Investigation Enhancement of Solar Still by Analysis Heat Transfer with Fresnel Lens and Phase Change Materials

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Abstract: One of the major issues facing the globe today is the lack of access to clean drinking water. Due to causes like population expansion, industrialization, urbanization, etc., water contamination significantly rises. Desalination has occasionally seen the development of a number of innovative methods, while solar distillation is thought to be more cost-effective. In this study, a steps distillation basin slope single basin solar still was used to examine the effect discusses the transformation of salt water into drinkable water by the Fresnel lens. When distillers were used with phase change materials, the temperature increased than it was without phase change materials, by increasing the working hours of the distillers, and thus increased productivity. But when distillers were used with phase change materials and a Fresnel lens, the productivity increased than it was due to the increase in temperature, as well as increased evaporation of water, as well as increased work The distiller works at night due to the presence of phase change materials, and thus the productivity of the distiller increased than it was before the lenses were placed.

The outcomes demonstrate that the employment of Fresnel lenses and phase change materials can successfully transform salt water into drinking water.

Keywords: Fresnel lens, Phase Change Material, Solar Desalination.

I. Introduction

In everyday living, it's critical to have access to clean water. Due to the rapid population increase and unsustainable consumption rates, the world's biggest issue this century is the lack of access to clean drinking water [1]. The substantial population expansion in emerging nations, as well as other economic and technological advancements, have all contributed to the rapid rise in global energy consumption [2]. The need for human energy consumption can be met by renewable sources like solar energy. It is available for free from the sun. Additionally, a solar still that converts salt water into fresh water uses solar energy. Solar water generation is a fairly old technique historically. Small-scale desalination is typically accomplished using solar stills. Low maintenance costs and ease of fabrication characterize solar stills. The raw material required to make solar stills is readily available and nearby. It is among the most significant and practical uses of solar energy. However, the productivity of solar desalination utilizing solar stills is low [3]. Fresh water makes up just 3% of the overall water resources. The majority of Frozen fresh water is discovered., in glaciers and ice shets. Only 0.3% of the fresh water in the globe is found in rivers and lakes. The availability of fresh water is also harmed by the growth of industries and the population. As a result, a lot of people lack access to sufficient and affordable quantities of drinkable water. One of the most affordable techniques for removing salt from saline water with the aid of sunshine is solar distillation. This process makes use of a solar still that comprises of a glass cover over a shallow basin. Evaporation results from the sunlight heating the saline water in the basin. Salts, minerals, and the majority of other pollutants are left behind as Water evaporation causes it to rise toward the glass cover. [4-5]. The Fresnel lens was a powerful sun concentrator and was constructed of acrylic plastic. At the ideal lens position angle of 30°, the dirty water vaporized in the minimum amount of time. When compared to a double slope basin, the multi-slope solar basin produces more water [6]. It is not required for the tilt on both sides of the glass to be equal in order to track the maximum amount of solar energy [7]. Under the same environmental conditions, stepped solar still and traditional basin are compared [8]. In this study, a Fresnel lens is used to pre-heat the water, which increases production rate and efficiency in comparison to a typical still.

II. Experimental Setup

The solar still is made of a plate of stainless-steel material, with a thickness of 2 mm, its surface area is 150 cm x 100 cm, and its height is 10 cm. It has been painted with a suitable material of black color. A Fresnel lens has been added to collect solar radiation. A single hole of 1.7 cm in diameter was drilled in each of the left and right sides to enter the salt water and to collect the purified water individually. The (base of the basin) was thermally insulated by glass wool with a thickness of 5 cm completely, except for the upper surface. The distillation device is supplied with water through a tube connected to a perforated tube to 7 holes distributed over the distiller basin. The condensate water droplets collected on the inner surface of the glass cover are collected in a container through a hole at the bottom of the collection basin of the distillation bowl. The cover of the solar distillation device consists of a piece of glass Dimensions (150 * 100) cm. 4 mm thick. Ten lenses were placed on the cover glass with dimensions (30 * 30) cm and a focal length of 30 cm. Figure 1: The new distillation system. A phase change material tank made of galvanized iron with dimensions (150 * 100 * 25) cm. It is located at the bottom of the drip to transfer the heat stored in the PCM to the basin surface.

