EXPERIMENTAL INVESTIGATION OF POLYMER GEL SOLAR POND

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ABSTRACT

Polymer gel solar pond is a promising technology which aims to reduce the heat loss occurring at the top convective layer of a solar pond. In conventional salt gradient solar pond, the heat stored in the lower convective zone is heated by the solar radiation transmitted through the upper convective zone and non-convective zone of the pond. Due to the buoyancy effect, the water heated at the lower convective zone will be raised to the surface and the heat is finally released to the atmosphere through convection. Such Convective heat losses inhibit the thermal energy storage and the storage capacity of the medium. To reduce the evaporation heat loss in conventional salt gradient solar pond, the UCZ and NCZ of the pond is replaced by the polymer gel. Polyethylene glycol is a polymer gel base which is capable of inhibiting the convectional heat loss from the surface of the pond and thereby it enhances the thermal energy storage capacity of the pond.

Keywords: Polyethylene glycol, UCZ, LCZ, HSZ, polymer gel.

I. INTRODUCTION

The sun is the primary source of heat energy, which is available in abundant on the earth which cannot be sourced out. The energy reaped from sun acts as a main source of renewable energy which is available in two different forms namely, light energy in terms of photons of energy packets and heat energy in terms of electromagnetic radiation.

The solar pond technology was developed during the beginning of 20th century[1]. The solar ponds are a typical thermal energy storage structures which collects large amount of solar radiation from sun and make it available when needed[2]. Solar ponds are used for desalinating the brine water, power production and supplies heat energy for process industries[3][4].

The salt gradient solar pond composed of three zones. The first zone, upper convective zone (UCZ) in that zone the fresh water is filled[2][5][6]. The fraction of the radiation is first absorbed by UCZ[4]. However this absorbed heat is lost through convection and radiation heat transfer through atmosphere the remaining radiation penetrates through second layer. The second zone, non-convective zone (NCZ) where, the brine density is gradually increases towards the bottom of the pond[6]. The depth of NCZ is half height of solar pond height[2][7][8]. The third zone, lower convective zone (LCZ) or heat storage zone (HSZ) in that zone the brine density is high compare to other two zones due to this the brine solution at LCZ is capable enough to store high heat for long duration[9][2].

In conventional salt gradient solar pond the solar radiation from sun reaches the water surface and the energy from the radiation is trapped by the solvent in the pond [10]. In salt gradient solar pond, the heat storage gradient is higher at the lower convective zone where the concentration of the salt is high and it reduces gradually to the upper convective zone[7]. The problems resulted from salt gradient ponds are environmental hazardous of salt handling and turbid discharge[11] .The main limiting factor for salt gradient solar pond is the heat convection taking place at the upper convective zone which results in escape of heat energy and evaporation of the solvent [12] .To avoid such undesirable evaporation loss from pond surface, polymer gels are made to float on the pond surface[2]. These polymer gel layer replaces the UCZ and NCZ in conventional salt gradient solar ponds[13].

II MATERIALS AND METHODOLOGY

2.1 Solar Gel Pond

The Dissolved air in the water increases the buoyancy resulting in the floatation of the gel layer. The gel density is lowered due to the addition of dissolved air, which enables the gel to float over 2 % salt water, or even less[13], the gel should satisfy the following criteria:

- Transparent of solar radiation,
- High viscosity,
- High specific heat and low coefficient of volumetric expansion over the operating temperature range of the pond,
- Nontoxic.

The dirt and debris falling into the pond are retained by the surface and can be cleaned off periodically. There are only two zones, lower zone being the saline water and the gel layer floats above the salt water hence no salt gradient layers need be maintained as in the case of solar pond, leading to low maintenance requirements[2]. If an appropriate gel is developed to float on water, then the environment hazard of salt handling can be eliminated[2]. The salt requirements are less in solar gel pond when compared to salt gradient ponds thereby reducing cost and environmental hazard [13][1].

2.2 Selection of Polymer Gel

Polyethylene glycol has been selected for the experimental investigation. Due to its good radiation absorption properties, low density, High Specific heat and readily soluble in water above 130^0C[13].

2.3 Construction of Polymer Gel Solar Pond

Fig 1: Polymer Gel Solar Pond

A polymer gel solar pond having top bare surface area of $1m^2$ and the bottom surface $0.6m^2$is constructed such that it is trapezoidal with the height of 0.5m. The glass wool and wood are used as an insulating material. The black matted low density polyethylene is used to bottom of the pond to trap the solar radiation[10] [14]. Sodium chloride used as a brine solution[5]. The concentrations of brine in the pond is20% from total percentage of water[8][10]. The K-type of thermocouple is used to measure the temperature of the pond.

Polymer used	Poly Ethylene Glycol
Brine solution	Sodium chloride
Insulating medium	glass wool
Bottom cover used	LDPE
Type of thermocouple	K Type
Required level of water	320 l
Salt	30 kg

TABLE 1: Specifications of Polymer Gel Solar Pond

The Table 1 gives the specification of polymer gel solar ponds and the instruments used in the investigation.

III. EXPERIMENTAL RESULTS

The experimental analysis of 320 litres capacity polymer gel solar pond was carried out during the month of February 2015 at meteorological conditions (Latitude 11°00"N, Longitude 77° 00"E) of Coimbatore, India. The temperature of various zones in the pond was measured using k type thermocouples and the solar intensity was recorded using pyranometer with the time intervals of 30 minutes.

