Experimental Investigation for the Solar Pond Performance at changing its depth in Kerbela city of Iraq

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Abstract: **A solar pond is an application that is used to store large amounts of thermal energy. Solar pond with a salinity gradient was constructed in this research salt containing sodium chloride was used with a concentration of 26%. Initial experiments were conducted with 0.3m thickness of the pond lower zone, then the thickness was changed to 0.4m. It was conducted in Iraq at Karbala (32.55°N, 43.97°E). Useful energy and thermal efficiency are key factors used to measure the performance of a solar pond. The results showed that solar radiation could be got at about 1 pm. The results also showed that the maximum lower zone's temperature of the pond with a thickness 0.3m and 0.4m is about 46.2 °C and 49.2 °C respectively. It was also concluded that changing the thickness of the lower zone improves the thermal energy, useful energy and thermal efficiency of solar pond by 6.5%, 21.7% and 14.5% respectively.**

Keywords: **solar energy, solar pond with a salinity gradient, sodium chloride, thickness of lower zone.**

I. INTRODUCTION

Solar energy accessing the surface of the earth is adequate to meet current global energy needs if used properly. Solar ponds are one type of solar energy system that could be used. Due to its construction method and size, a solar pond is a low-cost energy gathering and storage technology. The pond can be dug in the ground. The solar pond with a salinity gradient, is a pond with a salinity gradient built into it. The salt concentration mixed with water, in particular, grows with depth. [1].

The solar pond functions as an energy collector as well as a long-term thermal storage device. Divided the solar pond into three zones: the upper convective zone (UCZ), the non-convective zone (NCZ), and the lower convective zone (LCZ). UCZ is a uniform layer of fresh water at a temperature of about the temperature of the surrounding environment [2].

As the salt concentration in NCZ grows with depth, this layer acts as an insulator as well as a collecting and storage medium for heat. The third region is the LCZ, which has a relatively constant salt and temperature and serves as a primary mediator for heat accumulation, storage, and removal [2].

Alenezi, [3]. Increase in the thickness of the lower zone affects the storage area's temperature, which is reflected in the amount of additional solar energy absorbed by this layer. The thickness of the storage area was reduced to 0.3 m and thus got at approximately 80 °C. It is concluded from this that the lower the thickness of the storage layer, the better.

Kanan et al [4]. The bottom convection zone of the solar pond is used for storing and extract useful heat. The energy balance in the LCZ produces this heat. The thermal capacity of the solar pool grows as the thickness of the LCZ is increased, therefore it will take longer to heat up and cool down. Young fish cause the lower convective zone to heat up more quickly over the season. The thin LCZ, on the other hand, allows the gradient in the NCZ layers to be disturbed. As a result, the thickness of 0.7 m LCZ was selected as the recommended thickness.

Hasan et al [5]. In Nasiriyah, Iraq. Created a computational program to mimic the operation of a solar pond for a year. When the thickness of the storage layer is 1 meter, the efficiency of the solar pond for storing heat is exactly proportional to the size of the storage area. Because of the accumulation of heat inside the pond throughout the work months, the highest temperature of the pond water reached 145 °C. Heat losses from the pond's sides and the surrounding surroundings were also reduced.

Kanan et al [6]. The type of application for which a solar pond is designed depends on the thickness of the solar pond lower zone and on the amount of energy stored within that layer. The most important of these applications are heating and electricity generation.

Sayer [7]. The impact of growing the solar pond's thickness low-lying portion on its temperature was investigated. The thickness of this layer (LCZ) is varied between 0.5 and 4 m with a 0.5 m interval. With a thick of 0.5 m, the highest temperatures are got, while with 4 m thick, the lowest temperatures are got. The maximum temperature is around 115 °C and 75 °C with a thickness of 0.5m and 4m, respectively. Because of the LCZ's size discrepancy, this behavior occurs. Because the volume of water in the LCZ is tiny for a thickness of 0.5 m, the heat accumulation in the LCZ grows dramatically. The temperature in the LCZ slowly rises to a maximum of 75 °C with a thickness of 4 m.

II. STRUCTURE OF THE EXPERIMENT

As illustrated in Fig. 1, A square-surfaced solar pond and 45° sloped walls made of three layers, UCZ, NCZ, and LCZ, with thicknesses of 0.1m, 0.6m, and 0.3 m, respectively, was constructed. When the pond was built, it was subjected to the sun's natural rays. as well as other environmental factors. Daily measurements of solar radiation were taken from 8 a.m. to 5 p.m. During the test period, lower zone of pond temperatures was measured during a 24-hour period. The pond's overall efficiency and useful energy were estimated.

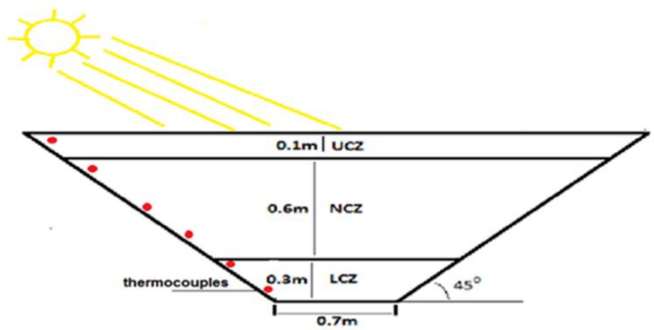


Figure 1: Schematic of salinity gradient solar pond in Iraq.

