RESEARCH ARTICLE OPEN ACCESS

EXPERIMENTAL ANALYSIS OF A TUBULAR SOLAR STILL WITH AN EXTERNAL HAET STORAGE SYSTEM USING PCM

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Abstract - In this paper external solar collector and double *slope solar* still having a phase change materials are connected and experiment was carried out. The output of *a solar* still connected to external solar collector and *the PCM* is analyzed with experimental setup. The solar energy falls on the external heat *collected* is *sent* to the solar still through *the heat exchanger*. To continue the evaporation process during night time the Phase changing materials *are used* to store solar thermal energy collected by the system at daytime as latent heat. The direct solar radiation used to heat the phase changing material, basin saline water and external heat collector. The external parabolic heat pipe having a 5000ml ethylene glycol heat transfer fluid a copper coil is immersed into the ethylene glycol.

INTRODUCTION

In this paper external solar collector and double *slope solar* still having a phase change materials are connected and experiment was carried out. The output of *a solar* still connected to external solar collector and *the PCM* is analyzed with experimental setup. The solar energy falls on the external heat *collected* is *sent* to the solar still through *the heat exchanger*. To continue the evaporation process during night time the Phase changing materials *are used* to store solar thermal energy collected by the system at daytime as latent heat. The direct solar radiation used to heat the phase changing material, basin saline water and external heat collector. The external parabolic heat pipe having a 5000ml ethylene glycol heat transfer fluid a copper coil is immersed into the ethylene.

I. EXPERIMENTAL SETUP DESCRIPTION:

In the current work senior current work the Solar still is designed in a way to provide thermal energy during both the day and night time by utilizing a phase change

materials (PCM) and it increases the efficiency of distillation process

The experimental setup consists of storage tank, parabolic trough collector (PTC), double slope single basin solar still with PCM arrangement. The newly designed Solar still converts brackish or brain water into potable drinking water by A evaporating the water inside the basin in with the help of solar energy and this process is similar to rain water cycle for hydrological cycle.

II. Storage Tank

Storage tank is a rectangular container with the dimensions mm x mm. It is made up of galvanized iron sheet and store it stores and it was 5 litres of saline water. It is placed at a height of 1900 m from the ground with the help of a stand. The saline water which is stored in the tank flows to the parabolic trough collector (PTC) through plastic tube with the help of gravity

Parabolic trough collector (PTC)

The parabolic trough collector (PTC) is used to collect direct and diffuse radiation from the sun and it concentrates the thermal energy on the saline water which is flowing through it. The temperature of water gets increased. In this process the PTC has a dimension of 975.36 mm breath, 2621.28 mm length, 243.84 mm height and thickness of 2 mm. It is made up of GI sheet. The parabolic trough collector is fitted with aluminum foil sheets for increasing the intensity of solar radiation by reflecting the solar rays at a particular point the PTC is held by two support stands from the ground.

The brine water flows through a heat exchanger setup in the parabolic trough collector and it consists of a copper tube of 2438.4mm length and 243.8 mm diameter. The copper material is used to enhance the heat exchange process because of its high thermal conductivity and ethylene glycol

The properties as shown in table is filled inside the copper tube. The copper tube holds 5 lites of ethylene glycol oil and it acts as a medium of thermal energy storage. A copper coil with a diameter of ¼ inches is fitted inside the copper tube for a length a of 2438.4 mm.

The saline water flows through the copper coil which is immersed in ethylene glycol and the ethylene glycol which is observes the thermal energy from the PTC and it transfer the heat to the saline water and this process increases the evaporating rate in double slope single basin solar still

Double slope solar still

The saline water from the PTC flows to the solar still through a 1/ 4 inch flexible plastic pipe. The double slope single basin solar still is a rectangular box made up of wood which consists of a rectangular tray made up of galvanized iron sheet the tray has a dimensions of 820 mm x 480 mm and height of 160 mm the thickness of galvanized iron sheet is 1.5 mm and it is coated in black colour to enhance the solar radiation by increasing the absorption capacity of the galvanized iron basin.