S. No	Time in Hours	Solar Intensity (W/m^2)	Gel Temp($^{\circ}C$)	LCZ ($^{\circ}C$)	η_c
1	10	471	45	53	25
2	10:30	464	47	54	25
3	11	455	48	54	27
4	11:30	475	50	57	26
5	12	481	51	61	29
6	12:30	487	59	63	30
7	1	522	59	67	30
8	01:30	504	60	65	30
9	2	491	61	63	30
10	02:30	487	61	61	29
11	3	489	62	62	29

12	03:30	487	58	60	29
13	4	475	40	60	29

TABLE 2: Experimental observations of Polymer Gel solar pond

S. No	Time in Hours	Solar Intensity (W/m^2)	UCZ (°C)	NCZ (°C)	LCZ (°C)	η_c
1	10	471	30	44	50	17
2	10:30	464	30	44	51	18
3	11	455	30	46	50	19
4	11:30	475	29	42	51	19
5	12	481	31	41	51	20
6	12:30	487	30	44	52	21
7	1	522	31	45	54	21
8	01:30	504	29	43	57	21
9	2	491	29	41	56	21
10	02:30	487	31	39	54	20
11	3	489	32	41	54	20
12	03:30	487	30	39	54	20
13	4	475	31	42	51	20

TABLE 3: Experimental observations of Salt Gradient solar pond

IV. DISCUSSION

From the results obtained it is evident that the heat storage capacity of the solar pond has been increased by replacing the UCZ and NCZ of conventional salt gradient pond by the poly ethylene Glycol gel layer.

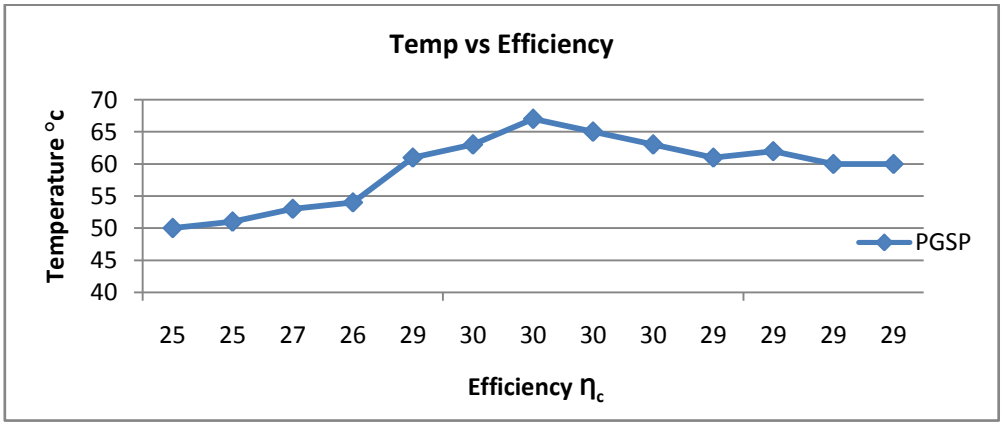

Fig 2: Temperature and efficiency comparison of PGSP

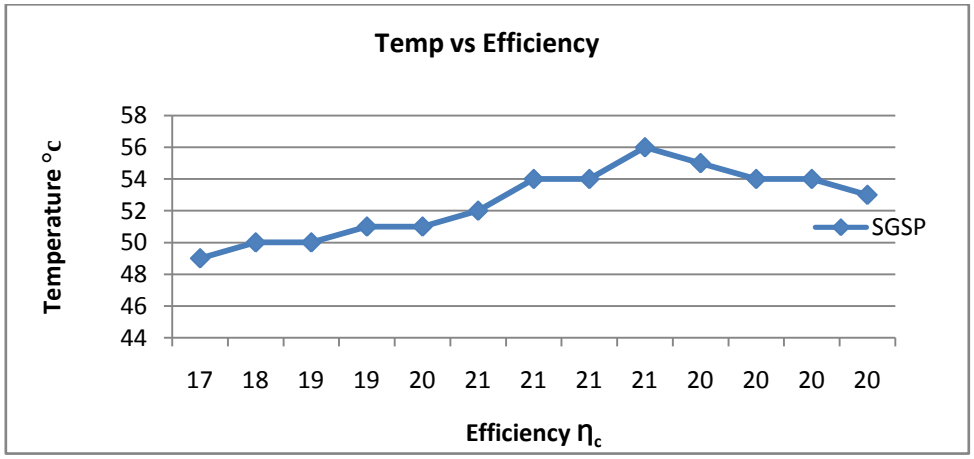

Fig 3: Temperature and efficiency comparison of SGSP

The LCZ temperature of the polymer gel pond reaches up to a temperature of 67°C and it yield a collection efficiency of maximum 30% when compared to conventional salt gradient solar pond's LCZ reaches a maximum temperature of 57°C and yields a collection efficiency of 21 %.

V. CONCLUSION

The experimental observation of 320 litres polymer gel solar pond shows the increase in the collection effficiency of the pond compared to same capacity conventional salt gradient solar pond. The increase in the collection efficiency of the polymer gel pond is due to the opaqueness created by the polymer gel towards the incident solar radition, which allows the radiant energy to be stored in the pond solvent instead of reflecting it back into the atmosphere. The losses associated with surface evaporation of pond solvent is reduced to a great extent by the floating polymer gel layer which inturn concentrates the temperature inside the pond.

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