Fig (1) Solar still with Fresnel lenses

III. Design and Procedure

On a single slope, experiments over a range of time periods were conducted. On a bright, clear day, it took nine hours, from 8:00 am to 22:00 pm. Since an experiment was conducted on days when the sun was shining well, when solar strength varies, the results are suitable for comparison. The solar panel was still set up in glass. The solar energy meter and the digital thermometer were used to measure the various parameters, including solar intensity, Temperatures of the glass, the water, the absorber, and the steam. All of the metrics as well as the condensate formation volume were measured every hour.

Fig (2) Distilled base included

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Fig (3) Distilled without a lens and with the lens

3.1Fresnel lens

More oblique light from a light source might be collected by a Fresnel lens. increasing the visibility of a lighthouse's illumination at longer distances. Fresnel lenses are often formed of glass or plastic, and their sizes range from large to small (ancient historical lighthouses, meters), medium to small (book-reeding aids, OHP viewgraph projectors). They frequently have thicknesses in the 1 to 5 mm (0.039 to 0.197 in) range, are flat, and virtually flexible. In this, the reading is first obtained using salt water, and the results are then obtained. There are two reading assignments. First, readings are made without the use of a Fresnel lens, leading to the creation of the related readings and graphs. Second, the Fresnel lens is used to take the readings.

IV. Result and Discussion

when the enclosure is filled with salt water and the installation is placed in an open area. The salt water inside the chamber and the phase-change materials in the storage tank were heated at the start of the day, when solar radiation was at its strongest. The phase transition materials produce extra heat whenever the radiation level is lowered. This causes it to heat up and start to evaporate, and the evaporating water then hits the housing's slanted glass. Utilizing the drain pipe, purified water is collected from the sides and put into the storage tank. Since the productivity of solar energy still directly depends on the amount of solar radiation that is accessible, continuous productivity must be compared to the solar intensity of days lived. The amount of solar energy on any particular day is obviously variable, and as a result, continuous productivity canot be fairly compared. The only option is to carry out the experiment in a climate where there are few fluctuations in solar intensity over the course of the eight days. In order to make the results comparable, the experiment was carried out over the course of eight days that were sunny and had nearly identical solar conditions.

Varying temperatures as a function of time

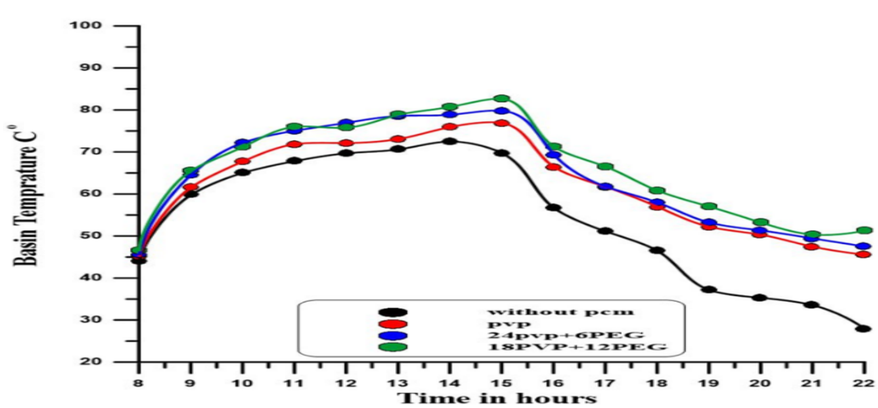

Figure (4) Temperature of the Solar Distillation Basin using PCM.

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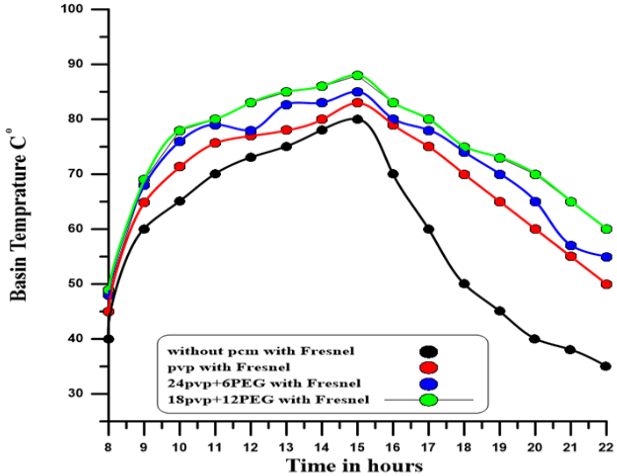

