SOLAR ENERGY STORAGE BY USING PCM MATERIALS WITH FOUCUSING LENS

M.Ruban[*1], S.Sivaganesan[2], C.Dhanasekaran[3], L.Karikalan[4]

[1]Assistant proferssor, Vels institute of science, Technology and advanced studies, Chennai
[2,3,4]Associate professor, Vels institute of technology,science and advanced Sudies,Chennai
[*1] rubanmurugesan@gmail.com

ABSTRACT

This Experimental work is on study of water desalination Processes using phase change material (PCM) and connected to a solar system was carried out. The PCM is used to store solar thermal energy collected by the system at daytime as latent heat, to provide heat during night time thus continuous operation. Thermal energy storage system (TES) is having parts like basin, tray, cooled glass and focusing lens. Water is in the basin and the PCM were heated by direct solar radiation and desalination water is collected by tray it's fixed in the basin. The produced water vapour from the basin condensed on the inner side of the water cooled glass cover. The water is condensate from salt water to fresh water. In this system we were using the focusing lens and its increase the amount of freshwater produced were studied. The production rate of desalinated water was proportional to the increase in ambient temperature and hot water circulation flow rate. There also is an optimum value of cooling water flow rate (about 12 ml/s) at which the unit productivity was the highest. Additionally, as the water level in the basin increased the productivity decreased. The unit was capable of producing 5600 ml/day.m2, of which means 55% was produced after sunset. This is economically used in desert and rural areas and evaluation reveal that such units are feasible mainly in remote areas.

Keywords: thermal energy storage system, phase change material, focusing lens, productivity

1. INTRODUCTION

This present study aims at exploring the Energy Storage Systems in both Solar and the Thermal which for addressing the real-world problems on Solar Water Heating Systems [SWHS] and Thermal energy storage systems [TESS]. In these storage systems are 'SWHS and TESS' by which using into the PCM materials on the solar and the thermal in energy process. Hence the solar energy and the thermal energy process which approach with its level of problems for producing and conversing the high and the low heat energy process in PCM materials. This thesis is organized into the seven chapters as follows. The first chapter deals with an Introduction, outlines the motivation of the work. In this Section provides the problems on research statement, the relevance of the work are highlighted and also deal with the contribution of the thesis. Further, the Scope of this research works; Literature review,Analysis on CFD, Comparative analysis of result and Conclusions and suggestions.

deals with backgrounds of Present Solar Water Heating Systems [SWHS] and Thermal energy storage systems [TESS]. It is going to test Performance and to conduct the continue analysis of an evacuated multi-stage solar water desalination system is an experimental study on an inclined solar water distillation system with simulation analysis with evaluated in this present solar desalination system.

The well-known PCM materials process of whose variants arise in many real life situations is a challenging its conversing the power problem. PCM is widely used as power conversing tools to find (near) optimal solutions for solving the energy storage systems' problem instances in reasonable running times. With this study, propose a set of robust and take advantage of parallel computation techniques to obtain solutions.

Most technical fields, including all those in engineering, involve some form of optimization that is required in the process of design. Since design is an open-ended problem with many solutions, the quest is to find the best solution according to some condition. In fact, almost any power storage system process involves trade-offs between costs and benefits because finding optimal solutions is analogous to creating designs – there can be many solutions, but only a few might be optimum or useful, particularly when there is a non linear relationship between performance and cost. A brief outline of the various chapters of the thesis is as follows:

- The review of literature survey on a survey of the current state of the art in the field of Solar Water Heating Systems [SWHS] and Thermal energy storage systems [TESS] is presented. This study provides a basic outline of the four optimizing techniques used in the experimentations. It provides clear studies related to the work. discusses the PCM Materials process based on SWHS ANS TESS System and analyses the results and its performance of methods provides the details of Analysis on CFD the experimental study the system and analyses the results.
- The Experimental work discusses the Design of the Solar and Thermal power storage systems. The findings clearly demonstrate that (as measured by an appropriate, suitably defined scale) is achieved with such a multi-level, PCM Materials approach. The comparative analysis of all the methods proposed in this research work with respect to previous studies.
- Conclusion concludes the overall research work which has been done. It provides highlights of the thesis work and proposes suggestions for future work.

