Abstract No: PO-29

An analysis on the optimization of the upper convective zone thickness to minimize the surface heat loss of a model salinity gradient pond

N. W. K. Jayatissa[1*], P. A. A. Perera[1] and R. A. Attalage[2]

[1]Department of Physics and Electronics, University of Kelaniya, Sri Lanka
[2]Faculty of Graduate Studies and Research, Sri Lanka Institute of Information Technology, Sri Lanka
jayatissa@kln.ac.lk*

Solar energy is a renewable energy source that provides enough energy to keep the natural cycles alive. Sri Lanka is a country near the equator that has abundant sunlight throughout the year. Solar ponds are a proven technology for storing thermal energy at low temperatures. In general, a solar pond consists of three layers: the upper convective zone (UCZ), the middle non-convective zone (NCZ) and the lower convective zone (LCZ). Part of the incident solar radiation passes through the UCZ and NCZ and is trapped in the LCZ. Unlike the other two layers, the top layer of the pond is directly exposed to the environment. The energy flows associated with the UCZ and their impact on the LCZ were the focus of this experimental study. The solar pond described in the present work is constructed in the premises of the University of Kelaniya, Sri Lanka (Latitude 6.97 N, Longitude 79.91 E). The pond has a surface area of 6 m^2 (3 m $\times$ 2 m) and a depth 1.5 m. The bottom of the pond and the walls are properly insulated to reduce energy loss through the walls and bottom. Since the UCZ is exposed to the environment, heat is lost from this area through convection, evaporation and radiation. The average UCZ temperature of the solar pond varies from 27.3 ^oC to 31.5 ^oC depending on the month of the year. This study shows that the total energy loss (radiation, convection and evaporation) of the upper surface varies between 11 Wm^{-2} and 57 Wm^{-2}. The convective heat transfer coefficient is directly related to the average wind speed, and in this study the wind effect is minimal because the water surface is blocked by the perimeter walls. Therefore, the wind effect is neglected in the energy calculations. The radiant heat loss is estimated to be about 40% of the total energy, assuming an emissivity of 0.83 for water. Since the wind effect was negligible in this study, the estimated evaporative heat loss is about 10% of the total energy. Depending on the solar insolation, energy from the NCZ and the total losses associated with the UCZ determine the heat storage of the UCZ. The easily adjustable parameter of an established solar pond is the thickness of the UCZ. A thicker UCZ can hold more incident solar insolation inside and this causes high temperature values in the zone. High temperature values in the UCZ minimize the conduction of heat transfer from the LCZ to the UCZ, while decreasing surface heat loss by convection and radiation. However, this process reduces the amount of solar radiation entering the LCZ. When the thickness of the UCZ layer was increased from 5 cm to 10 cm, the energy absorption increased from 42% to 47%. Similarly, increasing the thickness to 20 cm, resulted in an additional 6% increase. Therefore, ultimately it affects the LCZ heat storage. On the other hand, reducing the thickness of the UCZ decreases its temperature and allows more insolation to reach the bottom of the pond. Therefore, it is important to optimize the thickness of the UCZ and the results suggested that a thickness in the range 2 to 8 cm is optimal for the operation of the pond.

Keywords: Energy, Layer thickness, Solar Pond, Upper convective zone

Acknowledgment
This work was supported by the University of Kelaniya under the research grant RP/03/02/05/01/2010.