Experimental study on Solar Water Desalination using Phase Change Material

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Abstract : The only nearly inexhaustible sources of water are the oceans, which is of high salinity. However, the separation of salts from seawater requires large amounts of energy which, when produced from fossil fuels, can cause harm to the environment. Therefore, there is a need to employ environmentally friendly energy sources in order to desalinate seawater. In this project we designed a solar still (single basin double slope), which can be used for water desalination (removing salt content from water using solar energy). Probably, they are considered the best solution for water production in remote, arid to semi-arid, small communities, where fresh water is unavailable. However, the amount of distilled water produced per unit area is somewhat low in designed solar still which makes the solar still unacceptable in some instances. The purpose of this project is to study the effect of using phase change materials in a solar still, and thus enhance the productivity of water. In present work phase change material paraffin wax is used to store the solar thermal energy in the form of latent heat, which can offer high storage capacity per unit volume and per unit mass and we can get heat in the night time for desalination.

IndexTerms - Solar Basin, Radiation, Thermocouple, Phase change material, Paraffin wax.

I. INTRODUCTION

Solar distillation uses the heat of the sun directly in a simple piece of equipment to purify water. The equipment, commonly called a solar still, consists primarily of a shallow basin with a transparent glass cover. The sun heats the water in the basin, causing evaporation [1,2]. Moisture rises, condenses on the cover and runs down into a collection trough, leaving behind the salts, minerals, and most other impurities, including germs. Although it can be rather expensive to build a solar still that is both effective and long-lasting, it can produce purified water at a reasonable cost if it is built, operated, and maintained properly [3].

A basin type solar still is a simple device for obtaining potable water from contaminated or saline water using solar energy. Such a solar still is shown in Fig. 1. It consists of a blackened tray containing saline water, covered with a sloping glass roof. The collection troughs are attached at the lower edges of the glass covers. The water condenses on the inner surface of the glass cover, flows into the collection troughs due to gravity. The pure water is removed as product. Solar energy, which is transmitted by the glass cover and absorbed by the water and the blackened tray, heats the water in the basin. This absorbed energy conducted through the haze; radiated, or convected to the glass cover, or is carried by evaporation of water to the glass cover. The cover is substantially transparent to solar radiation and opaque to infrared radiation and serves as a condenser for the saturated vapours within the still. The glass cover transfers heat to the surroundings; by radiation to the sky and by convection to the ambient air [4,10].

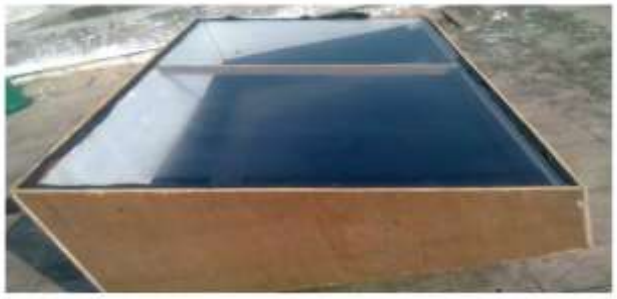

Fig 1: Single basin single slope setup

Fig 2: Single basin Double slope setup

Paraffin wax is a white or colourless soft solid, derived from petroleum, coal or oil shale, that consists of a mixture of hydrocarbon molecules containing between twenty and forty carbon atoms [5]. It is solid at room temperature and begins to melt above approximately 37 °C (99 °F); its boiling point is >370 °C (698 °F). Common applications for paraffin wax

include lubrication, electrical insulation, and candles dyed paraffin wax can be made into crayons. It is distinct from kerosene and other petroleum products that is sometimes called paraffin [7].

Fig 3: Paraffin wax

II. METHODOLOGY

Experimental setup (with out PCM)

⇩

Experimental readings

⇩

Results and Graphs

⇩

Experimental setup (with PCM)

⇩

Experimental readings

⇩

Results and Graphs

III. EXPERIMENTAL PROCEDURE

3.1 SOLAR WATER STILL BASIN

It is the part of the system in which the water to be distilled is kept. It is therefore essential that it must absorb solar energy. Hence it is necessary that the material have high absorptivity or very less reflectivity and very less transmitivity. These are the criteria's for selecting the basin materials.