This study presents energy storage of the system which supply and utilization in different times for measuring the heat time. Energy is disputed to a different storage and different systems which are perfected for using at different latent heat time. Hence there are several methods of storage in thermal energy like 1.Sensible heat 2. Latent heat and 3. Thermo-Chemical or Artificial heat sources in heat or Cooling of storage systems.

2. LITERATURE SURVEY

This study will focus on optimized thermo siphon. SWHS researchers have concentrated on the performance give attention to in different operating variables in STS. [04] Literature Reviews on the designs, aspects of SWH systems for upgrading thermal heating systems. An overview on this literature survey studies haven solar collectors which apply in different heat pump systems for applying in design characteristics, collectors, different passive and active techniques. For applying the differences which are heat enhancement methods and techniques into Inside flat-plate solar water heating systems [FPSWH]. [05] This study conducts an investigation and experimental effects from a different passive heat and active heat will be analyzed through in different enhancement methods which are twisted strips and baffles and collectors over a range of flow rates.

R. Thamaraikannn et al (2017) presented a review work which discusses effective methods to improve PCM heat transfer efficiency by the following five approaches: active methods of agitators, vibrators, scrapers and clay, microencapsulating and nano-encapsulating PCM, imbibing PCM with high conductivity particles, assorting PCM with graphite composite materials and improving contact surface extensively by fins and honeycombs.

Alain Joseph et al (2015) conducted a study of real-time performance of phase-change material (dodecanoic acid) for solar thermal energy storage. The results of this study supported the previous work indicating high energy storage densities in PCMs and their potential for use in solar thermal storage. It also experimentally proved the contribution of geometry of the tank's coil heat exchanger towards the quality of heat transfer.

The Solar thermal systems are mostly required to industries for using in the commercial applications and it also analyses the SWS. The SWS based on the energy systems which has been mostly analyses the storage systems. The storage system is Advanced Latent heat storage systems for environmental user-friendly in technological aids. [01] It used in a domestically, economically and most enhancements of the heat fraction of the renewable energy for utilizing the sources into an energy of conventional systems. An energy resource attracts the notable systems of different tanks and different absorption heating systems. A sustainability of PCM materials which are based on cascade solar cooling or heating resources in different areas. [02-03]. It presents a proper review most common collector and to get the performance of enhancement in different applications which used in different orientations. The minimal latent heat temperature deploys in solar water heating is well resembling in commercial appliances.

This survey collects the datas regarding the behaviour analysis in SWHS. It varies aneffects in different stratifications of storage tank and collectors under the weather conditions through the outcome of solar energy and different hot water flow dissimilarity will be examined.[06] This study will be defined on the designs of latent heat within SWHS in different flow variations and indicates the predictable the behavior of thermal and average performance through solar collector insensately to solar radiation. An introduction to operating variables how to handle in SWHS. As shown in Figure 1

3. EXPERIMENTAL WORK

The solar desalination setup used in this work is shown in Figure 1,2. It consists of five main parts: solar basin, double glass cover, focusing lens and tubes filled with PCM tray .The basin front side is facing south and inclined at an angle of 35^{o}. It is made from

Mild steel and painted black to improve absorption of the solar energy. It has a square bottom with an area of 1 m2, while, its height from front and back are 0.16 and 0.92 m, respectively.Water to be salted is placed at the bottom of the basin to a certain level. The basin has a double glass cover made of two glass layers placed 1 cm apart. Coolant water is passed through the double glass cover to lower the inner glass temperature. Lowering the glass temperature, increases vapour condensation and increases the driving force between the evaporation and condensation processes taking place in the same chamber. The condensate slips on the inner glass surface and falls into an inclined tray attached to the inner glass and ends in a collection tube, and then it is withdrawn as fresh water. Water in the basin is supplied via adjustment water tank (20 L); the tank has a float so that water

in the adjustment tank and the basin are both at the same level. Additionally, the level of basin water can be controlled via the float. A Water level indicator float on the water it gives feedback signal to the corresponding software with the help of level indicating sensor and basin having various temperature sensor its used for measure the PCM temperatures because the PCM were in separated tray around the water and water temperature. In that basin attached with additional train tray its help to collect purity form of water the tray consist 1.5m long and 0.15 m with and thickness is 0.003m and height is 0.02m .

