

Prototype of Salt Gradient Solar Pond as Alternative Energy Source for Coastal Communities in Bengkulu

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ABSTRACT

One of the developing technologies of renewable energy is the Salt Gradient Solar Pond (SGSP). SGSP utilize solar energy by storing its thermal energy in a pond of saline solution. Bengkulu Province has a high intensity of sunlights and a long coastline with abundance of salt water. Therefore, it is a very suitable location for further development of SGSP technology. The design of SGSP prototype had been carried out by using a 1 m³ cylinder as the saline solution pond. The density and temperature of the solution were measured at 11 points from the bottom to the top of the cylinder. The results show that the deeper of the pond the more density of the solution, in which the highest solution density was at the bottom of the pond, i.e. 1.206 gr/cm³. The average temperature of the solution was 44.2°C. The maximum temperature, which was 48.7 °C, was observed around the storage zone, about 0.3 m from the pond's bottom. The results of the measurements of salinity gradient and temperatures show that this prototype of SGSP is appropriate to be used for storing heat around the storage zone.

KEY WORDS: *Salt Gradient Solar Pond (SGSP), Bengkulu coastline, density, temperature, renewable energy*

1.0 INTRODUCTION

Subtitle should be labeled as 1.0, 2.0 etc. Nowadays, the energy crisis in the world is very worrying because it is closely linked to

the survival of human life in the future. Koyama [1] reported that The global share of energy source as of 2040 will be led from 29% oil, 25% from natural gas, 24% from coal, 14% from renewable energies excluding hydropower (solar energy, wind energy, etc.), 6% from nuclear, and 2% from hydropower. It can be predicted with the sophisticated increase of technology, as well as the increase of energy needs. It had been reported that availability of fossil energy such as crude oil, coal, natural gas were predicted no more than 150 years [2]. On the other hand, global warming becomes another serious problem which needs to be overcome immediately.

One of the energy sources is solar energy. The sun as the center of the solar system has magnitude of radiation about 3,85x10²³ kW. Atmosphere absorbs most of solar radiation moreover at least earth receives the heat about 990 W/m² in coastline [3]. Alternative energy sources developed is salt gradient solar pond (SGSP) technology [4]. It is a salt solution pond functioned to collect solar radiation and to save the energy for a certain time. Heat energy can be used for various purposes including heater, dryers, distillation and particularly as a source of power [5-9].

Bengkulu province is a region that has long coastline which reaches 525 km. Therefore, Bengkulu has large potential to develop salt gradient solar pond technology. At least there are two primary assets supporting the application of salt gradient solar pond in the coastline of Bengkulu. Firstly, Bengkulu has tropical climates which have abundance of sunlight intensity. Secondly, Bengkulu has long coastal region which lead to the availability of plenty raw salt materials. Consequently, salt gradient solar pond technology is one of the simplest technologies in the design and low in cost which can directly transform solar energy into heat energy [10,11].

2.0 METHODOLOGY

The prototype of The prototype of Salt Gradient Solar Pond (SGSP) is shown in Figure 1. Salt Gradient Solar Pond prototype has 1 m³

volume of tank for storing salt water solution. The tank was coated by thermal insulation made of glass wool and aluminum foil (first and second layer respectively) to minimize heat losses during storage. Furthermore, these coating were functioned to optimize the absorption of solar radiation. It is also aided by giving a black plastic at the base of the tank.

The tank was equipped with a sampler device for taking salt solution at several points on salt water layers. Afterward, the taken samples were employed to measure the density. The Measurement of temperature used K type thermocouples. Thermocouples were temperature gauge placed at several test points. The image of SGSP prototype can be seen in the Figure 1.



Figure 1: The prototype Salt Gradient Solar Pond (SGSP)

The tank was equipped with tank filler and the stand put beside it. The filler tank was used to mix water and salt in order to arrange the salinity level of each layer. Sampler position and K type thermocouple was positioned from the bottom to the top with 1 meter of height. The distance between each point is 0.1 m as shown in Figure 2. Thermocouples were connected with a data acquisition as the output of temperature readings. Measurements of density were carried out by taking samples as much as 10 ml at 11 test points. Furthermore, the density was measured using a pycnometer.