Figure (5) Temperature of the Solar Distillation Basin when Coupled with the Fresnel lens and PCM

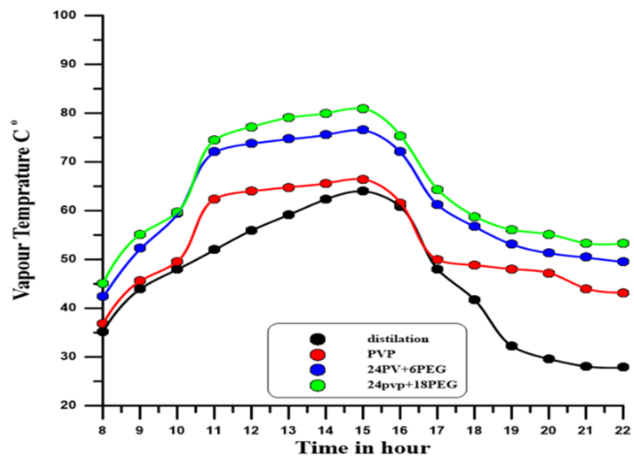

Figure (6) shows water vapour temperature during the solar still with using phase change materials

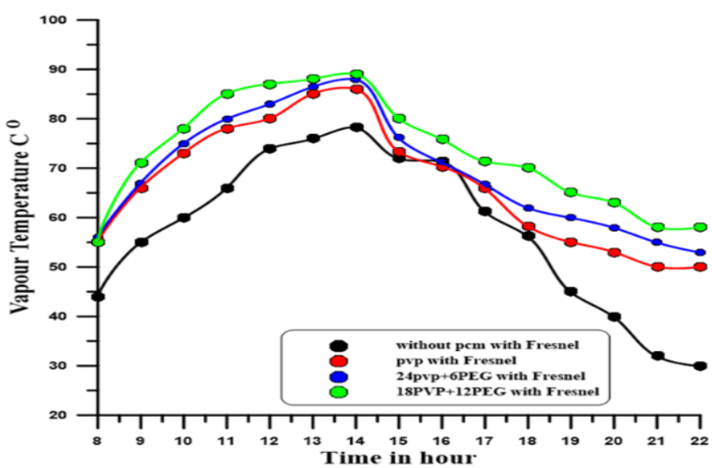

Figure (7) shows water vapour temperature during the solar still coupled with a Fresnel lens with phase change material.

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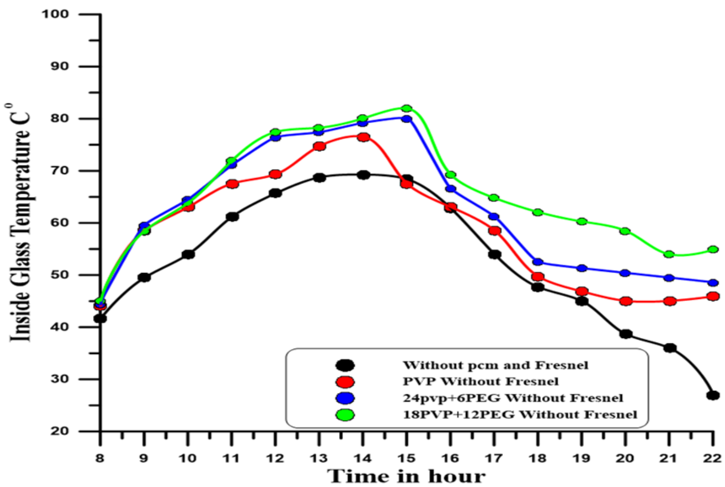

Fig. (8): Variation of glass cover inside temperature with time when used the solar still with phase change materials