The double class cover made on brittle silicon material 1.5m^{2}area and It consists of 10 parallel copper tubes of 8 mm diameter laid on the bottom surface of the solar collector. These tubes are spaced 10 cm apart and are covered with 4 mm specular glass. The maximum working pressure of this collector is 6 bars and the steady temperature at 1000 W/m2 and 30 ^{o}C is 110^{o}C. Water circulates through the tubes of the solar collector and the heat exchanger in the basin in a closed loop.Water circulation occurs by natural convection or by forced convection using a pump A stainless steel tub of distilled water (7 cm height, 70 cm length and 60 cm width) is attached to the bottom of the solar still. This tub contains 15 plastic tubes (2.5 cm outside diameter, 0.2 cmthickness, and 65 cm long). Every tube was filled with the PCM material (Sodium Thiosulfate penta hydrate (STSPH)). This inorganic salt was selected to be used in this study as PCM material because of several attractive features including its high latent heat of fusion per unit volume, small volume change at melting point, availability and low cost compared to other competitive PCM materials (Chang, 2015). In terms of thermal conductivity it is known that inorganic salts PCMs have much higher value compared to those of organic origin (such as paraffin) (Hadjieva et al., 2000, Su et al., 2015). The thermo-physical properties of STSPH used in the current work is given in Table 1. More details about the selection criteria of the PCM material is reported in (Al-Zghoul, 2016).

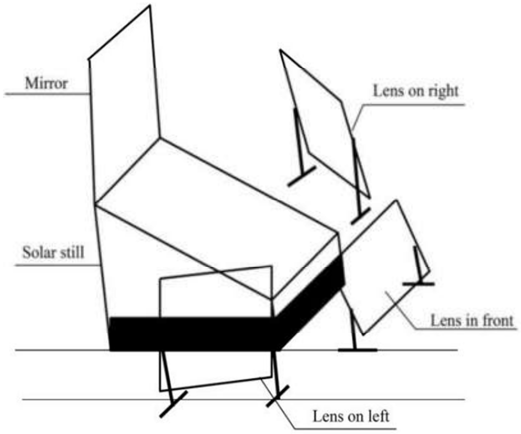

Fig.1

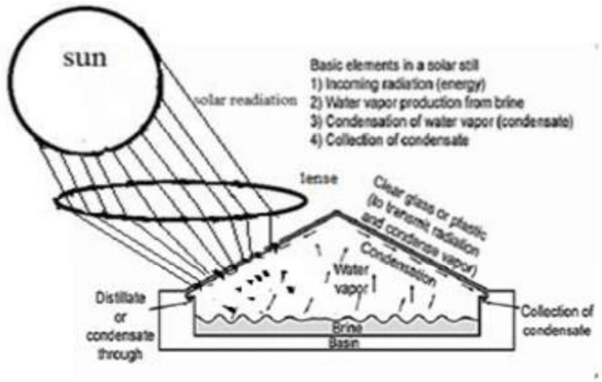

Fig.2

Year	Month	Date	Hour	Min	light	humidity	level	Ph1 (sea)	Ph2 (wat)	temp4 (pcm)	temp3 (wat)	temp2 (pcm)	temp1 (pcm)
2018	2	4	2	6	1426	11	35	8.6	7.8	62	58	68	65
2018	2	4	3	2	1331	11.7	36	8.6	7.8	71	67	70	69
2018	2	4	3	30	1289	12	38	8.6	7.8	73	71	71	72
2018	2	4	4	5	1212	12.3	40	8.6	7.8	65	73	68	67
2018	2	4	5	11	1173	13	41	8.6	7.8	59	56	61	59
2018	2	4	6	23	1090	13.8	43	8.6	7.8	46	48	45	47
2018	2	4	7	10	1038	14	46	8.6	7.8	40	37	38	38

