Progress of Solar Pond Technology

Bhuj and earlier projects

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Introduction

- Motivation
- Background
- Types of Solar Ponds
- Applications
- Advantages and Disadvantages

Motivation

A solar pond is simply a pool of saltwater which collects and stores solar thermal energy [1].

The attractiveness of solar ponds is that it is a low cost method of harnessing and storing solar energy which is renewable [2] . Various solar ponds to date are in :

1. Israel, 1958
2. Australia, 1964
3. USA, 1975
4. India, 1971

El-Paso Solar Pond, USA

Pyramid Hill Solar Pond , Australia

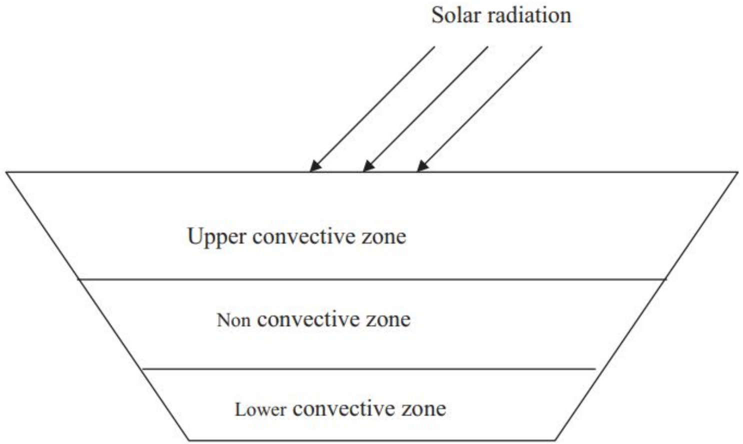
Background

- The first recorded reference to a natural solar lake was that of Kalecsinsky who described the Medve Lake in Transylvania [2].
- Por described a natural solar laken near Eilat, Israel, which has apparently been in existence for 3000 years.
- The idea of creating solar ponds was first broached by Dr. R. Bloch in 1954.
- The first solar pond was started in Israel.

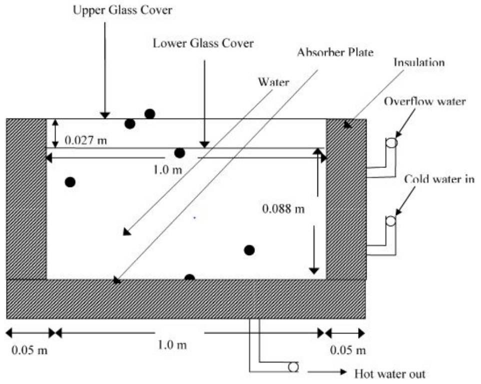
Israel Solar Pond

Types of Solar Ponds [1]

1. Salt Gradient solar Pond (SGSP)
2. Partitioned solar Pond (PSP)
3. Viscosity Stabilized Solar Pond (VSSP)
4. Membrane Stratified Solar Pond (MSSP)
5. Saturated solar pond (STSP)
6. Shallow solar pond (SSP)



Salt Gradient Solar Pond.



Shallow Solar Pond

Applications

Solar ponds can be used for [1,2]:

1. Heating of buildings
2. Power production
3. Industrial process heating
4. Desalination
5. Salt Production
6. Refrigeration
7. Aquaculture
8. Dairy industry

Advantages and Disadvantages

Advantages :

1. The approach is particularly attractive for rural areas in developing countries. Very large area collectors can be set up for low cost.
2. The accumulating salt crystals have to be removed.

Disadvantages :

1. The evaporated surface water needs to be constantly replenished.
2. There is maintenance costs.
3. No need of a separate collector.

Theory

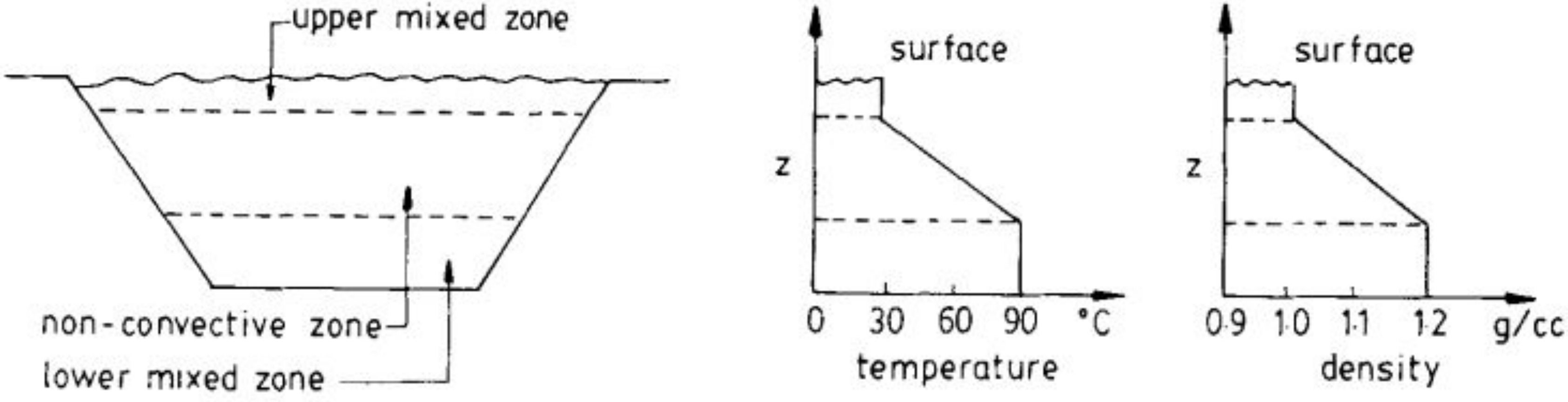
- Principle
- Zones
- Thermal Efficiency

