Desalination of Brackish Water with Parabolic Solar Concentrator

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Abstract

Desalination, the process of separating salt water and distilled water, requires a lot of energy, so combining a solar concentrator in the process allows a renewable energy source to power the process instead of non-renewable energy sources. A parabolic dish made of fiberglass was used to collect sun rays and use the thermal energy to boil the water and desalinate brackish water. The experiment showed the absorber was efficient enough, since the concentrator dish did not move with the sun throughout the day. The distillate output reached a maximum volume around 2:00 pm, when the curve of the parabolic dish was in the ideal position to catch the sun's rays. At this time of day, the system was able to produce 0.853 L of distilled water with incident radiation of 465 W/ m^2 . The system as a whole completed the function of purifying the water of salt, but the experiment of testing the absorption of solar irradiation through a parabolic dish did not prove to be efficient or significantly helpful. Five separate equations were used to solve for five unknown variables, including the distillate flow rate, and temperatures do the rear absorber, internal wall of the absorber, and internal wall of the absorber enlightened face. These predictions were the calculations for the theoretical distillate rate and average temperature. The experiment results do not show a significant difference between the collected distillate rates and average temperatures, and the theoretical ones. Aside from the immobile factor, the dish was not as effective due to human error of imperfections in attaching the stainless steel sheet segments to reflect the light on the dish.

Materials and Methods

Brackish water is placed bin, where a pipe carries the water to an absorber, which is located at the center of the parabolic dish. The dish had a aperture diameter of 1.8 m and was covered with stainless steel sheet segments to act as a reflecting surface. These reflective protections allow the concentrator to last long, and usually make the concentrator more cost effective as a whole. The absorber is an insulated cylinder that heats the brackish water to steam, using the sun rays from the concentrator.

The salt was dispensed into the sewage system is this scenario once only the sand was left. From here, the steam travels through the condenser, where the temperature is lowered and the water is condensed in a copper coil condenser. The distillated water then flows into a secure container where the water is in a state fit to be drank.

The temperature of the of the unit was measured with a Testo 935 digital temperature indicator. Every hour, the unit was tested for the distillation rate the various temperatures mentioned in the abstract. The calculated global efficiency for production was solved for using the formula $\eta = \frac{q_v}{Iac_g}$ where q_v is the evaporation heat flow, I is the incident radiation, a is the receiving surface absorber area, and c_g is the geometric concentration. The experimental efficiency increased as the time approached 2:00 and the began to decrease after the prime time of day.

Analysis

Figures

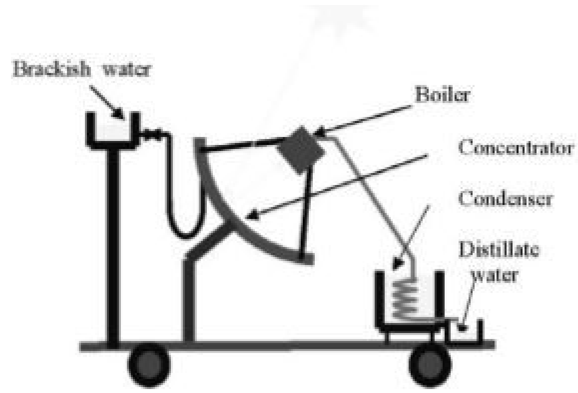


Figure 1: This figure depicts an experimental device that was made to test how effective parabolic solar concentrators would be in the desalination process.

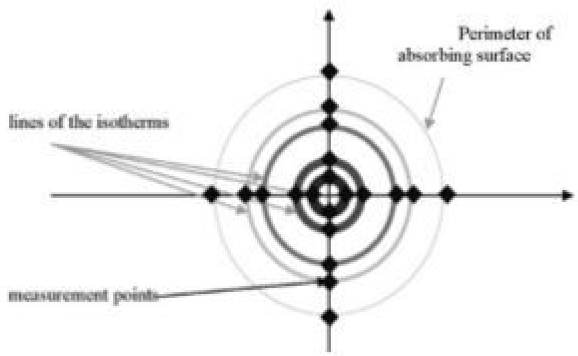


Figure 2: This figure depicts the distribution of isotherms on the enlightened face of the absorber.

