

Experimental Analysis Of A Solar Still With And Without Phase Change Material Under Climatic Conditions Of Vijayawada, India

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Abstract: Water is the main need for any kind of living things. The main source of the water on earth is Sea water. We have fresh water lakes and rivers around the world for drinking purpose, but the scarcity of water came in to existence in 20th century. Therefore, we need to use sea water, which is very plenty around the world, but presently the sea water is not used for drinking purpose. So, we need to convert the salt water in to fresh water for drinking purpose. There are many ways to convert salt water in to fresh water. The converting of salt water in to fresh water, we need more amounts of any type of sources like fuels, solar etc. This paper represents a water purification technique using solar energy named as solar desalination. Even though a lot of work has been done in previous research by using solar desalination technique, the use of Phase Change Material (PCM) to increase the efficiency of the solar still and compare the performance of the solar still with PCM and without PCM. A simple single basin stage still with an inclined transparent surface for the collection of condensed vapors as they fall down. The main purpose to use PCM is to increase the productivity during evenings (when sun is absent).

Key Words: Solar still, Phase Change Material(PCM) , Single basin still, Productivity.

1. INTRODUCTION

In this entire world we have several major issues that disturbs all the Human beings. One such major issue for human beings is fresh water scarcity. There are many seas and oceans that contain plenty of water, but it is salt water and it contains many impurities and minerals that humans cannot use for drinking purpose. So, there are many techniques that converts saline water to fresh water. The process of removing salts and minerals from the saline water (salt water) or targeted substance is called DESALINATION.

There are mainly 4 types of desalination processes: There are

1: Thermal Energy

- a) Evaporation
- b) Crystallization
- c) Filtration and Evaporation

2: Mechanical Energy

- a) Evaporation
- b) Filtration

3: Electrical Energy

- a) Selective Filtration

4: Chemical Energy

- a) Exchange

In Thermal energy evaporation process, there are 4 types

- 1.1) Multi-Stage flash distillation (MSF)
- 1.2) Multi-Effect distillation (MED)

1.3) Thermal Vapour compression (TVC)

1.4) Solar Distillation (SD)

Solar distillation: It is the use of solar energy to evaporate the saline water and produce the fresh water by removing salts and minerals in it within a closed system. The output is used for drinking purpose.

Solar desalination is of two types:

1. Direct method
2. Indirect method

Direct method: in direct desalination process, the solar energy from the sun is directly used to condense the water, no additional aid is used to enhance or increase the efficiency of the process.

Indirect method: in this technique, solar energy is not directly used. External support is given by a photovoltaic cell. This method provides more production when compared with direct method.

In direct method, the stills used are of two types:

1. Single basin solar still
2. Double basin solar still

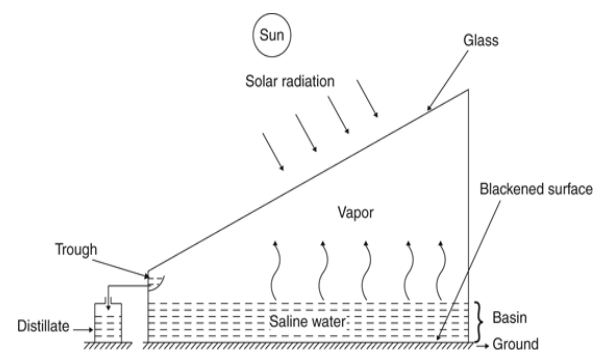


Fig 1: Single basin solar still

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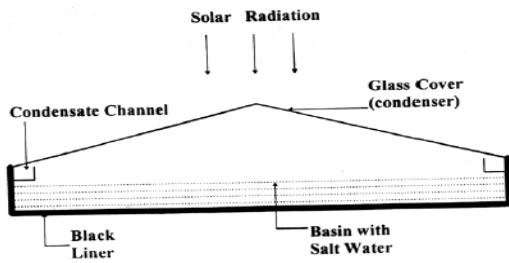


Fig 2: Double basin solar still

2 EXPERIMENTAL SETUP

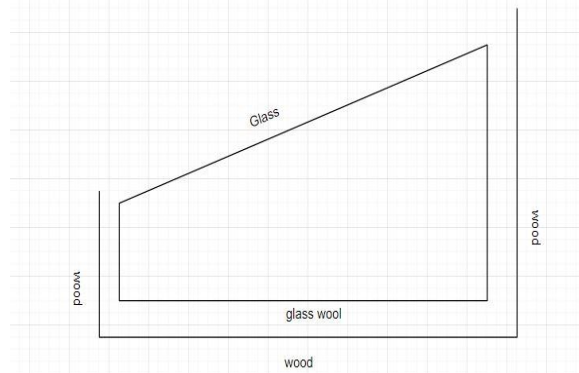


Fig 3: Experimental Setup

Dimensions of the still basin:

Length- 100cm
Width- 60cm
Height 1- 25cm
Height 2- 5cm

Galvanized iron sheet is used to make still basin to protect the basin corrosion which is much cheaper than steel. The still door is made of glass to make a free way for the solar energy into the still. The inner surface is completely painted with black color so that the still will absorb all sorts of radiations. To provide insulation to the still, the outer surface of the still is entirely covered with glass wool. whole still setup is placed in a wooden box to fit the glass wool and to provide much more insulation support and ease of handling. To avoid the escape of vapor from the still the glass door is tightly sealed by using rubber beading. inlet and outlet pipes are provided to the basin. The outlet opening is made in the bottom middle of the basin for the ease cleaning. A V-shaped aluminum ray is placed at the inclined of the still for the collection of fresh vapors. A V-shaped strip is attached to the bottom down inner surface of the glass to arrest the momentum of the water vapor droplets formed on the glass inner surface. **Concept of PCM:** A phase change material is a substance that absorbs, stores and releases the thermal energy. They have more latent heat of fusion. These materials observe energy in extreme conditions and releases later. The PCM used is paraffin wax. It is from alkane family. It consists of series of carbon atoms by strong covalent bonds. It melts at room temperature. It is placed inside the steel boxes to avoid the vapor losses after the phase change. Each steel box is completely welded on the opening side to provide perfect sealing. These boxes are placed inside the still to provide extra thermal energy.

Properties of paraffin wax:

Properties of Paraffin wax	Value
Melting temperature ($^{\circ}\text{C}$)	38
Latent heat of fusion (kJ/kg)	200
Solid density (g/cm^3)	0.90
Thermal conductivity ($\text{W}/\text{m}^{\circ}\text{C}$)	0.21
Solid Specific heat (kJ/kg $^{\circ}\text{C}$)	2.1

3 EXPERIMENTAL PROCEDURE

- 1.) Six thermocouples are placed in the solar still as per the requirement of the temperature readings.
- 2.) Thermo couples are placed on the outer surface the glass (T_{go}), inner surface of the glass (T_{gi}), in the water (T_w), on the still basin (T_b), in the middle of the still by freely hanging from the inner glass surface (T_v) and (T_s) for the surrounding temperature.
- 3.) Glass wool is used to provide insulation all over the still.
- 4.) Since water is the working fluid fill up to 2cm height of the basin with water. Make sure that all the openings of the basin are closed to avoid the loss of heat and vapour due to the opening.
- 5.) Make sure that the PCM is tightly sealed to avoid leakage of paraffin wax into the water because it will contaminate the water.
- 6.) As the whole system works under the solar energy the process starts at 9:00 AM in the morning.
- 7.) Note the temperature at every point where the thermocouples at every one-hour interval of time up to 6:00 PM.
- 8.) On day one, the readings are taken without PCM in the still, whereas on the second day with PCM.
- 9.) Radiation values are taken in both the clear sky days.

4 RESULTS AND DISCUSSION

The readings from solar still is observed and taken in 2 different days i.e. with and without PCM. The readings taken from the Day1 is without PCM and Day2 is with PCM material. And we can clearly observe the temperatures, radiation and productivity from two different days clearly varies.

Results without PCM:

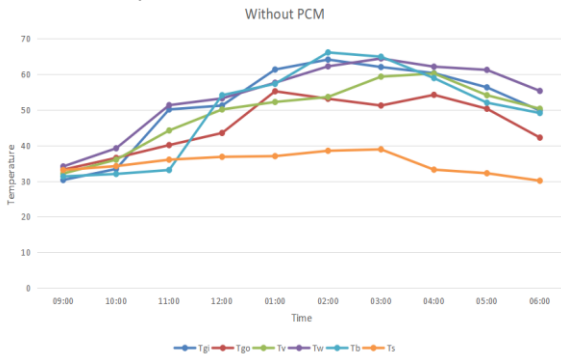
Time	T_{gi}	T_{go}	T_v	T_w	T_b	T_s
09:00	30.3	33.2	32.1	34.1	31.3	33.1
10:00	33.4	36.5	36	39.2	32	34.2
11:00	50.1	40.1	44.2	51.3	33.1	36
12:00	51.2	43.5	50.1	53.2	54.1	36.8
01:00	61.3	55.2	52.2	57.6	57.3	37
02:00	64.1	53.1	53.6	62.2	66.1	38.5
03:00	62	51.2	59.3	64.4	64.9	38.9
04:00	60.3	54.2	60.2	62.1	58.9	33.2
05:00	56.3	50.3	54.1	61.2	52	32.2
06:00	49.8	42.2	50.3	55.3	49.1	30.1