4. RESULTS AND DISCUSSIONS

The experiments reported in this work were conducted in the year of 2015. The experimental work involved two parts; parametric study to find the best conditions within a certain suitable range for each parameter. In this part, experiments were conducted from 9:30 until 16:30 solar time. The results were used to study the system performance and productivity during 24 hours operation (part two). Several experiments were performed on the days that have similar total solar radiation and ambient temperature for reproducibility purposes and as needed to study the effect of operational parameters.

Figure 2 shows the solar irradiation and temperatures variations of ambient (Ta), basin water (Tb), and of the PCM for a typical summer day (May 15, 2015). The maximum value of solar irradiation (830 W/m2) was reached at hour 13:00, which corresponded to maximum ambient temperature of 33.5 ^{o}C. However, the maximum basin temperature reached 65.2^{o}C with a delay of 90 min due to the thermal capacity of water, PCM and walls of the basin.

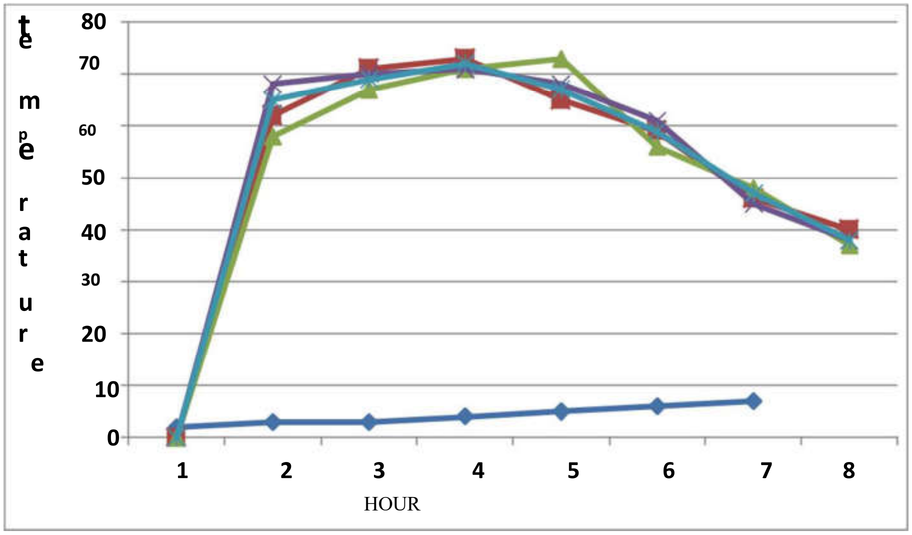

Fig. 3. Various temperature of PCM for corresponding hours

In this graph shows the various PCM temperature and it's how to react depending upon the time ,in this three PCM s are BBCL wax, red wax, copper brown Wax.