Kinds of the basin materials that can be used are as follows:

1. Leather sheet
2. Ge silicon
3. Mild steel plate
4. RPF (reinforced plastic)
5. G.I. (galvanized iron).

We have used blackened aluminum sheet (K= thermal conductivity= 237W/mk) (2mm thick).(SIZE:: 4′ X 2′ X 10 cm BOX OF AL).

3.2 SOLAR STILL WITHOUT PCM SETUP

A single basin double slope solar still (here simply referred to as „still-solar") was fabricated with Aluminium steel plate is shown in above fig 3.1 . The overall size of the basin is 0.6m x 0.6m x 0.3m . The bottom of the still was leveled with 8mm thick concrete to minimize heat loss through the basin and to spread the water uniformly. The concrete surface was black painted to improve the irradiance absorption capacity. The top is covered with two glasses of thickness 4 mm inclined at 20^0 on both sides supported by wooden frame.

The outer surfaces are covered with thermo cool layers. The condensed water is collected in the v-shaped drainage provided below the glass lower edge on both sides of the still. The condensate collected is continuously drained through flexible hose and stored in a measuring jar.

A hole in the basin side wall allows inserting the thermocouples for the measurement of the basin water, still and condensate temperature. Four thermocouples were placed in the basin at different locations. Two thermocouples are placed in the each side of the drain to measure the condensate temperature. The hole is closed with insulating material to avoid the heat and vapour loss. Another hole is provided for water inlet. Through this hole, water can be inserted to the basin [6,10].

Fig 4: Without PCM setup

The temperatures of water were recorded with the help of thermocouples in combination with a digital temperature indicator. The distillate water is collected in polythene bottles of capacity 2 liters. The collected water is tested by using the PH meter. The experiments were conducted at the open terrace of the Department of Mechanical Engineering during March 2018.

The observations were taken for 24 hours starting from 6 a. m.., The global and diffused irradiances on horizontal and irradiances on inclined planes, the temperatures of the atmosphere, condensate and basin water, and the masses of raw water supplied and condensate collected were recorded every 30 minutes.

3.3 SOLAR STILL WITH PCM SETUP

In this setup we are using the phase changing material as the storage medium to store the solar energy by changing their phase from solid to liquid and liquid to solid.

The present project consist as an equipment called solar still, which consist of a basin made up of Wood 0.108 m^3 volume , having a length of 60cm and 60cm width with 30 cm height. Inside this basin another basin is placed with a distance of 8cm leaving a gap from bottom and sides and in between this gap an insulation material (Thermo coal) is placed to prevent loss of heat.

The inner box is filled with phase changing material (PCM) with a thickness of 7cm, here the PCM used is Paraffin wax which will change their phase from solid to liquid during day time and liquid to solid in the night, above the PCM a 2, 4 and 6cm height of saline water is filled which will evaporate when gets heated by solar radiation [8,9]. At the top of the basin a transparent glass is placed at an inclination of 30deg which is having a thickness of 4mm which will allow the solar radiation to enter into basin consisting of water is shown in fig 4,5 & 6.

When water gets heated it starts evaporating and collects at the underside of the glass cover as vapours. This collected vapours move on to the condensate channel which is provided inside the basin. The basin also consists of one inlet at the rear end for water input and two outlets at front end to collect the water from two condensate channels.

Fig 5: With PCM

Fig 6: Solar still with PCM setup

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separated by periods. Initial paragraphs after the section title are not indented. Only the initial, introductory paragraph has a drop cap.

IV RESULTS AND DISCUSION

4.1. Distilled water output without PCM

Time(hrs)	Water output without PCM (ml)
09:00	0
10:00	10
11:00	30
12:00	60
13:00	140
14:00	200
15:00	170
16:00	140