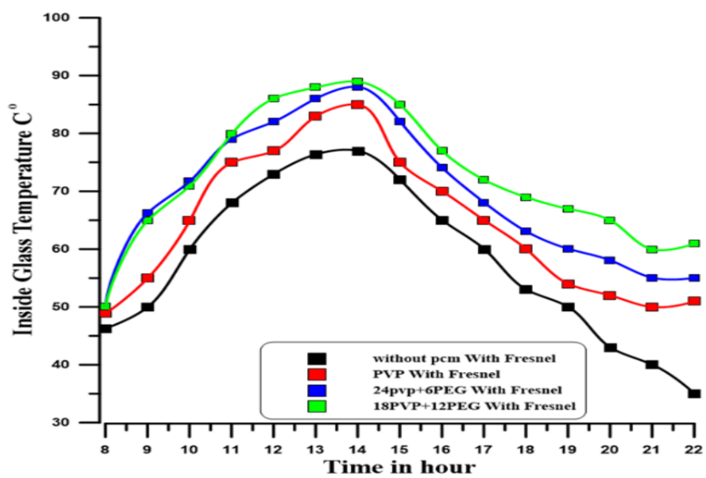

Fig. (9): Variation of glass cover inside temperature with time when the solar still coupled with Fresnel lens with phase change material.

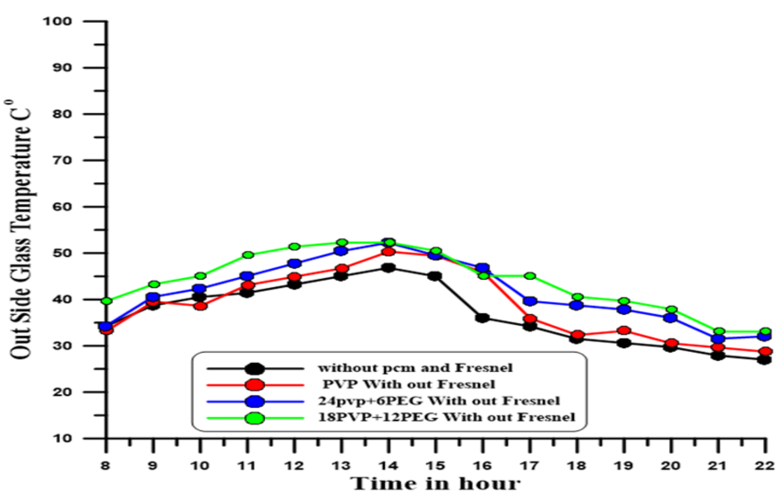

Fig. (10): Variation of glass cover outside temperature with time when used the solar still with phase change materials

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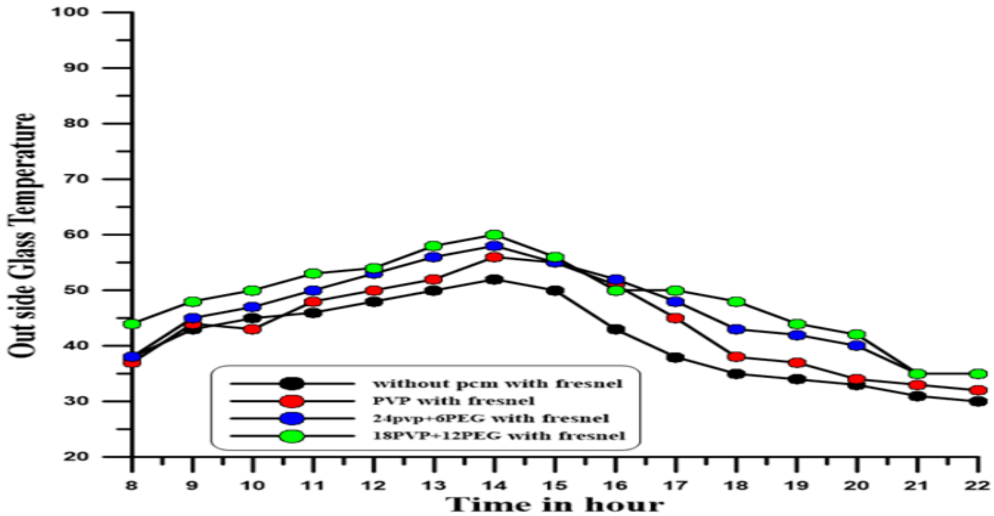

Fig. (11): Variation of glass cover outside temperature with time when the solar still with Fresnel lens and phase change material.