The dimensions of wooden Box which contains the tray 810 mm x 290 mm and it consists of two Glasses with a thickness of 4mm the roof portion of the double slope still is inclined at an angle of 32 degree the glass is bonded to the wooden Box with the help of silicon material to avoid the leakage between the glass cover and the basin. The wooden box is fitted with plastic pipe of 4 mm thickness for collecting and storing the evaporated water which is produced by the glass cover.

Phase Change Material

The thermal energy storage is classified into two types sensible heat energy storage, The latent heat energy storage works in a way by absorbing the heat and changing its face then the heat is rejected by the reversible process. The phase change material which is used in this experiment is paraffin wax and it is held in a rectangular container made up of G.I Sheet the dimensions of 600 mm X 300 mm X 50 mm thickness the rectangular box holds 5 kg of paraffin wax for thermal energy storage during day and night time.

The parabolic trough collector (PTC) is used to collect direct and diffuse radiation from the sun and it concentrates the thermal energy on the saline water which is flowing through it. The temperature of water gets increased. In this process the PTC has a dimension of 975.36 mm breath, 2621.28 mm length, 243.84 mm height and thickness of 2 mm. It is made up of GI sheet. The parabolic trough collector is fitted with aluminum foil sheets for increasing the intensity of solar radiation by reflecting the solar rays at a particular point the PTC is held by two support stands from the ground.

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Table 1
Specifications of the utilized PCM.

Specification	Value
Product number	PGSCRCo.PCM 28/ 315
Flammability	No
Toxicity	No
Corrosion	No
Phase Change Melting Temp. (°C)	28
Max. Temp. (°C)	55
Latent Heat (J/cm^3)	315
Approx. Specific Heat (J/gr/°C)	3.5
Specific Gravity (gr/cm^3)	1.4
Thermal Conductivity (W/m/°C)	0.6±15%
Super Cooling (°C)	2 to 4

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Experimental Procedure

The double slope single basin Solar still was designed and fabricated in Arasu Engineering College Kumbakonam, India. The experiments in combination of the parabolic trough collector (PTC) and phase change materials (PCM) with solar still where carried at in same climatic conditions of Thanjavur Tamil Nadu India [10· 57' 42. 102 " N 79· 23' 17. 214"] From February to March 2022 and the experiments were carried out from 09.00 a.m. for day time and 06.00 p.m to 06.00 am during night time the double slope single base in Solar still experiments were done by connecting and disconnecting the parabolic trough collector and then placing and removing of the phase change materials from the Solar still the work was carried out with a constant depth of 0.015 m and the saline water it was collected from Poompuhar Beach Nagapattinam district Tamil Nadu India.

The following parameters were measured during the experiment the intensity of solar radiation, ambient temperature, glass cover temperature, PCM temperature, heat exchanger fluid temperature, saline water temperature, PTC temperature and distilled water temperature the measurement are taken with an interval of half an hour the quantity of freshwater produced is also measured the PCM material is used as thermal energy storage medium the PCM observes thermal energy as sensible heat and it is converted into liquid after absorbing adequate amount of thermal energy. The PCM is converted into solid by rejecting the heat in the Solar still. The PCM is a source of heat during night time.

