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Performance and Efficiency Features of Bin Model Solar Instant Water Heater using Copper Plate Collector

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Abstract: ***The bin model solar instant water heater has been designed, fabricated and its performance has been evaluated in the Namakkal climatic conditions. Solar water heater is a required one, but it is expensive for rural people. In that case; the bin model solar instant water heater is a modern, simple and low cost system. This bin model solar instant water heater is fabricated without high cost components and the setup does not need the storage tank. This article presents and encompasses the technological developments of our setup. The performance and efficiency of bin model solar instant water heater is determined when using copper is an absorber part. The bin model solar instant water heater's performance, efficiency, copper plate temperature, loss ratio, mass flow was calculated and presented. This bin model solar instant water heater is ecofriendly, it used for both domestic and industrial sectors.***

Keyword: Solar instant water heater, Bin model, Typical collector, Efficiency.

I. INTRODUCTION

Developing nations such as India are energy insecure despite their high potential for renewable energy sources**.** Solar water heater is one of the most renewable factors for energy demands, and the cyclic methods of sun's energy is the needed one put to use via solar water heating. The life on the earth needs solar energy and quality water. Solar energy is a gift for getting hot water via solar water heater. In India we are getting solar energy throughout all the seasons. At the time, that there are many wonders in the world, sun has given more merits to the people. We did not fully know about the advantages of the sun's radiation and heat. That's why we use less amount of solar energy: To change these circumstances, this paper may create awareness for the rural people. The article is about how people can inflation the energy resources by using solar energy. The numbers of people who use water for drinking or other needs are particularly low in rural areas.

The solar water heater is one of the most important for the purpose of long term and use of natural energy at lower cost than the cost of quality hot water because today alternating fuels are essential.

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The developed countries have become aware of the significance of solar instant water heater that is being used in public places. First of all, people should realize that solar irrigation is available free of cost. Solar instant water heater is one of the most important machines in the solar power harvesting systems. Hot water in the specified temperature is also provided by solar water heater. This water heater will serve the hot water requirement for housing, factory and hotels. Even some rural people may eagerly come forward to use sun's energy and the bin model solar water heating ideology. The maintenance is besides mild [1]. This doctrinaire speed rectify the hasty getting hot water via solar heating may debug and dominate the protective environment. It's epic and historical design, especially for high heat yield with cheap cost and this is the main motto of this research work. In this investigation, bin model solar instant water heater's performance was studied. The water flow, efficiency of collector and reflector performance was analyzed.

II. EXPERIMENTAL SETUP

To study the performance analysis of the complete bin model solar instant water heater, the setup was placed on the top floor (open area) of Arignar Anna Government Arts College Namakkal-637002. Tamilnadu, India. The bin model solar instant water heater system involves of one specific inner tray (stainless steel), connecting equipments (tubes), external box (stainless steel), reflectors, glasses, good thermal conductor(copper), bad conductors which is saw dust. The inner tray placed in south direction angle facing that it fit to solar water heater and flare rays. The inner salver is a main part of the bin model sun water heating system. It is epic and historical design, especially for high heat yield with cheap cost. It collects the sun radiation and transfers the heat to water directly. In this inner salver exert absorber perceptible it is matched utterly is the black paint coated copper plate. The experimental arrangement is displayed in Fig.1 the external tray was used for insulated and domicile for heat waste from the reflectors or collectors. The water is given from a 1000 liter water tank. It flows into the collector system by a link pipe with half inch diameter[8]. It is a emblematic process however radiation are observed by inner tray section, and disseminate to the normal water. In this process, after fifteen minutes to thirty minutes (around) we received the hot water from the outlet pipe.

Fig.1.1 (a) Experimental setup of Bin model solar instant water heater for performance analysis

(b) Measurements of additional radiation (reflecting radiation)

III. RESULT & DISCUSSION

The performance of the bin model solar instant water heater has been studied about 10 days (average) for with and without reflectors. The average readings are taken for account and the graphs were drawn for the above. The performance analysis was taken for different parameters, Time vs Radiation, Time Vs water temperature [without reflectors], Time Vs water temperature [with reflectors] ,Time Vs copper plate outer temperature [with &without reflectors].

1.2 Time Vs Radiation

The experiment setup was tested by LPPYRO 03 pyranometer at Namakkal, TamilNadu, India, and the average radiation for about 10 sunny with reflector and without reflector collected data are used to examine the effect of reflecting radiation on the system. The system was set in operating from 9.30 to 3.30 hours. Fig. 1.2 clearly shows that during the test days, it was a good climatic condition.

