Concentrated Parabolic Solar Distiller with latent heat storage capacity

M.Gowtham, M.Sharath Chander, K.V.Sri Saila Mallikarujanan, and N.Karthikeyan

***Abstract*—In this research work is desalination is done by concentrating solar thermal energy through a parabolic trough concentrator. Studies were made improving the evaporation rate of the system. This is done through increasing the energy storage capacity through paraffin wax as latent heat storage material, maintaining low depths and utilization of various scrap materials for heat storage. Measurements of productivity in ml were taken between 10 A.M to 5 P.M. productivity improved by 54% on the performing all modifications.**

***Index Terms*—Desalination, Evaporation rate, Solar, Latent heat storage material, Parabolic trough concentrator.**

I. Introduction

Water is one of the most important resources for human life sustainability. Along with the supply of energy, access to freshwater is a fundamental need of all societies. Although water covers approximately 70% of the earth's surface, supplies of potable water are rapidly disappearing. This is because only 0.62% of the available water is in a form that can be traditionally treated for human consumption [1]. Energy storage plays important roles in conserving available energy and improving its utilization, since many energy sources are intermittent in nature. Short term storage of only a few hours is essential in most applications such as improving the latent heat storage, sensible heat storage plays a vital role in conservation of energy. During the last century, these potable water sources from both surface and ground water resources have been increasingly depleted due to increases in worldwide population. M.M. El-Kassaby[2] studied the complete design and fabrication for a distilled water apparatus using a line concentrator of parabolic reflector type, which can be used for sea water distillation along with a steady state theoretical model based on energy balance is presented. M.F. El-Refaie [3] has made analytical study of the performance of the stationary reflector/tracking-absorber (SRTA) solar collector with tubular absorber and found different multi-reflection zones of the mirror. Oommen and Jayaraman [4] analysed non-evacuated CPC cavities with flat or cylindrical absorbers. Rene tchinda [5] presented a mathematical model for computing the thermal performance of an air heater with a truncated compound parabolic concentrator having a flat one-sided absorber. Naghelli Ortega et al. [6] studied effect of concentrator as vapour generator for solar-ammonia and water adsorption refrigerator. S.Sentilkumar[7] found the effectiveness of three dimensional parabolic concentrator over two dimensional trough which is utilized for stream generation in in-situ stream generation mode. Rabl A [8-10] compared parabolic concentrator and studied the effect of maximum concentration. Balasubramaniam V et al. [11] designed a concentrator with stretched membranes. Phadatare MK [12] proposed that basin water depth is having significant effect on productivity of the solar still. Investigations show that, the water depth is inversely proportional to the productivity of still. Hasan [10] has conducted an experimental research on palmitic acid as a PCM for energy storage. The parametric study of phase change transition included transition time, temperature range and propagation of the solid–liquid interface, as well as the heat flow rate characteristics of the employed circular tube storage system.

Comprehensive lists of most possible materials that may be used for Low temperature latent heat thermal energy storage materials, as reported by Abhat [11]. Thermal energy storage systems for heating and air conditioning were reported by Lorsch et al [12]. Chauarsia [13] and Gu et al. [14] reported that paraffin wax could be used as a storage system for solar water heating. Kurklu et al. [15] designed, developed and studied the thermal performance of a new type of water-PCM solar collector. The solar collector consisted of two adjoining sections, one filled with water and the other with a paraffin wax. This water-PCM solar collector has many advantages over the traditional solar hot water collectors in Turkey in terms of total system weight, cost and energy storage applications. Recently, Canbazoglu et al. [16] compared solar water heating systems with Kaygusuz [17] also carried out an theoretical and experimental study to determine the performance of PCM storage, and the variation of the outlet temperature with different values of NTU (the number of transfer units of the storage unit) for water-based solar heating systems. Tiwari et al. [18] presented an analysis of PCM storage for a water heater by incorporating the effect of water flow through a parallel plate placed at the solid-liquid interface. Wick type solar stills [23], a plastic water purifier [22] and stepped solar still were developed. The materials that improves the heat transfer were studied by velmurugan et al[24]. The effect of various depth of water [25] in the solar still is verified by Khalifa and Hamood. The parabolic concentrator solar distiller with latent heat storage material and energy storing materials are studied. To enhance the productivity the solar distiller, materials like sponges, pebbles, mild steel billets are used.