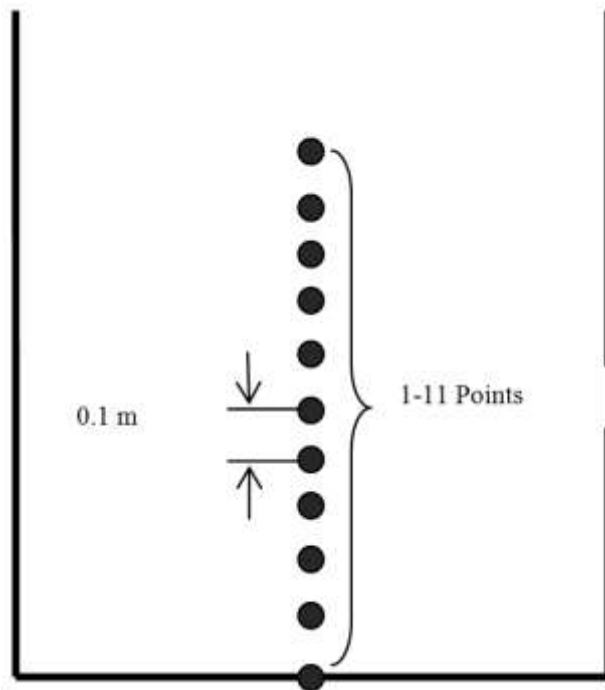


Figure 2. Arrangement of test points

3.0 RESULT AND DISCUSSION

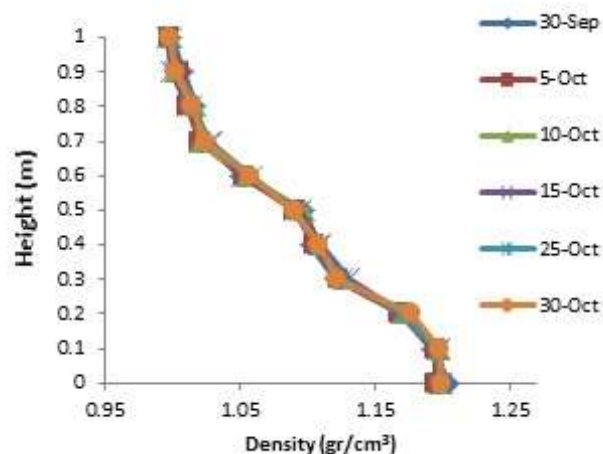


Figure 3. Density Profile of Test Points

Figure 3 shows the density profile for each test points with variation of height on SGSP prototype. On the basis of the density measurements at each test points, the highest density around 1.2

g/cm^3 was visible at the bottom of the pool as shown in Figure 3. The layer was used as the heat storage layer or storage zone. It was in accordance with the temperature measurements at each point of the tests at several different times.

The salinity of test points with different height (meter) in storage tank with variation of density (gr/cm^3) is shown in Figure 4. It can be seen that the highest density obtained was in the bottom of the pool. Here in, the density value increase with the decreasing of depth or reach the bottom of pool. The increment of density tends to be linear, along the depth until reached the bottom of the pool. Each symbol in Figure 4 expresses the depth to the bottom of the pool.

