Introducing a new technology for seawater treatment with solar energy

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Abstract

Solar desalination has been used for long time to obtain potable water from seawater, but because of a number of technical difficulties, the technique has not been commercialized to serve industrial-scale or large communities demand of water. With the current trend of population increase in the world (and in South-East Asia in particular), affordable water desalination techniques will be highly required, as most current techniques, including those using distillation or membranes, have high initial and running costs. The technique suggested here will significantly reduce the running cost of water desalination units. With a simple distillation process requiring only solar energy to evaporate the water, this technique will introduce, for the first time, a practical way to desalinate seawater at a significantly low running cost. Successful implementation of this technique will be of good value to the economies of countries are exposed to sunshine for long hours per day or year, most valuable incorporation of this technique is expected to be in countries of the equatorial region having long coasts.

Introduction

Solar stills have been used for water treatment for a long period of time [1]. In 1952, an American magazine mentioned that the US air force developed a solar still to aid pilots whose planes are shot down by managed to reach sea lavel [2]. However, although the technique seems simple and easy, it has not been used industrially, or to produce desalted water in large amounts. There is a patent in Pakistan [3] about the use of solar still in water desalination with large enough production of desalted water (40 L/m^3/day).

With all knowledge and advances within the seawater desalination techniques, there is still an area for a lot of improvement. Currently, most seawater desalination in the world takes place either through distillation (with conventional heating techniques) [4] or with membrane separation, with reverse osmosis as the mostly used desalination technique with seawater [5]. This is the case even in countries like Saudi Arabia, where seawater is easily accessible, solar energy is available for most of the year, but not a lot of advancement has been made to improve the quality of water desalination techniques there through the use of solar energy and solar stills.

Solar stills are mainly distillation equipment, where the water is heated with the accumulation of heat thanks to the Infrared (IR) radiation from the sun. As the temperature increases inside, the water starts to evaporate then condense on the glass wall of the solar still, similar to the water cycle in nature.

Looking particularly at South East Asia, it is easy to notice a water crisis might be on its way, with increasing water shortage problems [6]. This is having a strong impact on development economics in this region, and its massive impact may threaten the livelihood of many people in the region [7].

Problem with the Current Water Desalination Systems

Currently, costs of seawater desalination are too high. This is logical because of the nature of the techniques used.

When looking at seawater desalination techniques, they can be easily divided into two techniques, mainly distillation based and membrane based. Distillation based techniques include Reverse Osmosis (RO), Micro Filtration (MF), Nano Filtration (NF), Ultra Filtration (UF). In one separation process there may be more than one membrane technique used together. For example, MF and UF are used as pretreatment for seawater before it is treated with RO [8]. Cost of seawater treatment membranes is also considered high.

What makes the process more costly is that, because of the nature of RO membranes, very high pressures must be used to push the water through the membrane. This problem is not faced for example with brackish water treatment, as the concentration of salts is usually lower than that of seawater, so the membranes do not require such a high pressure to push the water through. In case of seawater desalination, pressures required for the treatment may reach around 70 bars, which means cost increase on two sides:

1. The pumps required to provide such a high pressure are costly. Add to this that all parts of the pump in contact with sea water have to be corrosion resistant. Sea water is known to be highly corrosive. This is an addition to the capital cost required for the membrane themselves
2. The power required to run such pumps is not low. The pumps working to pressurize the water to such head have a high running cost. These pumps require a lot of power to reach this head. Consequently, the running cost will also be high.

The information stated above explain, in a summarized way, the reason why the costs of seawater desalination are high. With such high costs, for a very important material like water, there should be a way to come up with a new technology which can be used for the water treatment.

Seawater Desalination, a New Technique

Seawater desalination is certainly a cheap and less costly technique to use. On one hand, the use of solar energy for the distillation represents a much way which is less costly to run the desalination process. One technique is already available, where the membranes are used to remove the salt from the water, but instead of powering the pumps with electricity from the grid, electricity is generated from solar cells. From the running costs perspective, this technique is certainly less costly than using the power from the grid or from diesel generators for example. However, its main problem is that there is a significant increase in the capital cost of the desalination system, as the cost of solar cells, and their additional accessories, is still high compared to the running cost for the power from the grid.