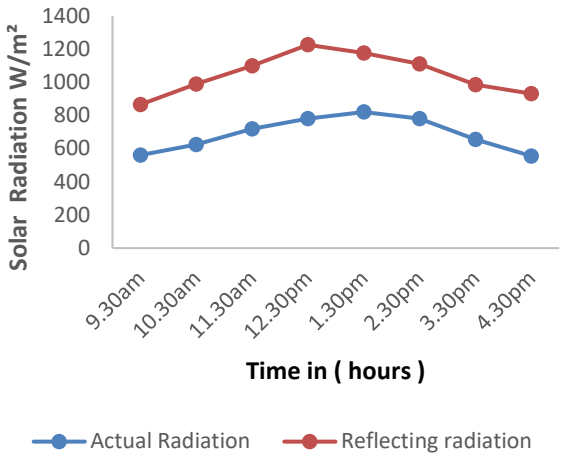

Fig.1.2Time Vs Radiation

Initially, the system was gained the normal radiation with the starting range of 786 W/m^2 was achieved, and it was exposed to direct sunlight without reflectors. During the initial hours of exposure, a gradually rise in radiation was noted. From Fig 1.2 shows the variations of the measured the radiation of system obtained highly, when the reflecting mirrors are placed. It can be seen in radiation increased from 1020 W/m^2 to 1490 W/m^2 it increases about 46 % with reflecting mirror, at peak value which is much different from the radiation harvesting area of the system. This study also aims at using perfect mirrors and increasing the radiation on certain time.

For analyzing the Bin model, results of the water average temperature are noted on the 6 hours of daily time duration. The Solar radiation, ambient temperature, external radiation are measured by Pyranometer, temperature sensors. The variation of useful radiations, and the temperature gained by the receiver throughout the day are noted. It has been observed that as the Solar radiation, increases the temperature of the copper sheet temperature increased. On experimental days, the Solar radiation varies 750 to 1490 W/m^2 with reflectors and the solar energy obtained this by system has been increased by 45% at peak hours due to reflectors.

The hourly variation of solar radiation and ambient temperature on a clear sunny days at typical analysis. The highest radiation is maximum during 12 to 1.30 pm as the level is above 1000 W/m^2 without reflectors. The radiation range from morning to evening is nearly similar for average conditions. The graph shows that as the time of the day increases the ambient temperature increases gradually. The Solar radiation absorbed by the system was obtained to be higher at the middle of the experiment and decreases steadily as the experiment progresses with time. This is because variation of radiation throughout the day increasing time radiation and ambient temperature also increases normally [2-4].

The relationship of reflector angles and time. The reflector setup was manual type, (not automatic), it has 20° to 60° angle adjustment depends upon the sun. This is help to focusing and reflecting large amount of radiation into collector, and improving the efficiency of output of the entire bin model solar instant water heater.

As expected small scale of efficiency decrease with the adjustment of reflector angle. Variation of the outcome of copper collector with respect to reflection angels is studied with bin model solar instant water heater. The effect of angle relation of time, when 12.45 pm to 2.30pm, receiving the maximum yield radiation at the range of angle **45°**. The analysis it is determined the optimum angle for good solar radiation reflectors.

1.3 Time Vs Water Temperature [Without Reflectors]

In this section a graph has been plotted to show water inlet temperature, water outlet temperature of the bin model water heater without reflectors (formally plain setup) at different time of the day. The following below 1.3 graphs showed clearly when time increases water outlet temperature also increased. The water inlet temperature has been observed around 30°C to 35°C commonly in the entire experimental work at average.