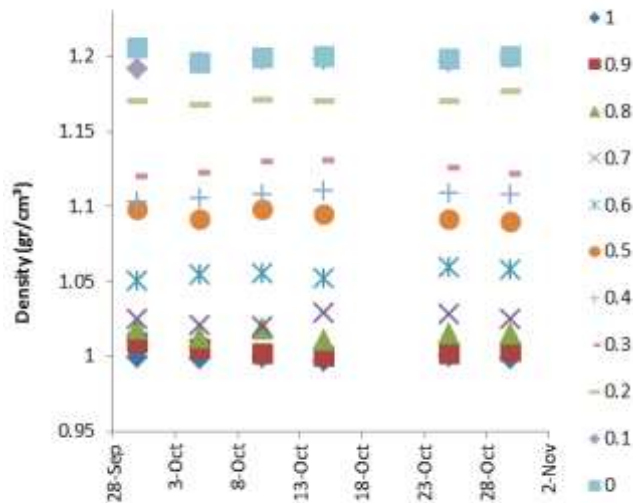


Figure 4. Salinity of Test Points

The temperature distribution at different height of the pool in solar pond is shown in Figure 5. The temperature distribution tends to be like parabolic, where the temperature increased with the increasing of heating time from 9:00 AM until 17:00 PM. The temperature reached the peak around 15:00 PM at 0.3 m height in each hour data captured. The highest temperature achieved was 48.7°C in the storage area of the zone at the height of 0.3 m from the bottom of the pond at around 15:00 PM.

Figure 6 shows the average temperature distribution on the height (m) of the Salt Gradient Solar Pond (SGSP) prototype for 6 days data captured. Similarly, the temperature distribution tends to be like parabolic compared to Figure 5, where temperature increases with the decreasing of height of pool depth. The temperature of liquid reached the peak around 0.3 m height in each day of data captured. The highest average temperature for whole experiments was 44.2°C at 5 October data captured.

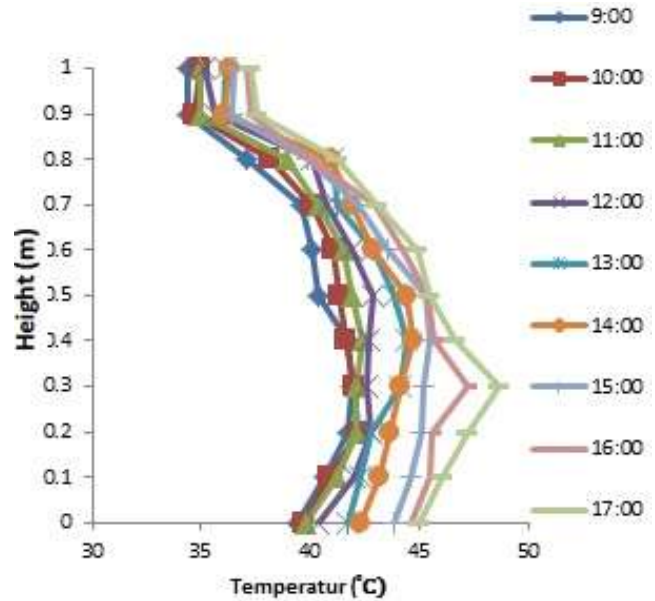


Figure 5. Distribution of temperature in different height

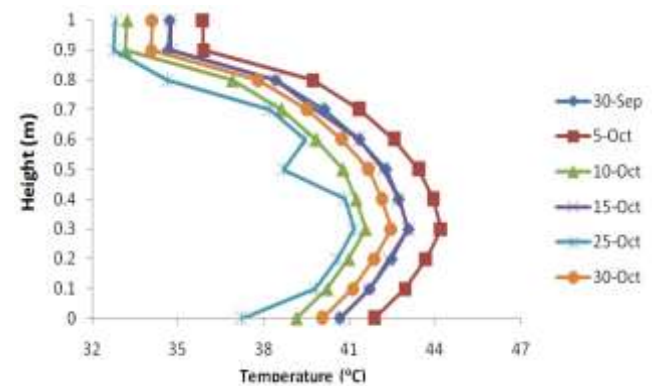


Figure 6. Average temperature on the height of the entire testing time

4.0 CONCLUSION

Overall, there was a gradual increase in density of SGSP from the top to the bottom. It was indicated that the layer formation SGSP going well, and the largest density at the bottom of the pool was 1.2 g/cm^3 . Therefore, it can be concluded that the zone of storage prototype was located in these particular areas which have higher density than others. While, the highest average temperature in the whole experiments was 44.2°C and the highest temperature that could be achieved was 48.7°C in the storage area of the zone at the height of 0.3 m from the bottom of the pond. It reveals that salinity

and temperature gradient of SGSP prototype has been already well and can be used to store the heat in the storage area of the zone.

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