II. Experimental Setup

In this Experimental setup, a solar concentrated distiller is

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Gowtham.M et al.is with Department of Mechanical Engineering, Thiagarajar College of Engineering, Madurai, Tamilnadu, India.
E-mail: gowthamtce@gmail.com.

designed with latent heat storage material shown in fig 1. Values are used to control the flow of saline water to the basin of the concentrator. Basin of length 0.9m and diameter 0.15m is provided for evaporating the saline water. It is fabricated of 2 mm thick GI sheet and coated with black paint to increase the absorption of heat. Parabolic concentrator of length 1m and width 0.5m depth 0.125m is used to concentrate solar thermal energy to the basin made out glass mirror. These dimensions were calculated based on which concentration of sunlight focuses on the basin. Concentrator is tilted to various angles manually every hour. Basin is covered with double slope glass cover for condensing the distilled water. Basin is enclosed with pipes containing paraffin wax, which acts as latent heat storage material for the system. Glass cover is inclined in 10 degree on both sides. Leather sheet was used to prevent leakage from any gap between the glass covers and the still box Poly Vinyl Chloride (PVC) tubes were used to discharge the distilled water from each unit to the bottles. The inlet water was fed into the still using flexible hoses. Various modifications done are explained.

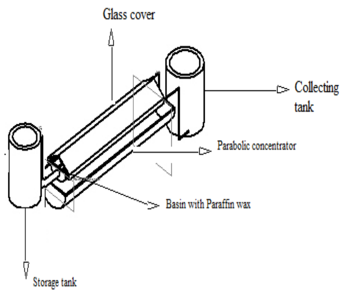

Fig 1. Experimental set-up

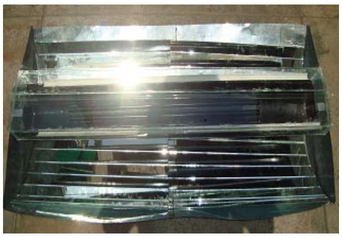

Fig 2. Solar distiller with Paraffin wax

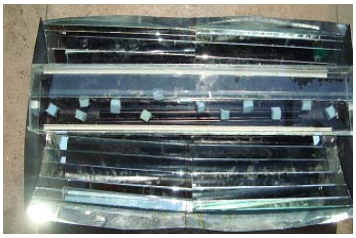

Fig 3. Solar distiller with sponges

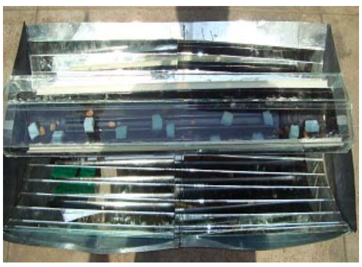

Fig 4. Solar distiller with sponge and Pebbles

Fig 5. Solar distiller with Steel billets.

A. Solar distiller with paraffin wax:

Paraffin wax improves the latent heat storage capacity of the solar distiller. There by improves the heat storage capacity of the basin shown in figure 2.

B. Solar distiller with paraffin wax and Sponges:

To increase water exposure area, sponges were used in solar distiller as in figure 3. The exposure area increases due to the capillary action. This will increase the evaporative area as well as evaporation rate.

C. Solar distiller with paraffin wax and Pebbles:

In addition to Latent heat storage materials, Pebbles were added to previous modification shown in figure 4. It was observed that the productivity of still increased due to the higher volumetric heat capacity of the pebbles.

D. Solar distiller with paraffin wax and Mild Steel billets:

In the solar distiller with latent heat storage materials, Mild steel billets having high thermal conductivity are added as in figure 5, leads to heat storage capacity of the basin is improved.

III. Results and Discussion

Latent heat storage material, sponge, pebble and mild steel billets were used to enhance the productivities of the solar distiller. Performances of the solar desalination unit with various modifications were studied. Productivity of the system for depth of 1 cm and 2 cm depth are measured.