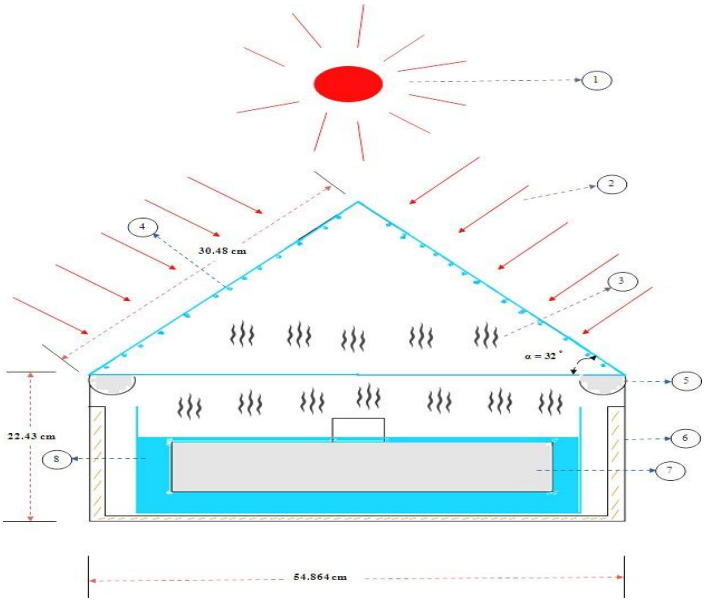


Figure No: 2.1 Experimental line diagrams

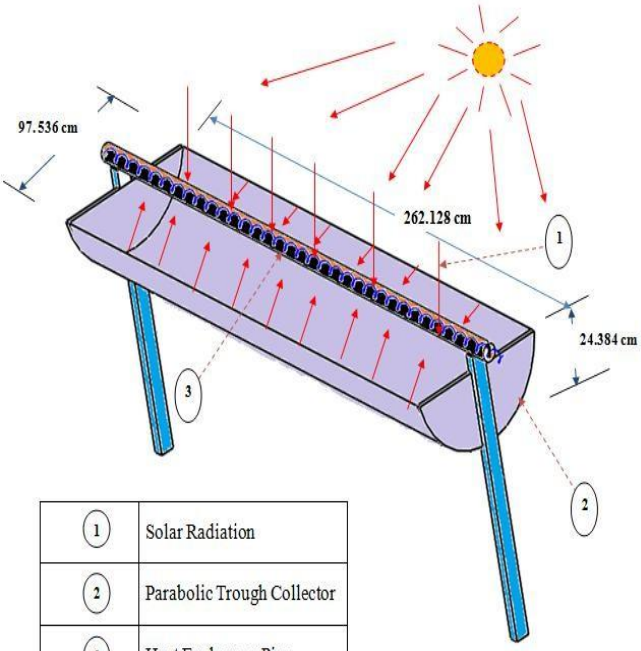
1	Sun
2	Solar Radiation
3	Water Evaporations
4	Water Droplets
5	Collected Water
6	Wooden Box
7	PCM Box
8	Salt Water Tray