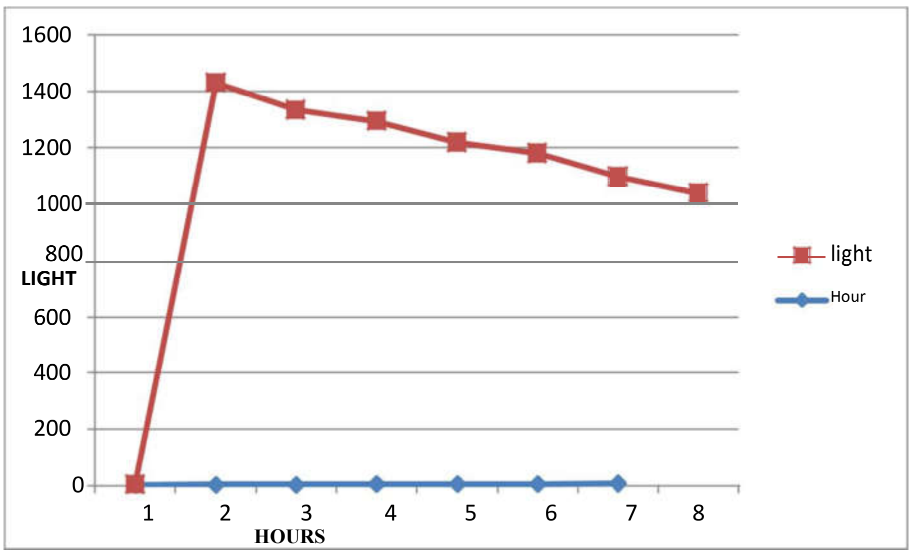

Fig. 4. Various lighting for corresponding hours

In this graph shows the light inside the profile and it's how to change depending upon the time

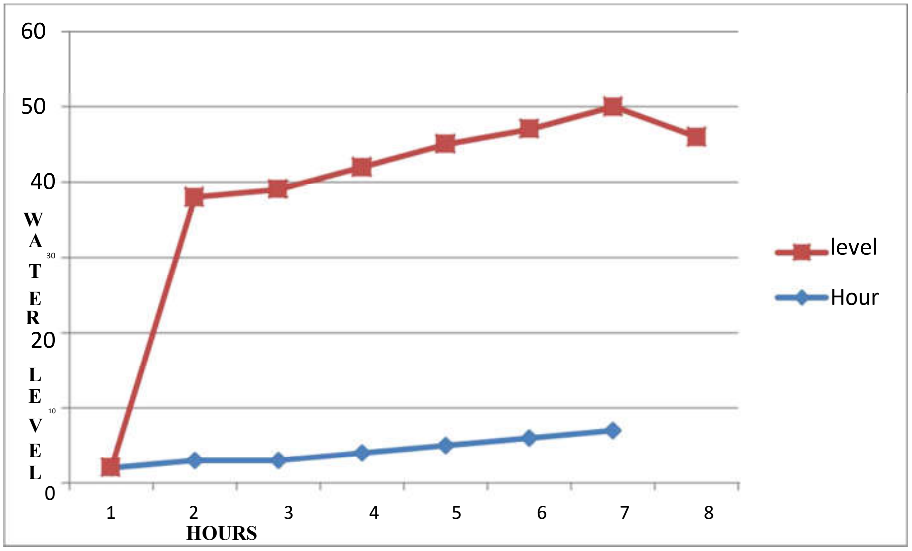

Fig. 5. Various Water level for corresponding hours

In this graph shows the water level inside the profile and it's how to change depending upon the time

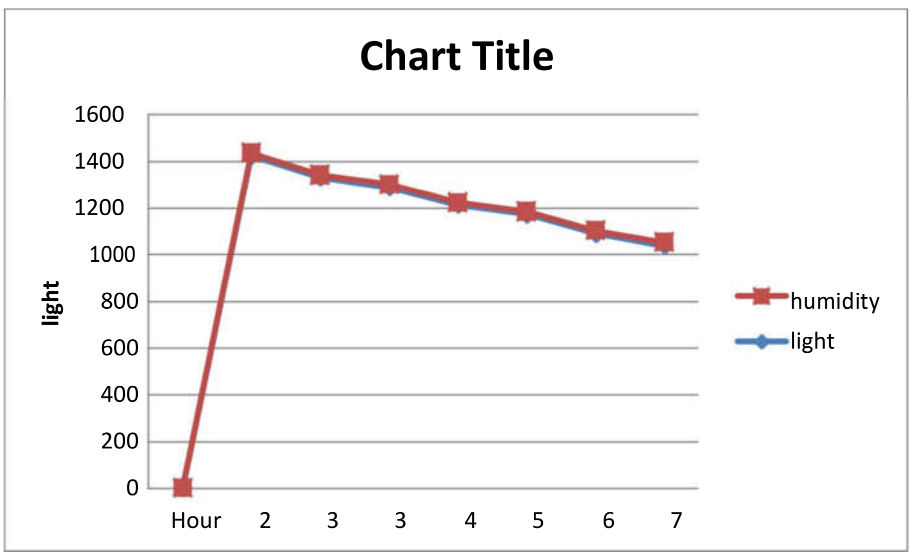

Fig. 6. Various Water level & humidity for corresponding hours

In this graph shows the light inside the profile and it's how to react with humidity level