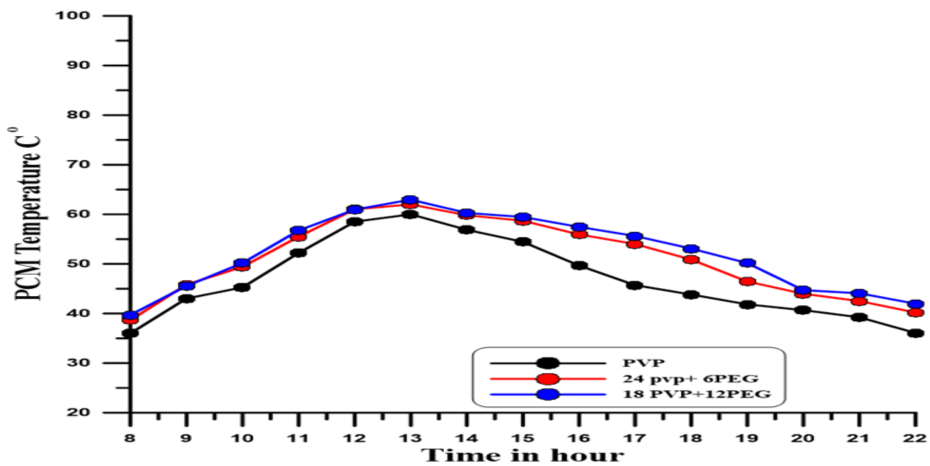

Figure (12): Variation of PCMs temperature with time when used the solar still

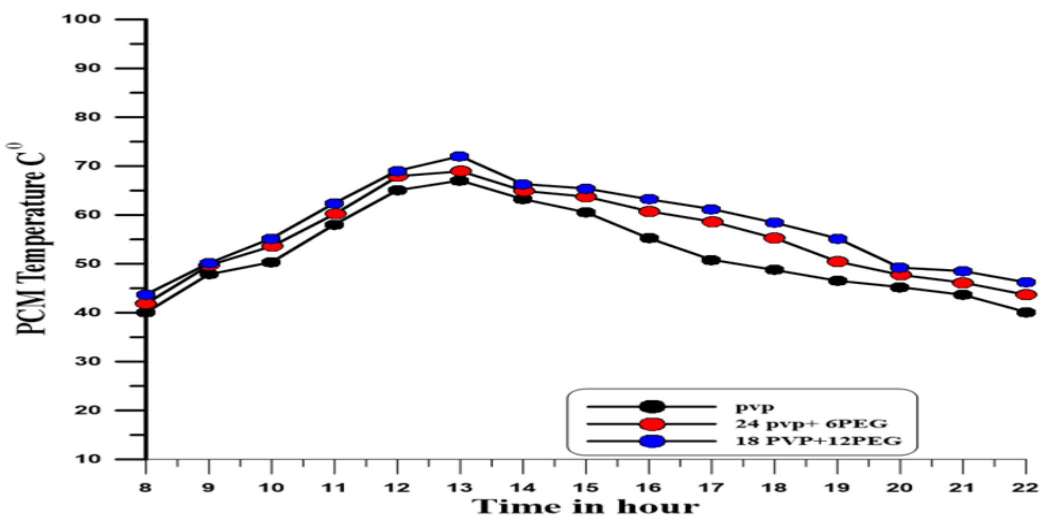

Figure (13): variance of PCMs temperature with time when the solar still coupled with Fresnel lens

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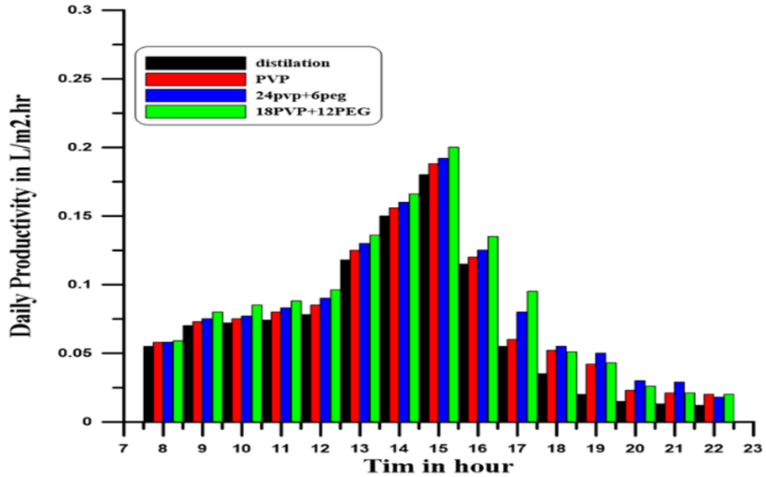

Figure (14): Variation of daily productivity with time when used the solar still with phase change materials.