FIGURE NO: 2.1 EXPERIMENTAL LINE

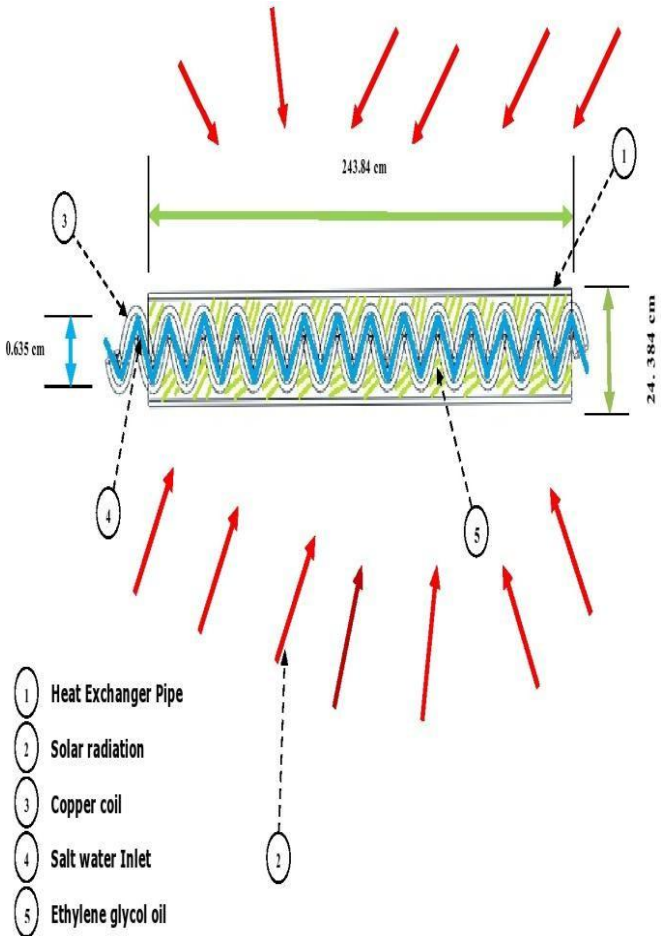
2.3 Heat exchanger pipe

A copper pipe of 60mm x 460mm x 0.5mm is filled with 5000ml of ethylene glycol fitted to the focal point of parabolic trough collector as shown in Fig.2.3. A copper coil immersed in the ethylene glycol heat transfer fluid. The solar radiation absorbed by the ethylene glycol oil is filled in the copper pipe. The inlet salt water flows through the copper coil and receive heat energy from ethylene

glycol. The properties of the ethylene glycol are given in the Table.2.1. The low thermal conductivity plastic tubes are used to transfer the salt water from the inlet solar still



1	Solar Radiation
2	Parabolic Trough Collector
3	Heat Exchanger Pipe



Properties of Ethylene glycol:

S.No	Properties	Values
1.	Molecular weight/mole	M=62.069
2.	Boiling point, K	470.5
3.	Density, g/cm^3	1.109
4.	Viscosity, kg-m-s	0.016
5	Surface tension/m^2	0.047

Table.properties of the heat transferfluid Phase Changing Material (paraffin wax)

Color A box of size 600mm x 300 mm x 50mm shown in is filled with 5000g of paraffin wax. The absorption is enhanced by the applications of black coating on the outside of the box. During day time the solar radiation is absorbed by phase changing materials. The stored heat energy is used to continue the evaporation process after the sun set. The properties of phase changing materials are

Figure Phase change material (PCM BOX)

Figure :PCM (PARAFFIN WAX)

Experimental measurements:

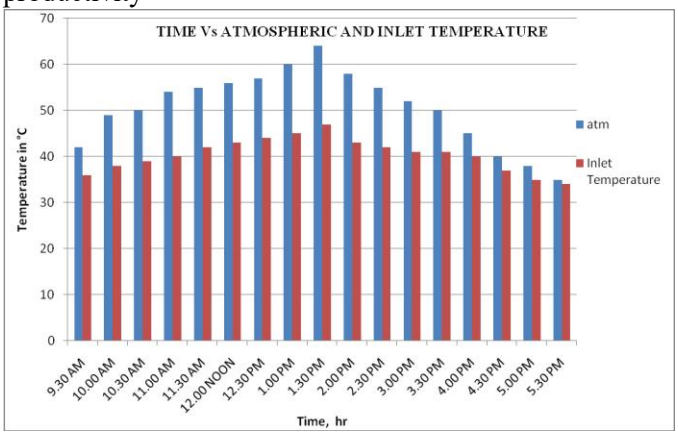
During the month January to July of 2019 the experimental measurements were done on morning between 9.00am to 5.30 pm and evening 5.30 pm until morning 9.00am. The following readings are taken during the functioning of experiment atmospheric temperature (Ta), inlet water temperature (Tin), heat transfer fluid temperature (Tf), heat transfer pipe surface temperature (T ps), solar still surface temperature (Ts), PCM box surface temperature, PCM temperature, output fresh fresh water quantity is measured for every half an hour. The temperature measurement is done with the help of thermometers. A calibrated flask placed near to solar still to collect condensed fresh water at a flow rate of half liter per hour during daytime. The performances were compared with and without phase change materials and parabolic trough collector.

Outcome and discussions

The experimental result of solar still with paraffin wax and external heat collector was studied. From 9.30 am to 5.30 pm and 6.00 pm to 9.00 am readings were noted during January to July 2019. The evaporation rate increases with improving the drinking water production of the solar still. So here we planned to improve the salt water evaporation rate by connecting still with phase changing materials and external heat collector.

