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Performance Evaluation Of Solar Still – Steric Acid As A Pcm

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ABSTRACT
The simplest application of a thermal solar energy installation is in the distillation of water. The solar distiller purifies water by first evaporating and then condensing it. Distilled water contains no salts, minerals or organic impurities. It is not, however, aseptic, as is sterilized water, of which more later. Distilled water can be used for: drinking purposes, applications in hospitals replenishing batteries, and so on. Such an installation is suited to areas where water is ample but polluted, salty or brackish; naturally, there must also be abundant sun. Finally, glass or UV resistant transparent foil which is the most important material in the construction must be available and affordable. A reasonably functional solar distiller is able to produce adequate amount of water, so as to make it economically justifiable.
Keywords: Thermal Energy, Solar Energy, Distillation, Water, Solar Still.

I. INTRODUCTION
Energy is the basic input required to sustain economic growth and to provide basic amenities of life to the entire population of a country. Energy can be an effective weapon in the battle against object poverty in a country like India. Like other developing countries, India is also in the process of planning and development such needs a quantum of energy for its developmental plans. It is the level and pattern of utilization of energy from different sources in any country, which is an index of industrial development and standard of living. Basically energy is utilized in four key sectors of our economy namely Agriculture, industry, commercial and the households.

Due to increasing gap between demand and supply of energy there is an urgent need to utilize the different forms of non-conventional energy sources such as solar, wind, biomass etc. Among these energy sources one of the most important sources is solar energy

II. EXPERIMENTAL SETUP
2.1 Description ForBasin Type Solar Still:

Fig. 1: Solar Basin

Fig. 1 shows the schematic of the solar still with simple basin. The experimental setup consist of following things

- Storage tank
- Glass wool
- Insulated basin plate
- Glass cover
- Measuring jar
- Temperature measuring devices

The plastic storage tank of capacity 25 liters was used in order to avoid corrosion. Water from the storage tank enters the still through flexible hoses and a valve ‘V’ to maintain constant water level in the still. The valve controls the mass flow rate. Poly vinyl chloride (PVC) hoses were used for greater flexibility. The still basin was painted black. The area below the basin was filled with glass wool for insulation purpose. A small glass piece obstruction was fixed on the inside surface of the glass cover, to facilitate the deflection of the concentrate return in to the collection channel, which in turn affixed with the wooden box. The gliding water from the channel was transferred in to the measuring jar through the flexible piping.

This experimental set up was designed. The inner dimensions of the basin 100X100 cm^2.The upper glass cover is tilted at 20^0 with respect to the horizontal. Installed and tested at Sri Venkateswara College Of Engineering and Technology, Chittoor, Andhra Pradesh, India. The whole experimental setup was kept in the North-South direction.

Copper-constantan thermocouples were used for temperature measurement. The Condenser surface of the still is made of 4 mm ordinary glass. The bottom of this still is insulated with 50mm. Filled the water up to 8 cm depth.

Thermocouples are fixed at the following locations:

- Still basin plate
- Water and
- Outside of the glass cover

Temperatures were measured at more than one location and averaged for the case of base plate temperature and basin water temperatures. Thermocouples are integrated with temperature indicator and selector switch.

2.2 Description for Solar Still With PCM As Storage Medium:

This is as similar to the basin type solar still, but we have placed stearic acid at the bottom in the basin and placed a tray to store water. The height of the tray is of 8cm and the water is poured in it to a height of 8cm. Here PCM is used to store heat in the day time and release the heat during night which gives continuous production of distilled water.

Fig. 3.1 shows the schematic of the solar still with simple basin. The experimental setup consist of following things

- Storage tank
- Glass wool
- Insulated basin plate
- Glass cover
- Measuring jar
- Temperature measuring devices

The plastic storage tank of capacity 25 liters was used in order to avoid corrosion. Water from the storage tank enters the still through flexible hoses and a valve ‘V’ to maintain constant water level in the still. The valve controls the mass flow rate. Poly vinyl chloride (PVC) hoses were used for greater flexibility. The still basin was painted black. The area below the basin was filled with glass wool for insulation purpose. A small glass piece obstruction was fixed on the inside surface of the glass cover, to facilitate the deflection of the concentrate return in to the collection channel, which in turn affixed with the wooden box. The gliding water from the channel was transferred in to the measuring jar through the flexible piping.