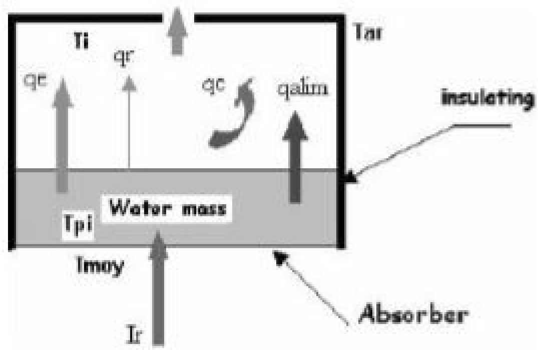


Figure 3: This figure depicts the gain and losses of exchanged powers at the level of the water mass.

Figure 1 is relevant to the article because the idea is centered around the device that was made to test and see if parabolic solar concentrators could be used for the process of desalination. This pertains to our project as we are looking for different techniques to desalinate dirty water. This could be one of the ways we consider. Figure 2 is relevant to the article as it talks about the distribution of the isotherms and the contribution of these to the boiling of the water. This is relevant to our project as we are looking for effective ways to boil the water, and the idea of solar concentrators could be an option. Figure 3 is relevant to the article as it shows the energy gained and lost within the system of the solar concentrators. This is relevant to our project as it shows us what energy is gained and lost when using the design.

Tables

Time (h)	Incident radiation (W/m^2)	Distillate output (L)	Ambient temp. (°C)
09:00	352	0.255	28.0
10:00	409	0.612	28.5
11:00	441	0.785	28.6
12:00	455	0.725	29.6
13:00	453	0.776	30.0
14:00	465	0.853	30.8
15:00	420	0.749	29.8
16:00	405	0.737	29.4
17:00	217	0.378	29.0
18:00	150	0.242	28.5

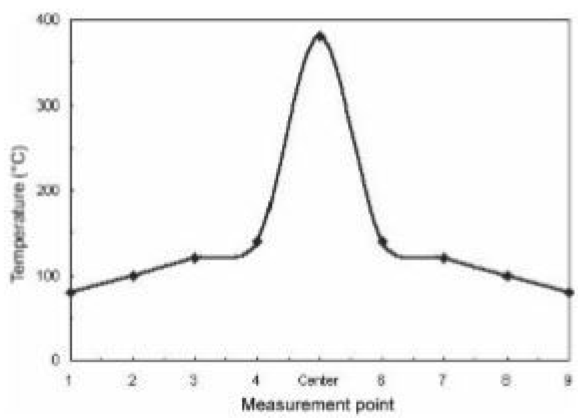
Table 1: This table shows the experimental obtained data of the absorber average temperature.

Time (h)	Theoretical distillate output (L)	Experimental distillate output (L)	Relative difference (%)
0.375	974	255	74
0.4167	1136	612	46
0.4583	1225	785	36
0.5	1265	725	43
0.5417	1259	776	38
0.5833	1294	853	34
0.625	1165	749	36
0.6667	1122	737	34
0.7083	585	378	35
0.75	394	242	39

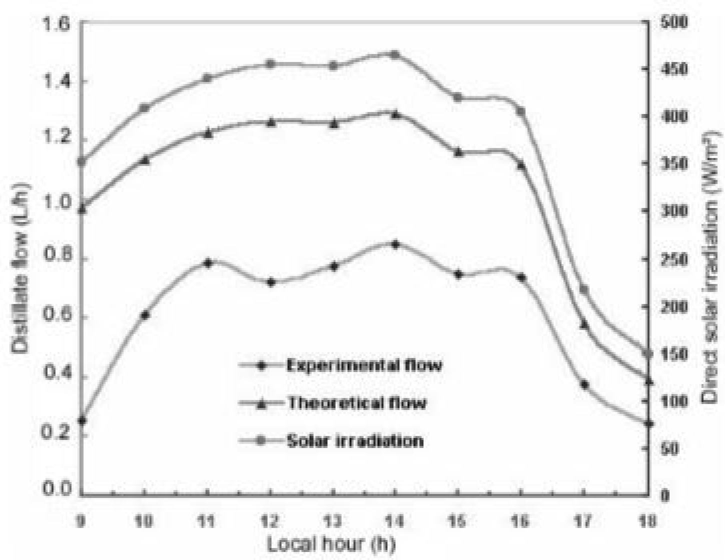
Table 2: This shows the relative difference for the distillate water output.