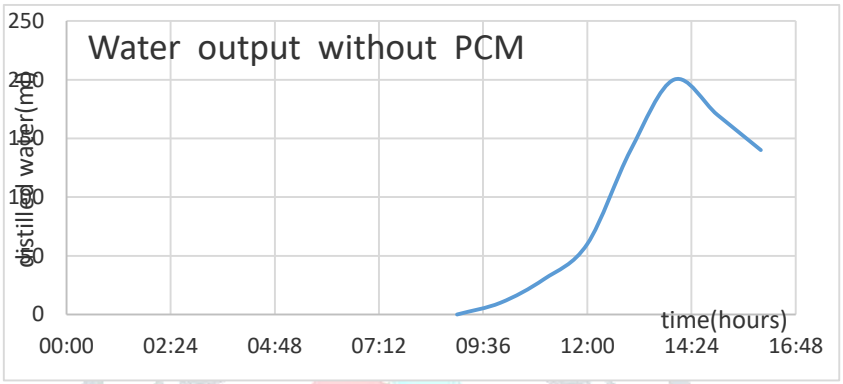

Fig 7: Graph for distilled water output without PCM

4.2. Distilled water output with PCM

Time(hrs)	Water output with PCM (ml)
09:00	0
10:00	10
11:00	10
12:00	40
13:00	110
14:00	260
15:00	200
16:00	180

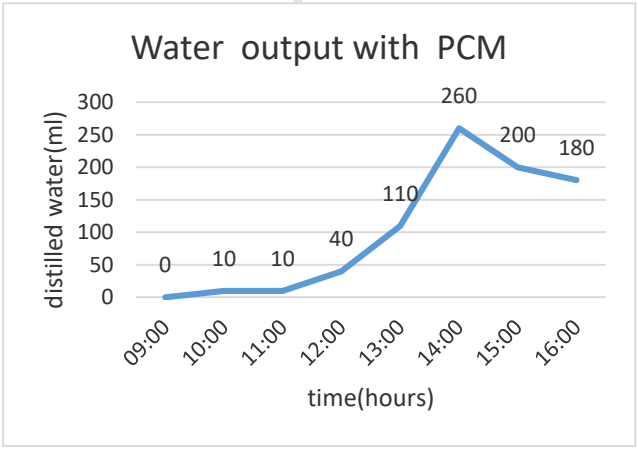

Fig 8: Graph for distilled water output with PCM

4.3. Comparison of distilled water output with and without PCM

Time(hrs)	Water output without PCM (ml)	Water output with PCM (ml)
09:00	0	0
10:00	10	10
11:00	30	10
12:00	60	40
13:00	140	110
14:00	200	260
15:00	170	200
16:00	140	180

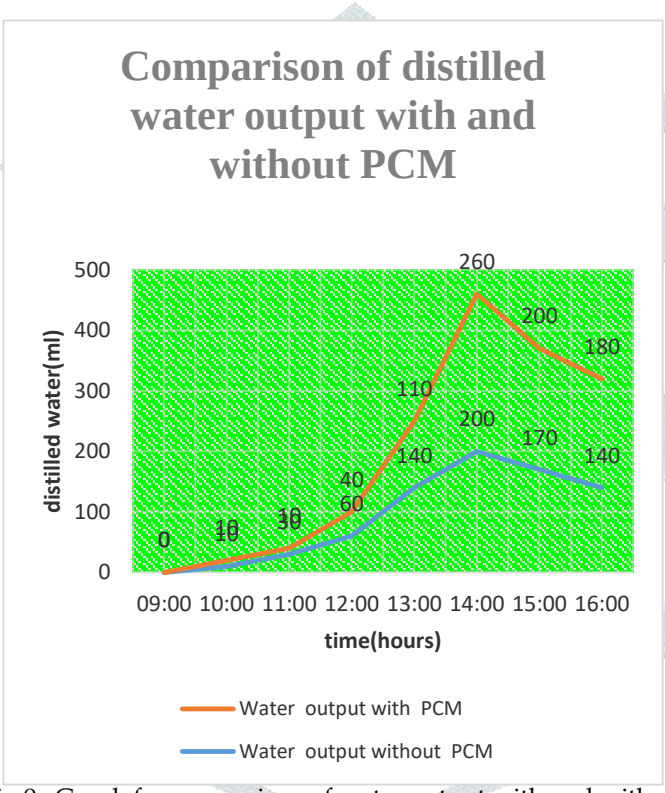

Fig 9: Graph for comparison of water output with and without PCM

V CONCLUSION

The purpose of this work is to evaluate the increase in the productivity of the solar still by using phase changing material (PCM) as a storage medium. Based on the experiment conducted and discussion carried out, the following conclusions are drawn.

As we compared the distilled water output from with and without phase changing material,

From graph the distilled water output for with and without phase changing material, the distilled water output from with phase changing material (paraffin wax) is greater than without phase changing material.

The use of PCM as storage material in solar still results in increased distilled water output.

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