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Copper-constantan thermocouples were used for temperature measurement. The Condenser surface of the still is made of 5 mm ordinary glass. the bottom of this still is insulated with 50mm. Filled water up to 2 cm depth. These thermocouples are fixed at the following locations: sill basin plate, water and inside of the glass cover. Temperatures were measured at more than one location and averaged for the case of base plate temperature and basin water temperatures. Thermocouples are integrated with temperature indicator and selector switch.

2.3 Phase Change Material:

A **phase change material** (**PCM**) is a substance with a high heat of fusion which, while melting and solidifying at a certain temperature, is capable of storing and releasing large amounts of energy. Heat is absorbed or released when the material changes its phase from solid to liquid and vice versa. Fig 3.2 represents the stearic acid used.

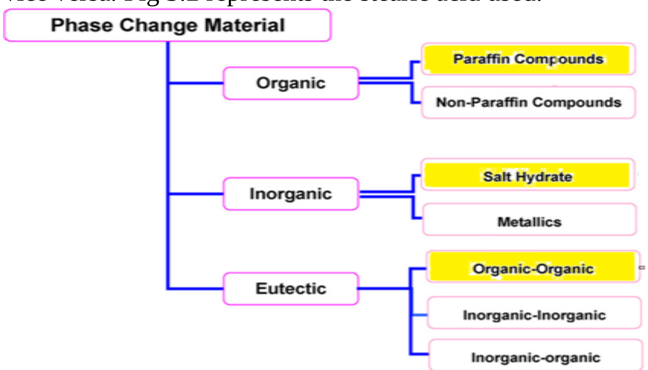

Fig. 2: Classification of PCM’s

Fig. 3: PCM in Heat reservoir

Fig. 4: Complete Experimental Setup of Solar Still

2.4 Selection Of Heat Storage Materials:

Phase change materials (PCM) are ''Latent'' heat storage materials should possess the following properties Conditions considered for PCM selection are:

- Melting temperature in desired temperature range
- High latent heat of fusion
- High thermal conductivity, specific heat and density
- Small volume change on phase transformation
- Non-toxic, non-flammable and non-explosive material
- Low cost
- Large-scale availability
- Less Literature Available on selected material

In addition to the above criteria there are some other properties required. They are:

➢ **Thermodynamic properties:**
- The phase change material should possess
- Melting temperature in the desired operating temperature range
- High latent heat of fusion per unit volume
- High specific heat, high density and high thermal conductivity
- Small Volume changes on phase transformation and small vapor
- pressure at operating temperatures to reduce the containment problem
- Congruent melting
- Suitable phase-transition temperature
- High latent heat of transition
- Good heat transfer

➢ **Physical properties**:
- High density
- Small volume change

➢ **Kinetic properties:**
- No super cooling
- Sufficient crystallization rate
- High nucleation rate to avoid super cooling of the liquid phase

➢ **Chemical properties**
- Chemical stability
- Complete reversible freeze/melt cycle
- No degradation after a large number of freeze/melt cycle
- Non-corrosiveness, non-toxic, non-flammable and non-explosive
- Materials
- Long-term chemical stability
- Compatibility with materials of construction
- No toxicity
- No fire hazard

➢ **Economic properties**
- Low cost
- Large-scale availabilities

III. RESULTS AND DISCUSSIONS

The present work deals with performance evaluation of basin type and solar stills with PCM by using experimental setup. We are comparing the efficiency of both stills.

The work has been presented in the following sections.

1. Performance evaluation of basin type solar still and its validations.
2. Performance evaluation of solar still with PCM and its validations.
3. Comparison of Basin type and solar still with PCM.