III. MATERIALS AND METHODOLOGY

3.1 Salts

To store thermal energy in solar ponds, a variety of salts can be utilized, each with its own set of characteristics and effects on the pond's performance. Sodium chloride was one of the salts employed in this study. These salts have the advantage of being easy to obtain due to their widespread availability on the market, as well as being less expensive than other forms of salts, at high the temperatures is stable and has a good solubility.

3.2 water used.

Reverse osmosis technology was employed to purify the water used in the solar pond. This water is such that it contains relatively few salts and other solids. The local municipal water contained 360 TDS of solid particles, whereas the water utilized in the pond included only 14 TDS. As a result of the low thermal conductivity of this water, salt was gradually added to construct the needed layers of the solar pond.

3.3 Experimental steps.

The pond was gradually filled., beginning with a 0.3m thick LCZ layer that was saturated with salt of sodium chloride at a 26 percent concentration. The NCZ layer was then placed with 3 levels, each with a 0.2 m thickness and 2% to 4% salinity, and was applied in layers as the depth increased. The UCZ layer, which was salt-free and 0.1m thick, was then applied. The pond was kept open for many days to allow the sun to warm its layers. Thermocouples were used to record the temperatures., and solar radiation was observed during the study. For the lower zone, these steps were repeated with a 0.4m thickness for the lower zone.

3.4 Thermal efficiency and useful energy.

The thermal efficiency of a solar pond can be calculated using the useable energy at the highest salinity concentration., as shown in the equation below [8]:

$$\eta = Qu/ I \qquad (1)$$

where Qu is the useful energy, calculated as

$$Qu= Ms\ cps\ \Delta T \qquad (2)$$

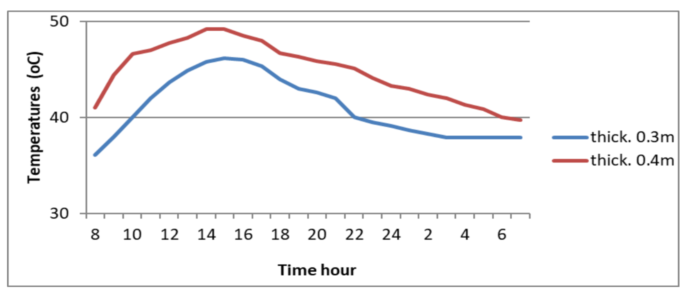
where Ms is water mass of lower zone, cps is the specific heats for water, ΔT is difference the temperature between the LCZ and ambient air,) I (is the solar energy incident on the pond

$$I= Ho*A \qquad (3)$$

where Ho is the solar irradiance on the [9].

IV. RESULTS AND DISCUSSION

Temperatures in the solar pond and daily radiation intensity were measured; the highest results, 1384 W/m2, were discovered at 2:00 p.m. The results also revealed that 0.4m thickness had the highest temperatures when compared to 0.3m thickness. Figure 7 shows the temperatures at two thicknesses in the pond's lower zone, Figure 2 shows that temperatures rise as the lower zone's thickness grew. Can conclude that a solar pond with 0.4m thickness has a higher heat storage capacity than 0.3m thickness.



Figures 2: Temperature distribution in the LCZ with two thickness.

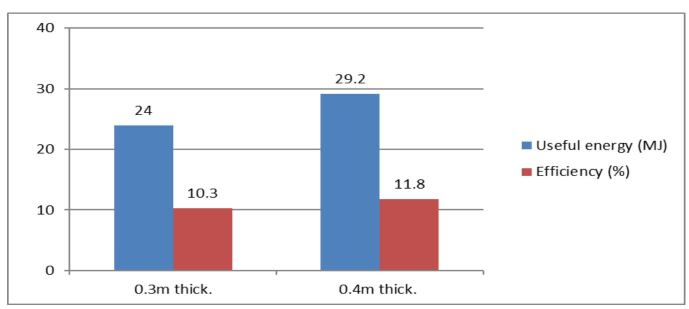


Figure 3: Useful Energy and thermal efficiency of Solar Pond with two thickness.

V. CONCLUSION

With two thicknesses for LCZ of the solar pond. The conclusions below were drawn:

1. When 0.4m thickness was used, the pond's LCZ temperature hit 49.2 degrees Celsius.; while reached 46.2 °C when 0.3m thickness was used.
2. When 0.4m thickness was employed instead of 0.3m, the calculated usable energy and performance were higher; the results were 24 MJ and 10.3% for 0.3m salt and 29.2 MJ and 11.8% for 0.4m, respectively.
3. The beneficial energy and thermal efficiency of the pond rise with a rise in the lower zone thickness of the pond, according to the experimental data. The results also showed that increasing the thickness of the solar pond boosted its performance.

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