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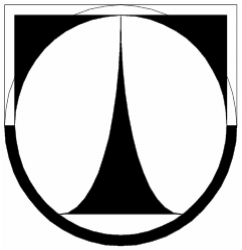

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Preliminary Design and Thermal Study of a Solar Pond Used to Heat a Tourist Hotel

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Abstract: *Solar pond is the simplest technique of the direct conversion of solar energy into thermal energy, and it is a solar collector and a solar thermal storage at the same time. It is known that any watery basin can absorb the radiation and convert it into heat, but most of the natural basins lose heat quickly due to phenomenon of convection within the basin, evaporation and thermal conduction across the surface of the basin, so a basin with a gradual concentration of salinity will be able to prevent the effect of convection and prevents evaporation and thermal conduction across the surface of the basin too. Because of the large thermal storage capacity of the solar pond and after taken some procedure to reduce the thermal losses a typical solar pond takes several weeks to lose only 10 °C even in the absence of the solar radiation, thus the solar pond converts intermittent solar energy into a reliable and continuous source of energy. A preliminary design and thermal study of a solar pond used to heat a tourist hotel was explained in this research.*

1. Introduction

Solar pond with a gradual concentration of the solution is an acid contains a large degree of concentration of brine at the bottom of the pond and decreasing degree in the concentration near the surface of the pond. The sun's rays penetrate the pond, part of them are absorbed by the water during the penetrating while the bulk of the sun's rays is absorbed by dark bottom of the pond (this bottom could be with a black cover or is painted black), as a result of absorption of the sun's rays the temperature of the lower layers of the pond increases where the large degree of concentration of salt, thus the deeper water is with greater intensity (compared with surface water). As is well known that density of pure water decreases when is heated, so if there was no gradient concentration of salt within the pond the convection currents occur from hot water at the bottom of the pond toward the upper layers of the water near the surface. However, the increasing intensity of salt at the bottom prevents possibility to thermal buoyancy resulted from convection, and the heat transfer toward the surface of the pond will be by conduction only, this transition is slow, so it allows the lower layers in the pond to maintain relatively high temperatures *90-100 °C*.

2. The use of solar ponds for central heating

Solar pond converts solar energy into heat energy, and it can store this energy which makes it attractive in using central heating (Fig1). Solar pond can provide the heat needed for heating for several days in spite of absence of the sun's rays, by increasing the depth of the lower storage layer it can achieve seasonal storage of heat.

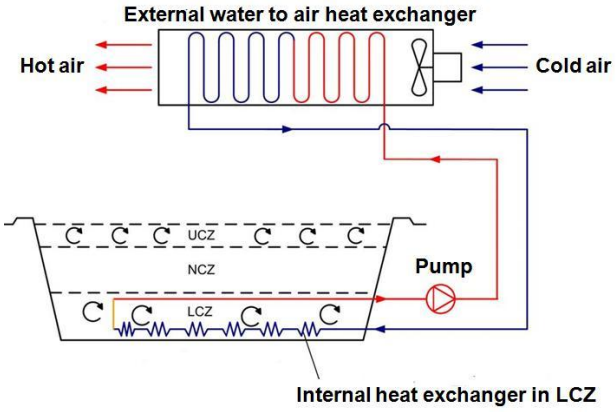

Figure 1: Scheme of heating circuit used solar pond [1]

Economic studies of heating systems have shown that use solar collectors that store thermal energy from the sun for more than ten

days is non-economic way, therefore, the solar pond that can store heat for a long time can be used in the temperate regions as an integrated heating system without the need to an auxiliary source of energy. In this research a preliminary design and thermal study of a solar pond used to heat a tourist hotel in the city of Palmyra in Syria was explained, where the needed energy to heat the hotel has been calculated in advance.

Model solar pond is that with gradient salinity of the model (Base-Case) that are design according to equations (SGSP).

Imposed solar pond is located at 36 degrees north latitude, and 40-45 degrees east, and is also situated at a height of 300 m above sea level.

3. Experimental data and analysis

There are three basic stages to design the required solar pond: [2]

1- Calculate area of solar pond.

2- Thermal budget of solar pond.

3- The amount of heat collected in the storage area.

Calculating area of solar pond

The Information required to estimate the size of the pond is as follows: [2]

1- The annual average temperature of the pond t_s=95 °C.

2- Average annual temperature in the city of Palmyra t_a=18.1 °C.

3- Annual solar radiation I=210 W/m^2.

4- Annual heat rate Q_t= 620 kW.

5- Latitudes of the region 30-36 degrees north latitude

After done the calculations by the way mentioned we found that:

radius r=96 m, so the area of the solar pond: A=28953 m^2

Thermal budget of solar pond

The SGSP generally consists of three distinct zones: the upper convective zone (UCZ), non-convective zone (NCZ), and the lower convective zone (LCZ), as shown in (Fig 2) the UCZ is the topmost layer and usually a thin layer of fresh water. The NCZ is just below the UCZ and has linearly increasing salinity gradient downwards. It acts as transparent insulation to prevent heat loss due to convection from the LCZ. The LCZ is the bottom layer, with a nearly constant and uniform high density. Because of serving as the solar-energy collection and heat storage medium, it is also called the storage zone [4].