Basin type solar still with the following specifications:

- 1.00X1.00 m base and 0.6m rear height with the tilt of 20^0
- Mass of water 20kg
- Location: Chittoor (Latitude 13^0N,75^0E)

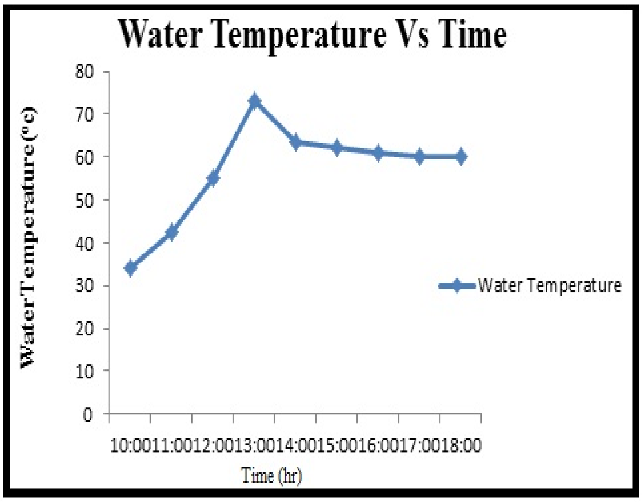

FIG: 5 VARIATION OF WATER TEMPERATURE WITH TIME

Fig. 5 shows the variation of water temperatures during the day. It is observed that the temperature is maximum at the solar noon and lesser during the morning hours. This is because of availability of larger quantity of the in solar during the Solar Noon which results higher evaporation rates of the basin water.

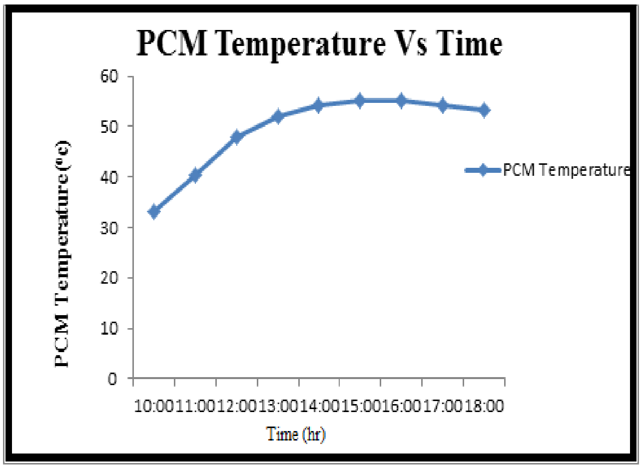

FIG: 6 VARIATION OF PCM TEMPERATURE WITH TIME

Fig.6 shows the variation of water temperatures during the day. It is observed that the temperature is maximum at the solar noon and lesser during the morning hours. This is because of availability of larger quantity of the isolation during the Solar Noon which results higher evaporation rates of the basin water and hence more accumulation of distillate in the solar still. The Glass is tilted at 20^0. Thickness of the Glass is 4mm.

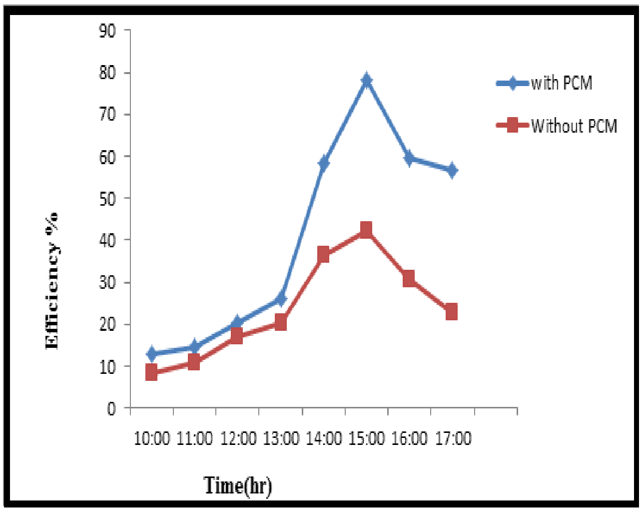

FIG: 7 VARIATION OF EFFICIENCY OF DISTILLED OUTPUT WITH TIME

Efficiency of the solar still depends on various factors like heat loss coefficients, constructional features as well as external factors like solar isolation available at the location and environmental factors like wind speed.

Fig. 7shows the variation of efficiency with respect to the Local solar time for a Basin type solar still. It is observed that the instantaneous efficiency attains a peak value is increased. This discrepancy is again due to the variation in the weather conditions as well as the inlet water temperature conditions.