Table 1 pertains to the article as it shows the different factors that contribute to the heating up of the absorber, which is part of the solar concentrator system. This is relevant to our project as we need to know the temperature of the absorber in order for the water to boil enough to eliminate the contaminants. Table 2 is relevant to the article as it shows the relative difference output of the distilled water in the solar concentrator system. This pertains to our project as we need to know how the experimental and theoretical output compared so we can know if this method is effective or not.

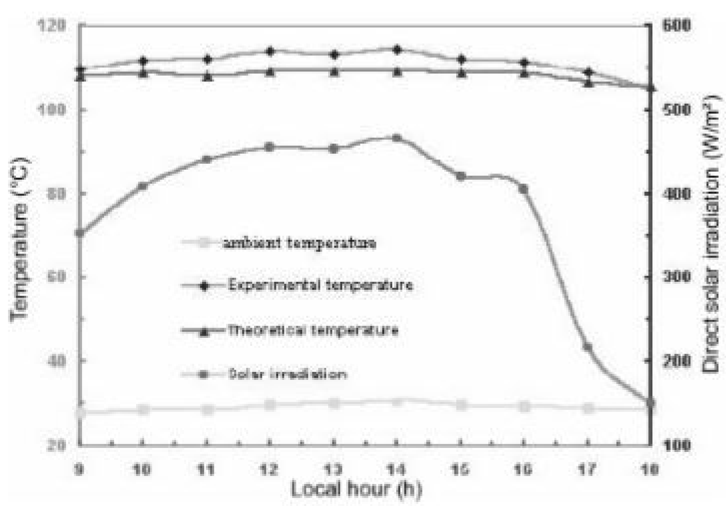
Graphs



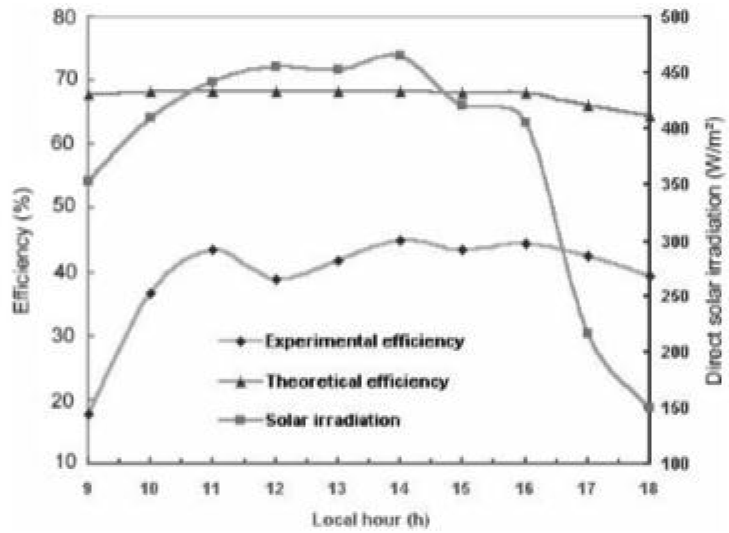
Graph 1: This graph shows an example of evolution of the temperature on the diameter of the absorber enlightened surface.



Graph 2: This graph shows the experimental and theoretical distillate flow rates and solar irradiation vs local time.



Graph 3: This graph shows the experimental and theoretical average temperatures of the absorber enlightened face and solar irradiation vs local time.



Graph 4: This graph shows the experimental and theoretical instantaneous global efficiency and solar irradiation vs local time.

Graph 1 is relevant to the article as it shows the temperature on the surface of the absorber in the solar concentrator system. This pertains to our project as we need to know the temperature an absorber should be reaching in order to be effective. Graph 2 is relevant to the article as is as it shows the experimental and theoretical flow rates of the solar concentrator system. This is relevant to our project as we need this data to know how effective this system is and whether we should use it also. Graph 3 is relevant to the article as it shows the experimental and theoretical average temperatures of the solar concentrator system. We need to know this because it lets us know of the system lived up to its expectations and if we should use a similar design. Graph 4 is relevant to the article as it shows the experimental and theoretical instantaneous global efficiency and solar irradiance vs time of the solar concentrator system.

This pertains to our project as this data also lets us know the efficiency of the overall system and whether it is trustworthy enough to use for our desalination plant we want to make.

References

Chaouchi, Béchir. (2007). Desalination of Brackish Water By Means of a Parabolic Solar Concentrator. *Desalination*. Retrieved September 26, 2017 from https://www.sciencedirect.com/science/article/pii/S0011916407004778.