the pipes which are then heated up so that the water gets evaporated and converted into stream. The stream is then used to evaporate the next batch of incoming seawater.

The major drawback of (MED) is that the high amount of temperature that has to be maintained uses up a lot of fuel and due to complex machinery used in the process there is a constant need of maintenance of these machines.

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2. PROPOSED METHODOLOGY

In comparison to the conventional forms of distillation, passive water filtration can work on its own with no manual help needed, the process occurs on its own with no manual work needed. Even though it not as efficient as other methods which are in use, passive approaches aim at improving the cost in the desalination process and increase s the dependence on small plants as they have lower capital investments and lower management costs, especially isolated and desert like places. The idea here is to build a distiller which will not use any kind of non-renewable source of energy and would work only on energy derived by the sun and also to make the process completely passive manner[1-2]. The proposed modular distiller can be used to desalinate seawater or from other water body passively by using low-temperature heat without using mechanical or electrical or any other material or equipments that have high costs, when made to work under normal conditions(Fig. 2,4) . Every layer of the proposed machine consists of 2 layers of special conducting plates mainly aluminium based, each installed with a layer of selectively permeable micro fibres. The separation of liquid is be achieved by using either a hydrophobic micro porous membranes, as is used in membrane distillation [3-6], containing porous holes between the selectively permeable layers. Two of the techniques can be used in this process. The use of selectively permeable membrane prevents salt contamination of fresh water in condensing layer [2]. The top most part of the distiller is installed with a special kind of metal sheet which amplifies the heat of the sun rays and the use of a special kind of high density transparent plastic sheet printed by a 3D printer is covered on top of the metal sheet which allows to absorb the sun's rays and also acts as an insulator. The metal sheet used is called a TiNOX sheet which is commercially sold solar absorber. The bottom most part of the distiller is dipped in sea water, it is used to create a temperature gradient between the top and bottom of the distiller. We shall see about the working of the distiller in the next parts.

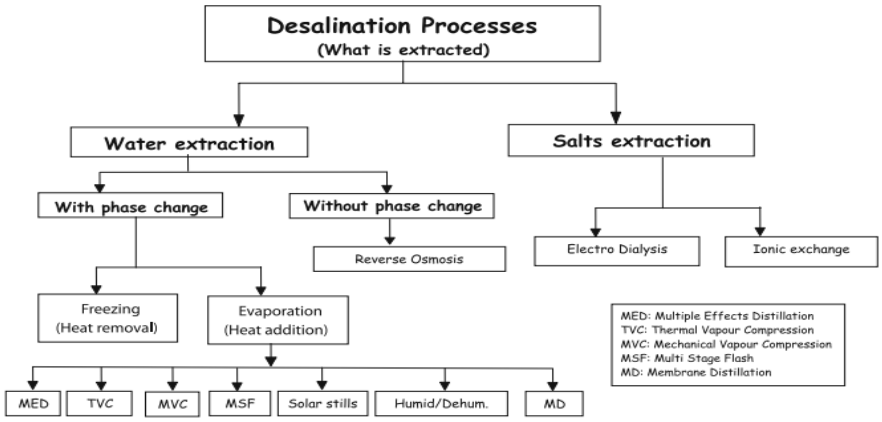

Fig.1: Desalination technologies classification based on what is extracted from the feed stream

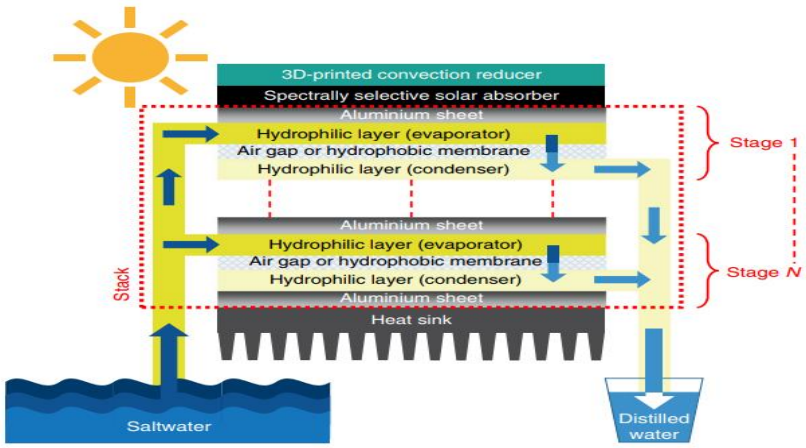

Fig. 2: Schematic representation of the machine.