Principle

In a clear natural pond about 30% solar radiation reaches a depth of 2 metres. This solar radiation is absorbed at the bottom of the pond. The hotter water at the bottom becomes lighter and hence rises to the surface. Here it loses heat to the ambient air and, hence, a natural pond does not attain temperatures much above the ambient. If some mechanism can be devised to prevent the mixing between the upper and lower layers of a pond, then the temperatures of the lower layers will be higher than of the upper layers. This can be achieved in several ways. The simplest method is to make the lower layer denser than the upper layer by adding salt in the lower layers.

- [3]

Zones of a Solar Pond

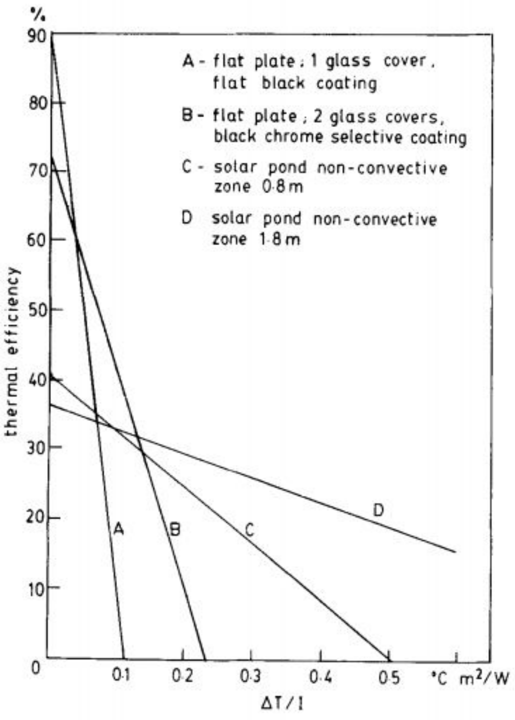


Thermal Efficiency

The thermal performance of a solar pond can be represented in a form similar to that used for conventional flat plate collectors. Assuming a steady state condition,

$Q_u = Q_a - Q_e$

where Q_u = useful heat extracted, Q_a = solar energy absorbed, Q_e = heat losses.



Variation of thermal efficiency with AT/I, where AT is the temperature difference between the storage zone (or absorber) and the ambient, and I is the intensity of solar irradiation.

The Bhuj Solar Pond

History

- Construction began in 1987 at the Kutch Dairy, Bhuj [4,5].
- Collaborative effort between the Gujarat Energy Development Agency, Gujarat Dairy Development Corporation Limited, and TERI under the National Solar Pond Programme of the Ministry of Non-conventional Energy Sources.
- After its start-up in September 1993, hot water supply to the dairy continued till April 1995. The hot water supply was resumed in August 1996, in April 1997, the solar pond was handed over to the dairy.

Development

The total cost of construction for the solar pond was 90,000 dollars. It progressed in four phases [5] :

1. Initial construction and operation of pond
2. Failure analysis
3. Re-establishment and hot water supply to dairy
4. Salt addition and renewal of hot water supply

‘An inexpensive lining scheme, consisting of alternating layers of clay and LDPE (low density polyethylene) combination was used for lining the pond. The pond attained a maximum temperature of 99.88C under stagnation in May 1991 but developed leakage soon after. A failure analysis that was carried out subsequently indicated that the leakage was caused by the combination of high stagnation temperature and large air pockets below the liner. The lining scheme was re-designed and the pond re-established in June 1993. Hot water supply to the dairy started in September 1993 and continued until April 1995. After an interruption of nearly one year, hot water was resumed in August 1996.’

Heat Extraction System

The heat extraction system consisted of brine suction and discharge diffusers, a brine pump, associated piping, controls, and instrumentation. Both the suction and the discharge diffusers were installed on the same side of the pond. Keeping in view the problem of fouling, a shell-and-tube type heat exchanger was chosen. Brine was on the tube side, which was made of cupro-nickel. The pond is capable of delivering 80,000 liters of hot water daily, at 70 degrees C or above.

Heat Extraction system.

Economic Considerations

Economically favourable considerations for building solar ponds are :

1. Abundance of inexpensive salt
2. Level land
3. Nearby inexpensive salt supply
4. Combining with other industries like process heating, desalination, etc.
5. Arid regions with abundant brackish water (for water desalination)

For the bhuj plant, the payback period works out to less than 5 years.

Conclusion

Solar ponds are an inexpensive way of accessing solar energy and storing it. However, it has its issues and is only economically viable on large scales. The Bhuj Solar Pond is a good example of using solar ponds in a rural area in conjunction with other industries to make it more economically attractive.

Further research is aimed at addressing the problems, such as the development of membrane ponds. These use a thin permeable membrane to separate the layers without allowing salt to pass through.

References

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