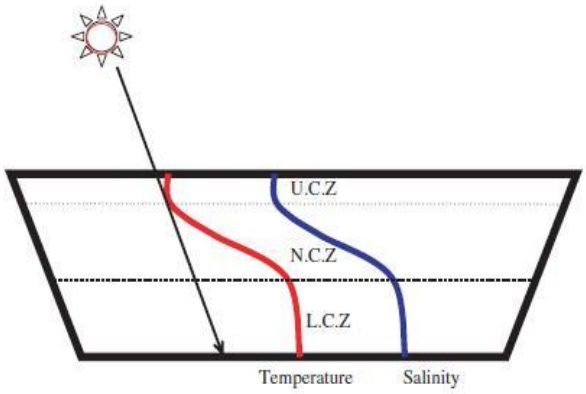

Figure 2: Solar pond [3]

To study thermal budget of solar pond this relationship is used:

$m_s.c_p.(ds/dt)=Q_t=Q_s-Q_l$ [2]

Where:

m_s [kg]: Mass of water in the storage area.

c_p [kJ/kg.K]: Specific heat capacity of the storage area.

ds/dt [K/s]: Rate of change of the temperature of the storage area with time.

Q_t [kW]: Heat load required to heat the hotel.

Q_s [kW]: The amount of heat accumulated in the storage area.

Q_l [kW]: Total loss heat in the storage area.

Q_t: Heat load required to heat the hotel

Q_t is calculated by taking into account the followed points:

First point: Calculate the amount of thermal losses from all surfaces of each room in the hotel by the followed equation:

$Q=K.A.\Delta T$ [2]

Where:
K [W/m^2.K]: Heat transfer coefficient.

A [m^2]: Surface area.

ΔT [K]: The difference between inside and outside surface temperatures.

Second point: Calculate heat loss from the floor.

Third point: Calculate the thermal losses due to leakage.

Anyway, Q_t is given in advance, where Q_t*=620 kW.*

Q_s: The amount of heat accumulated in the storage area

Q_s is calculated using this relation:

$Q_s= I_p.A$ [2]

where:
I_p: Solar radiation striking the pool, *it is calculated as follows:*

$I_p=0.31.f.I$

Where:
f: correction factor related to latitude, it is from tables, f=0.97.
I: Annual solar radiation, *I=210 W/m^2,* after calculation: I_p *=63.147 W/ m^2* .

A [m^2]: The surface area of the pond.

After calculations: Q_s*=1828.295 kW.*

Q_L: Total heat loss in the storage area

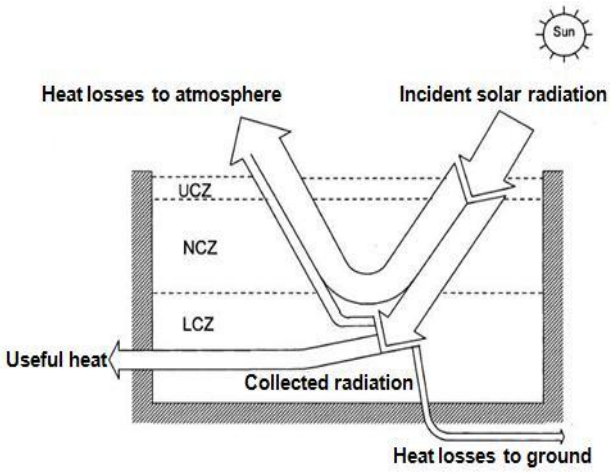

Figure 3: Heat losses from the solar pond [4]

It is calculated as follows:

$Q_L=U_a(t_s-t_a)+U_g(t_s-t_g)$ [2]

Where:
U_a [kW/K]: Coefficient of heat loss between the surface of the pond and the surrounding, U_a*=12 kW/K*

U_g: Heat loss coefficient between the pond and the ground, U_g*= 3.5 kW/K*

t_a: Temperature of the surrounding

t_g: Temperature of the ground=t_a

t_s: The temperature of the spot containing the pond

after calculations: Q_L*=1191.95 kW*

then the thermal load providing from the pond could be calculated *Q:*
Q=*1828.295 -1191.95=636.345 kW*

This value is approximately equal to the heat load needed to heat the hotel Q_t .

4. Conclusions

1- Technique of solar pond is a simple and cheap way to convert solar energy into heat energy and to store this energy

2- We do not need to have special equipment of store heat because of the possibility of retaining the long-term heat

3- One of the biggest benefits of the solar pond is that it employs renewable energy. Especially nowadays, where we are facing global issues such as global warming

4- Solar pond power is non-polluting, a renewable and natural resource,

5- One disadvantage of solar ponds is that they require a specific location that is not readily available in all areas. A solar pond should be large in order to harness enough energy from the sun to use as electricity or heat. Therefore, the pond needs to be located in a flat, open area of land, in an area that is exposed to sunlight. While a solar pond can be placed in a smaller area, or a less sunny area, the results may not produce much energy.

5. References

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