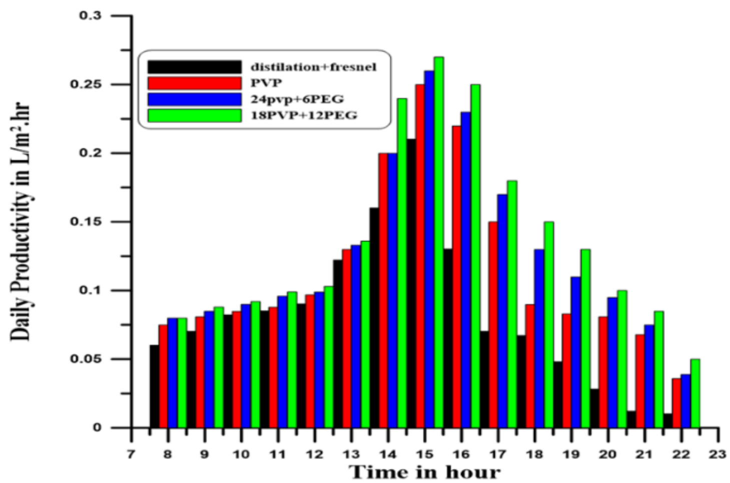

Figure (15): Variation of daily productivity with time when the solar still coupled with Fresnel lens with phase change material.

Hourly Overall Thermal Efficiency

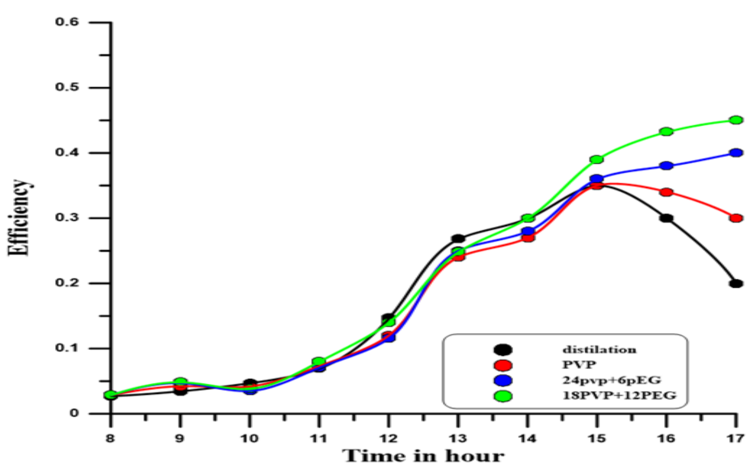

Fig. (16): The overall thermal efficiency variation with time when used the solar still with phase change materials.

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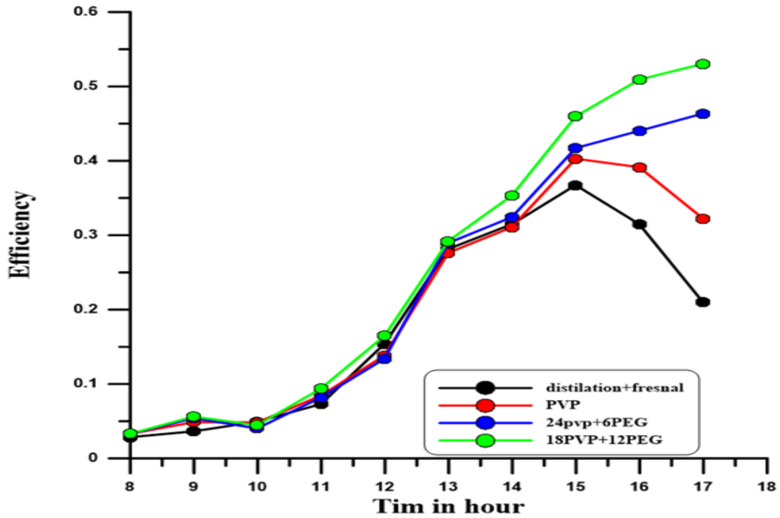

Fig. (17): The hourly variations of the solar still overall thermal efficiency with time when the solar still coupled with Fresnel lens with phase change material.