A. Solar distiller without paraffin wax:

The graphs drawn below illustrates the variation of productivity with time for various depths in basin without paraffin wax.

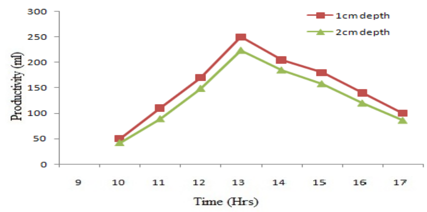

Fig 6. Productivity of distiller without paraffin wax

B. Solar distiller with paraffin wax:

The graphs drawn below illustrates the variation of productivity with time for various depths in which the pipe containing paraffin wax. The water output increased in lower depth for each hour due high heat transfer. The productivity was about 33.34%

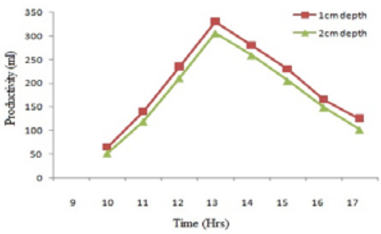

Fig 7. Productivity of distiller with paraffin wax

C. *Solar distiller with paraffin wax and Sponges:*

It is observed that due to the presence of paraffin wax and sponge,the water output is increased to 38.41% latent heat storage type stilll due to the addition of sponge when compared to conventional still.

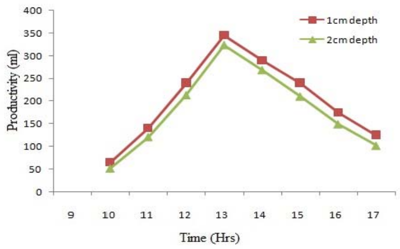

Fig 8. Productivity of distiller with paraffin wax and sponges

D. *Solar distiller with paraffin wax and Pebbles:*

Due to the presence of Paraffin wax, sponge and pebbles, the overall water output is increased to 42.85% in vapour adsorption type still when compared to conventional still Because Volumetric heat storage of pebbles.shown in fig.7.

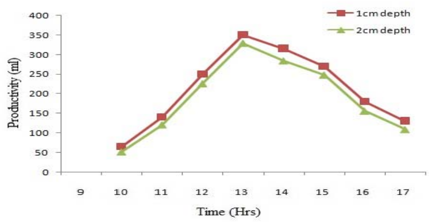

Fig 9. Productivity of distiller with paraffin wax, sponge and pebbles

E. *Solar distiller with paraffin wax and Mild steel scraps:*

Due to presence of Paraffin wax and mild steel scraps heat storage capacity and thermal conductivity of metal increases the productivity to the maximum of 54.08% compared to the convention setup.

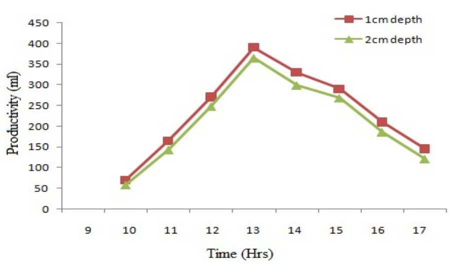

Fig 10. Productivity of distiller with paraffin wax and Metal billets

F. *Productivity of solar distiller:*

The following graphs shown below was the comparative illustration of the productivity of various modifications using Paraffin wax, sponge, pebbles and mild steel scraps per day.

The bar chart shown below fig.11 was per day productivity of solar distiller for different materials.

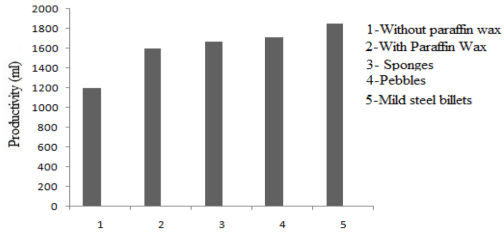

Fig 11. Overall Productivity of solar distiller

IV. Conclusions

Experiments carried out with solar distiller individually analyzed having 54% higher productivity compared to conventional solar distiller. Analysis on maintaining lower depths were studied. Overall productivity based on the various materials was studied.

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