5. CONCLUSIONS

The experimental study of a solar still Wax (BBCL) as PCM and connected to an external solar collector led to the following conclusions:

1. The selected PCM worked well to energy during night time period without any change in thermal behavior

2. Increasing the cooling water supply flow pace from 6 to 10 cc /s increased the productiveness, but increasing the flow pace to 1Phoebe ml/s decreased the productivity slightly causing negative effect.
3. The productivity of the unit of measurement increased with increasing the circulation flow of hot water from 2 to 30 ml/s. The productivity tripled by going from 2 to 30 ml/s.
4. The PCM becomes more effective at
lower masse shot (lower horizontal surface) of water in the wash basin . Changing the level from 10 to 5 cm doubled the unit productivity.
5. The highest daily productivity of the unit achieved experimentally was 5300ml/twenty-four hour period .M2

REFERENCES

1. Al-Kharabsheh, S., and D. Yogi Goswami. "Experimental study of an innovative solar water desalination system utilizing a passive vacuum technique." Solar Energy 75.5 (2003): 395-401
2. Tiwari, G. N., and Anil Kumar Tiwari. Solar distillation practice for water desalination systems. Anshan Pub, 2008
3. Shatat, Mahmoud, Mark Worrall, and Saffa Riffat. "Opportunities for solar water desalination worldwide." Sustainable cities and society 9 (2013): 67-80.
4. Shatat, Mahmoud IM, and Khamid Mahkamov. "Determination of rational design parameters of a multi-stage solar water desalination still using transient mathematical modeling." Renewable energy 35.1 (2010): 52-61
5. Aybar, Hikmet Ş., Fuat Egelioğlu, and U. Atikol. "An experimental study on an inclined solar water distillation system." Desalination 180.1-3 (2005): 285-289.
6. Reddy, K. S., et al. "Performance analysis of an evacuated multi-stage solar water desalination system." Desalination 288 (2012): 80-92
7. Li, Chennan, Yogi Goswami, and Elias Stefanakos. "Solar assisted seawater desalination: A review." Renewable and Sustainable Energy Reviews 19 (2013): 136-163.
8. Karagiannis, Ioannis C., and Petros G. Soldatos. "Water desalination cost literature: review and assessment." Desalination 223.1-3 (2008): 448-456.
9. Banat, Fawzi, and Nesreen Jwaied. "Economic evaluation of desalination by small-scale autonomous solar-powered membrane distillation units." Desalination 220.1-3 (2008): 566-573.

10. Delyannis, E-E. “Status of solar assisted desalination: a review.” Desalination 67 (1987): 3-19.

11. Ghaffour, Noureddine, Thomas M. Missimer, and Gary L. Amy. “Technical review and evaluation of the economics of water desalination: current and future challenges for better water supply sustainability.” Desalination 309 (2013): 197-207.

12. Qiblawey, Hazim Mohammed, and Fawzi Banat. “Solar thermal desalination technologies.” Desalination 220.1-3 (2008): 633-644

13. El-Nashar, Ali M. “Effect of dust deposition on the performance of a solar desalination plant operating in an arid desert area.” Solar energy 75.5 (2003): 421-431.

14. El-Nashar, A. M. “Optimizing the operating parameters of a solar desalination plant.” Solar Energy 48.4 (1992): 207-213.

15. Goosen, Mattheus FA, et al. “Thermodynamic and economic considerations in solar desalination.” Desalination 129.1 (2000): 63-89.

16. Chafik, Efat. “A new seawater desalination process using solar energy.” Desalination 153.1-3 (2003): 25-37.