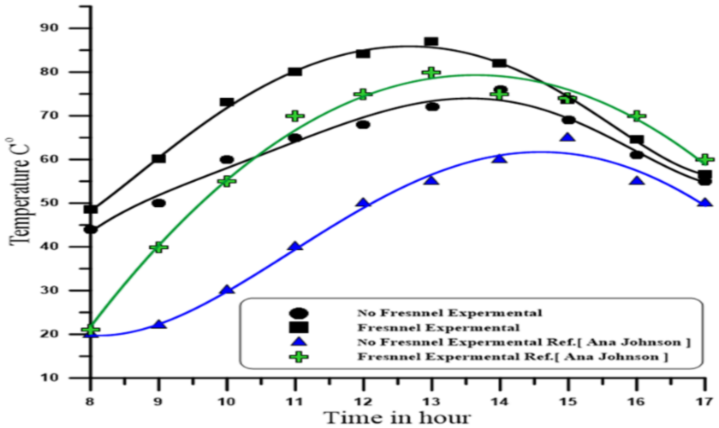

Figure (18) The measured temperatures during experiments water temperature

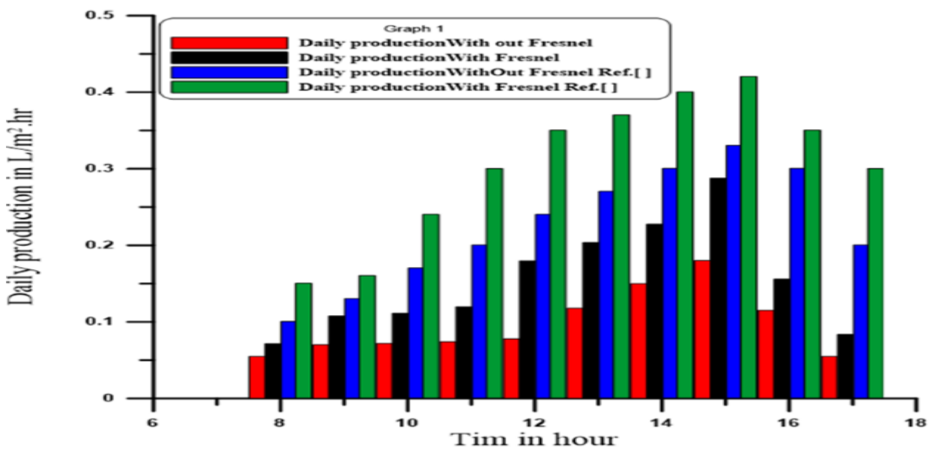

Figure (19) Cumulative water productivity

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V. Conclusions

This study was conducted as to observe the applicability of the Fresnel lens and phase change materials in solar still, which is conducted through experiments on solar stills the study revealed that incorporating the Fresnel lens and phase change materials can enhance the overall production of distillate from a solar still, this study has opened up the possibility of further exploration in this field through more vigorous experiments. The findings can be summarized as:

The new shape of the distillation enhances the daily production volume by increasing the surface area for absorb of the sun.

1. 1.Fresnel lens increases the total production from a solar still. The addition of Fresnel lenses increased the average and total production rate.
2. Using Fresnel lenses and phase change materials and causes more evaporation of feedwater, thus leading to higher total production per total solar by 36%.
3. The presence of the runway led to an increase in the surface area for evaporation, and thus increased productivity.
4. 4-By comparing the daily production amounts of three different mass flow rates, it was found that the best rate was 1 liter/min, where the production amount reached 1.2 liters/day.
5. 5-The use of phase change material (PCM) in the solar distillation system enhances the production of distillates. When using PCM, the system uptime improves from 3 to 4 hours. which increased the production rate
6. 6-When PVP (30 g) was added to the distillation system, the daily production amount increased to 1.2 L/day. The production increased to 1.34 liters per day after collection (24 g of PVP with 6 g of PEG). The largest daily yield was produced during mixing (18 g PVP with 12 g PEG), reaching 1.45 liters per day.
7. 7-When use lens with pcm PVP (30 g) was added to the distillation system, the daily production amount increased to 2 L/day. The production increased to 2.2 liters per day after collection (24 g of PVP with 6 g of PEG). The largest daily yield was produced during mixing (18 g PVP with 12 g PEG), reaching 2.5 liters per day.
8. 8-A comparison was made between the experimental results and the numerical results. The highest percentage error was 9%.

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