Where as

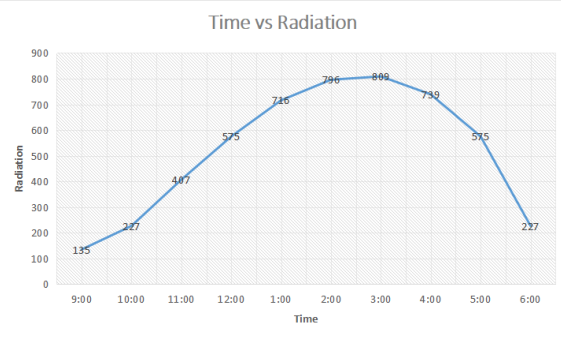
T_{gi} = Inner glass temperature
 T_{go} = Outer glass temperature
 T_v = Vapour Temperature
 T_w = Water Temperature
 T_b = Base Temperature

Ts = Surrounding Temperature

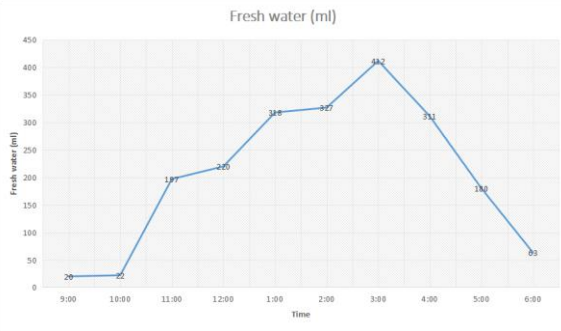
Time vs Temperature:



Time vs Radiation:



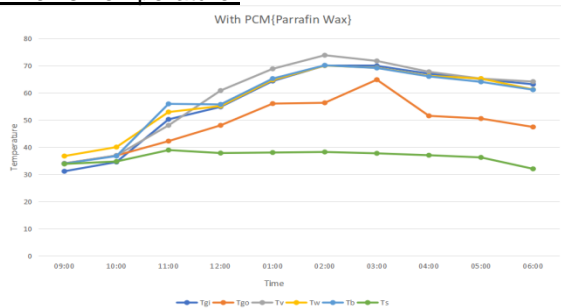
Time vs FreshWater (ml):



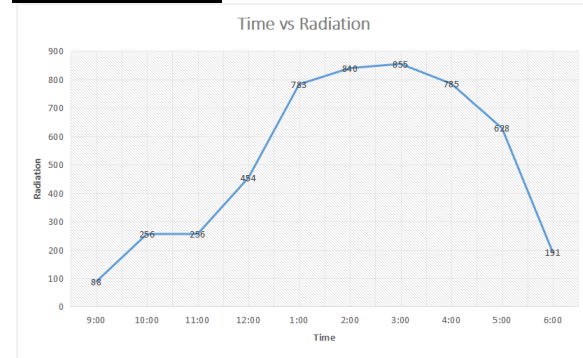
Results with PCM:

Time	Tgi	Tgo	Tv	Tw	Tb	Ts
09:00	31.2	34.1	34.1	36.8	34	33.9
10:00	34.6	37	37	40.1	36.8	34.8
11:00	50.3	42.3	48.1	53	56	39
12:00	54.9	48.1	60.9	55.2	55.8	37.9
01:00	64.4	56.1	68.9	64.8	65.3	38.1
02:00	70.1	56.4	73.9	70.1	70.2	38.3
03:00	70	64.9	71.8	69.3	69.2	37.8
04:00	67.1	51.6	67.8	66.3	66.1	37.1
05:00	65.1	50.6	65.3	65.3	64.1	36.3
06:00	63.2	47.5	64.2	61.3	61.2	32.1

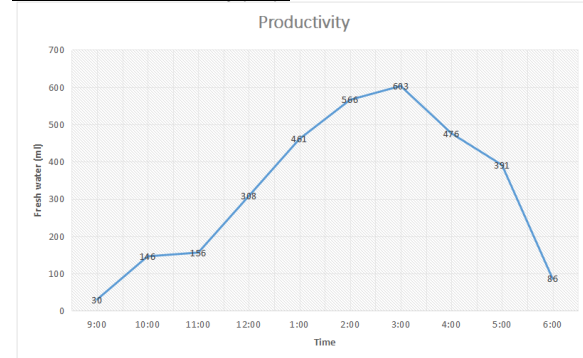
Time vs Temperature:



Time vs Radiation:



Time vs Productivity(ml):



When the solar still is tested without phase change material the productivity of fresh water 2070ml. And when it is tested with phase change material the productivity of fresh water is 3223 ml. By this observation it clearly saying productivity of fresh water increases by 1153ml. Not only with the help of PCM but radiation takes main role in the productivity, In the graph 2 and graph 5 the radiation varies. On day 2 the radiation is more and at the time of radiation the productivity is also more and by the evening the PCM helps to increase the productivity. Clearly shows that radiation is proportional to productivity of fresh water. The PCM also plays a major role in increase in the productivity.

5 CONCLUSION

The performance of the solar still when PCM is increased and improved when without PCM. It gives less productivity but is the way of increasing the efficiency of solar still. But it should be conducted in only particular areas because it has melting point of nearly 46 degrees and less than this temperature it will not melt, and the process will not be happened. The performance will get better when the basin water is less in quantity because it can heat the water completely and evaporate quickly.

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