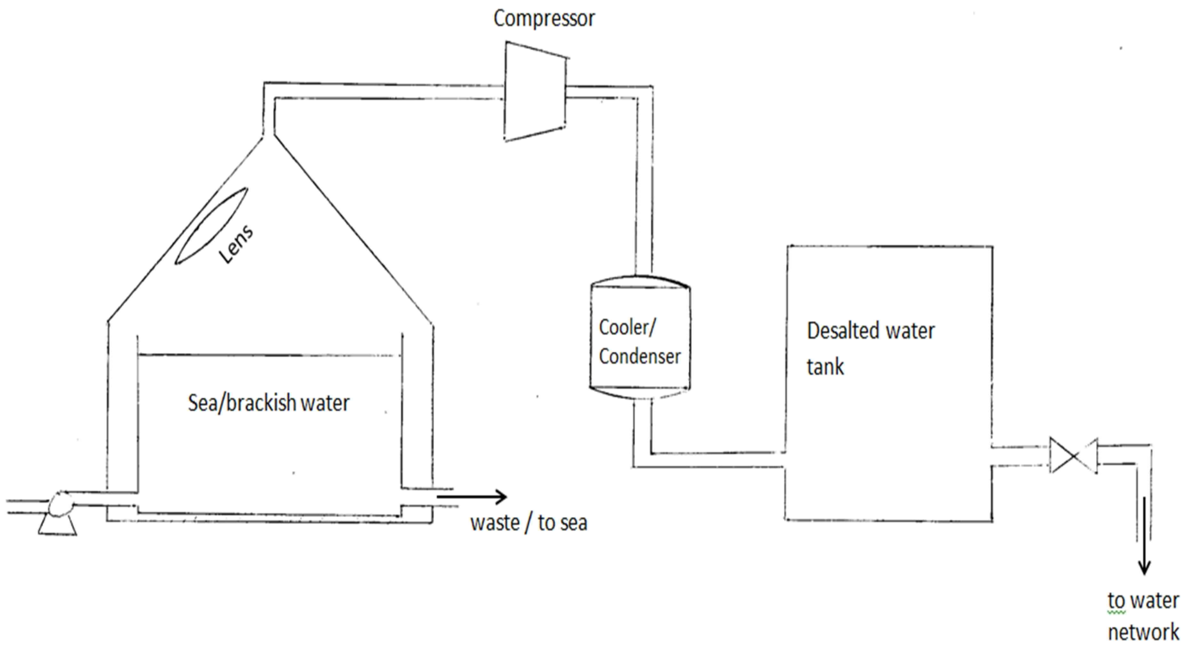

Figure 1. A schematic diagram for the suggested solar desalination technique.

The suggested technique is an addition to the already established solar still technique. As mentioned above, the solar still technique is currently being used, but usually in small scale production of water. It can produce amounts which are enough only to cover the needs of a small area, but cannot be used industrially or to cover the need of large communities.

The suggested technique runs the process as follows:

1. Seawater is fed to the tank. The tank is placed in a transparent housing, to allow the light to enter and increase the temperature with IR rays.
2. The sunlight is focused with a lens, or a number of lenses. The increased temperature inside will make the evaporation of seawater easier.
3. To decrease the difficulty of the evaporation process, a compressor is used to withdraw the air from the housing and compress it. The air taken will be saturated with water vapor, at relative humidity 100%. Once the air is compressed, vapor drops will start to form on the walls of the pipes carrying the compressor output.
4. The steam and water are passed through a cooler/condenser. As the process is run with an excess of seawater available, the vapor will be condensed in copper pipes submerged within a seawater tank. Copper offers high thermal conductivity, and has higher resistance to the corrosion caused by the salts in the seawater.

5. The water, now mostly condensed, will pass by the water within the distilled water tank. Air which still contains small amounts of water vapor will be passed within the water, where any water vapor still in the gas phase is expected to be condensed.

Technical Problems within the Suggested Technique

There is a number of problems within the suggested technique. These problems can be summarized as follows:

1. **Glass brittleness and pressure accumulation within the distillation chamber**
   This is one of the problems which are highly likely to face the technique, especially at its first stages, or after the compressor is shut down and is turned on again. In this case, the situation within the chamber will require the accumulation of some pressure, so that there is enough steam within the air leaving the chamber.
   The cause of this problem is mainly because of the brittleness of glass. Glass is known to be very brittle, and so it cannot be used with high pressure difference between the inside and the outside of the chamber.
   This problem can be solved by using another material of construction for the chamber walls. A more suitable material here can be poly methyl methacrylate. This material is known to be not as brittle as glass, and it has higher transparency than glass. These two advantages make it a suitable suggestion.
2. **Increase of boiling point with the increased pressure**
   It is known in thermodynamics that the boiling point of any liquid increases with pressure. This problem is quite related to the situation mentioned in point 1. above, but it can be solved through good control of the pressure within the chamber. Once pressure reached a specific point, the compressor can start automatically, withdrawing all the increased pressure from within the chamber. This also highlights the need that the chamber should be tightly closed, so that no vapor or gas entry can happen except through the compressor.
3. **Low production rate of solar desalination systems**
   This is a significant problem with solar desalination. Not a lot of water evaporates, and with the increased temperature within the glass housing it is difficult to condense more water. This technique solves the problem by running the condensation process outside.

4. **Scaling and salt disposition**

   Scaling, or salt disposition, is another well-known problem in almost all solar desalination techniques. In RO systems for example, there must be some backwash to remove the accumulation of salts from the membranes.

   In the current system, the system simplicity offers a simple solution. In case enough water can evaporate, the seawater entry/exit can be run as a continuous process. This implies that the seawater should be left for enough time within the system to reach the required temperature and start to evaporate.

   On the other hand, if the water must be kept within the chamber until it reaches the required temperature, salt disposition can take place. This still does not represent a problem, as the seawater can be equipped with an internal plastic layer in which all the salt disposition takes place. Once it reached a specific concentration, this plastic layer is discarded with all the salt in it, a new plastic layer is placed and the tank can be filled with a new batch of seawater. This second solution is more suitable for seawater in areas containing calcium salts which have decreased solubility with increasing temperature.

Impact of this technique on Water Supply

Establishing this model and designing this equipment will ensure a more robust water safety policy and easier accessible potable water supply for Malaysia. Malaysia is already starting to face a water shortage problem [9], which places water safety as a government priority especially in Sarawak [10].

Conclusion

A new technique for solar desalination has been introduced here. The expected technical problems have been briefly discussed, and suggested solutions have been offered. This technique, once implemented, will offer a less-costly, more environementally-friendly way to desalinate seawater.

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