Temperature Measurement in Experiment

The temperature of the complete setup was measured at various positions to ensure the drinking water productivity



Temperatures Evolution of inlet tank and atmospheric temperature during summer time

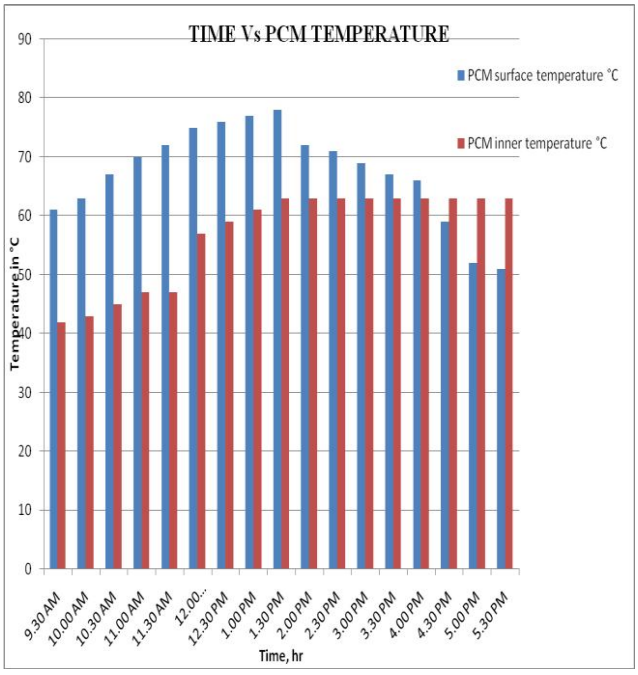
The above Fig. 2.7 shows the temperature value of inlet salt water tank temperature (Ti), and atmospheric temperature for every half an hour. From the graph atmospheric temperature increases up to 1.30 pm and then it falls down. It is mentioned that the maximum atmospheric temperature is approximately 1.30 pm. The atmospheric temperature increases with increases the inlet tank temperature up to 1.30 pm and then it falls

down. It is mentioned that maximum temperature reached at 1.30 pm. The solar energy takes the time to transmit to the fluid medium. Fig 2.7 shows the 17°C is the maximum variation among the atmospheric and inlet water temperature.

Temperature value of still coupled with external heat collector

The above Shows the temperature values of heat transfer fluid temperature (Tf), heat transfer pipe surface temperature (Tp) and solar still glass temperature with a double slope solar still for every half an hour. Fig.2.8 shows that the atmospheric temperature increases from the morning up to 1.00 pm then it falls down. It is mentioned that the maximum value of the temperature is 1.00 pm. During 1.00pm the inlet tank temperature is maximum then it decreased as shown in Fig.2.8.

The inlet salt water temperature increase from the morning up to 1.00 pm then it decreased with time as shown in Fig.2.8. It indicates during 1.00 pm maximum temperature attained. The solar radiation gets time to transmit to the still. The 3°C is the temperature variable among the fluid and fluid pipe surface temperature. The 10°C is the variations of temperature between glass surface temperature and fluid temperature



Conclusion

The experimental analyzes and output of solar still with external heat collector and paraffin wax discussed. External heat collector receives energy from the sun and its send to the solar still through the combined actions of ethylene glycol oil and copper coil. The evaluation between the output of steel with an external heat collector and phase change material is performed. The result shows that the outcome of a solar still without external heat collector and paraffin wax material is lower than the output of steel with external heat collector and paraffin wax. The output of fresh water is increased by combining the still with external heat collector and phase change material. The daily drinking water outputs for different arrangement are noted. The output and percentage of potable water for solar still is 1252ml also 25.04%. The fresh water output and percentage of fresh water is 2122ml and 42.44% for still with paraffin wax. The fresh water output and percentage of fresh water is 2055ml and 17.86% for still with external heat collector. Fresh water output and percentage of fresh water is 3515ml and 28.57% for still with external heat collector and paraffin wax. The productivity of a solar still with an external heat collector and paraffin wax is higher than the solar still without parabolic trough collector and PCM.

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