It is observed that the peak value at noon is because of availability of more isolation and more heat dissipation from Stearic acid.

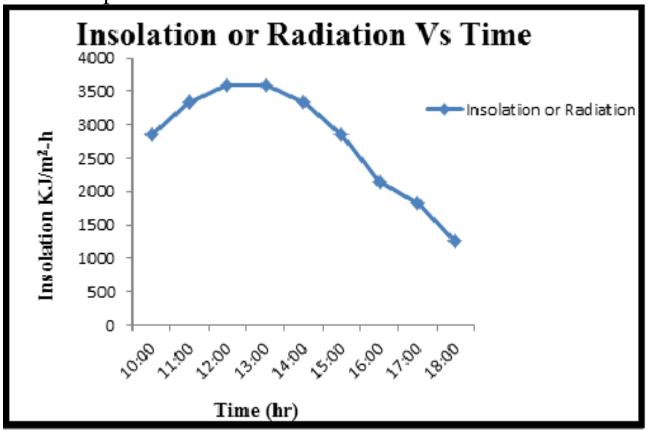

FIG: 8 VARIATION OF INSOLATION WITH TIME

Fig. 8 shows the variation of water temperatures during the day. It is observed that the temperature is maximum at the solar noon and lesser during the morning hours. This is because of availability of larger quantity of the isolation during the Solar Noon which results higher evaporation rates of the basin water.

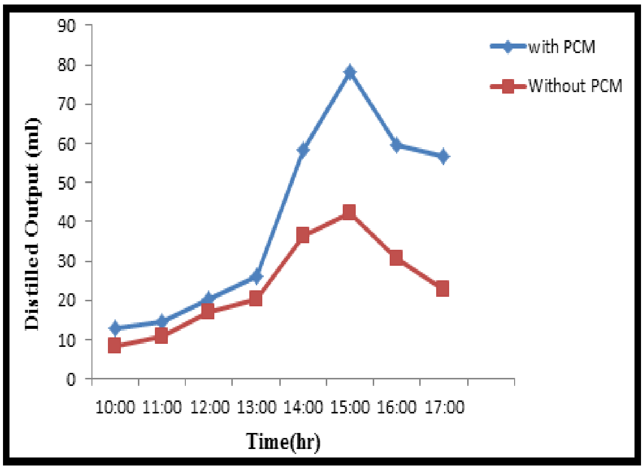

FIG: 9 VARIATION OF DISTILLED OUTPUT WITH TIME

Fig. 9 shows the variation of distillate collected during the day. It is observed that the output is maximum at the solar noon and lesser during the morning hours and later part of the day. This is because of availability of larger quantity of the isolation during the Solar Noon which results higher evaporation rates of the basin water and hence more accumulation of distillate in the solar still.

We are getting 4.3 liters per day. And with PCM the distilled output obtained is 5.6 liters per day and it is 28% more efficient than distilled water obtained without PCM.

IV. LIMITATIONS OF THE EXPERIMENT

- The predicted Values/results may be different from the observed results due to variations in the climatic conditions.
- The model is based upon estimation of solar insolation for clear days and hence the actual insolation may vary and so also the distillate collected.
- The accuracy of Results depends greatly on the specification of the material properties like thermal conductivity and emissivity/Absorptivity
- In appropriate property values can result in unrealistic results and so the user should have an idea about the values.
- In order to arrive at the optimized design for solar still several iteration has to be carried out.
- The experimental values are based upon certain assumptions and hence the results may vary.

V. SUGGESTIONS FOR FUTURE WORK

- The present work can be extended by arranging fins and wick type Basin.
- Double slope passive solar still with heat reservoir can be coupled with hot water storage tank
- Double slope passive solar still with heat reservoir can be coupled with active solar still
- Different types of stills with external thermal source are coupled in order to achieve higher production rates.

VI. CONCLUSION

The significant conclusions of the experiment are:

- In this study, a single slope passive solar still with heat reservoir was fabricated which could be used during night time also.
- With PCM as heat storage material, an improvement of 28% in the distillate production is obtained compared to normal solar still.
- The still continues to produce fresh water after the sunset. More than 12% of total water production is pertaining to this time.
- It does not need pumping systems and operators to change to the night mode usage.

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