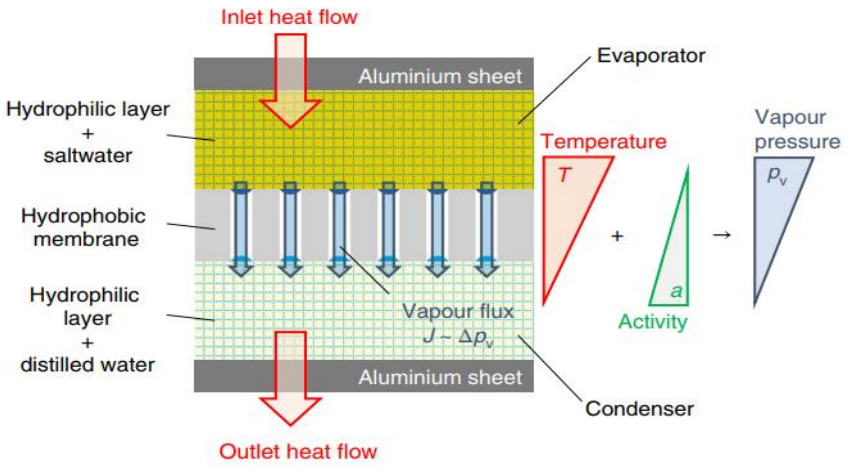

Fig. 3: Schematic representation of heat flow and distillation process.

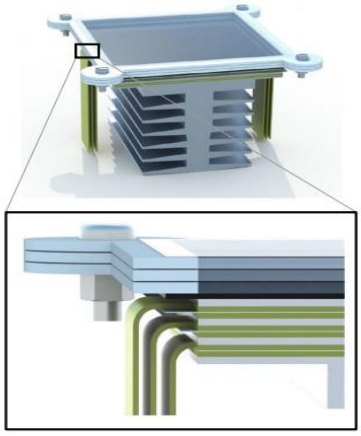

Fig. 4: Isometric view of proposed machine.

3. WORKING PRINCIPLE OF THE DISTILLER

The distiller works on various basic scientific processes like evaporation, vaporisation and condensation to name a few. If we look at (Fig.3) then we would be able to understand the process in a better way, first the water rises in the capillary tube due to capillary suction as the water first enters the top most part of the distiller, which is highly heated up due to the use of special conducting layer of aluminium and the special type of insulator that traps the heat, the water gets converted to vapour now as the bottom most part of the distiller has a heat sink which is submerged in water and is cooler that the top most part of the distiller, the temperature gradient makes the vapour in top most part of the distiller to come down in this course the water passes through N no.(here N represents the number membranes that we wish to attach to the distiller according to the amount of water we want to distil.) Of selectively permeable membranes and due to this process it gets filtered. The bottom most part being much cooler the water gets condensed and then the distilled water is collected separately. As the distiller is at a significant height from the ground the distiller water comes out of the distiller by the help of gravity [1].

4. LABORATORY TESTS

The distiller was tested under both laboratory and real life working conditions and in both the cases it was pretty successful and was capable of producing large volumes of fresh water.

5. CONCLUSION

In conclusion we propose a new methodology that would help us to desalinate sea water to fresh water without the use of any mechanical moving parts or without any non-renewable source of energy which makes the device highly cost efficient. This device would prove to be a life saving device at the time of natural disasters, as it is capable of working without fuel or electricity. In this way it could provide the area of disaster with fresh water even if the place might be not getting electricity. Thus, this device would be very beneficial for mankind.

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