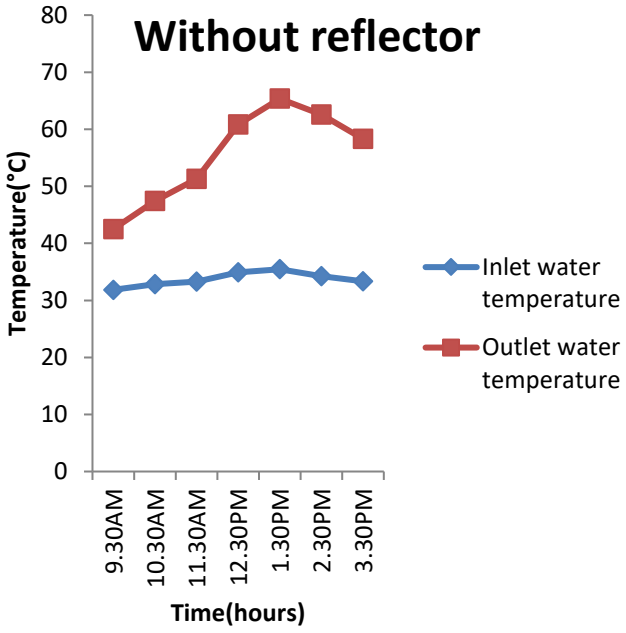

Fig.1.3 (a) Time Vs Water Temperature [Without Reflectors] for 60 liters/hr

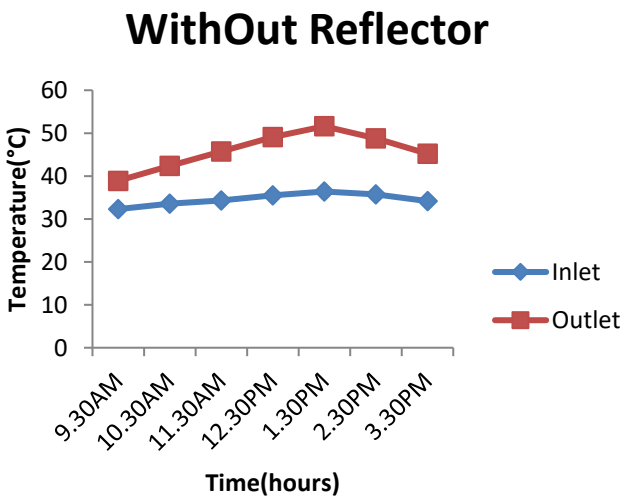

Fig.1.3(b)Time Vs Water Temperature [Without Reflectors] for 120 liters/hr

The heat absorbed by the Copper collector was observed to be higher as time increases . The outlet was gradually increased with around 4 °C to 8 °C for every hour. The maximum temperature obtained by 65 °C at the time of 12.30pm to 1.30pm, without reflectors for the rate of flow of water is 60 liter / hr. From figure 1.3 both the maximum temperature obtained by 51 °C at the time of 12.30 to 1.30 pm without reflector for the rate of flow of water is 120 liter/hr. This is good expected outlet temperature for good sunny days. The maximum temperature of the copper collector was observed to be increasing at minimum amount of inlet water flow 60 liter/hr. The lowest outlet temperature is while obtained for both 60 liter/hr and 120 liter/hr at 3.30pm to 4.30pm.

1.4 Time Vs Water Temperature [With Reflector]

The detailed analysis of Bin model Solar instant water heater is studied with suitable reflectors and the various measurements like inlet and outlet water temperatures are measured for the flow rate of 60 liter/hr and 120 liter/hr. The collected data brought out for different scale conditions. To compare the day long performance with different scale situation, an important inlet conditions is necessary. Hence, the hourly variations of output on typical analysis is shown in the Fig.1.4 both The experimental validation of inlet and outlet with reflectors are indicating parameters is done by a graphical study. The below Fig.1.4 indicates the variation of water outlet temperature with inlet temperature.

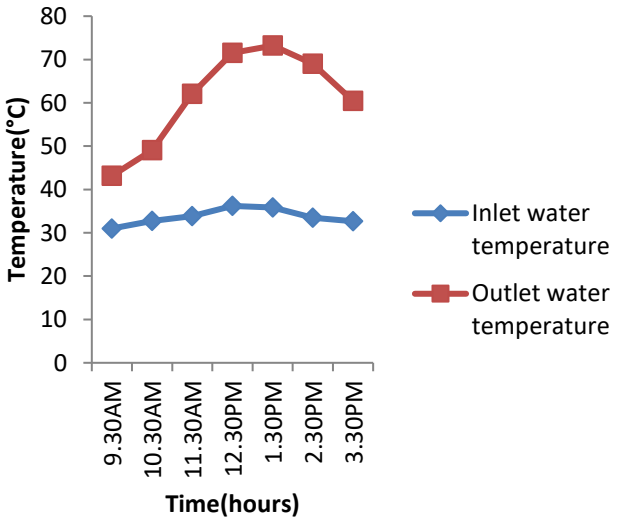

Fig. 1.4(a)Time Vs Water Temperature [With Reflector] for 60liters/hour

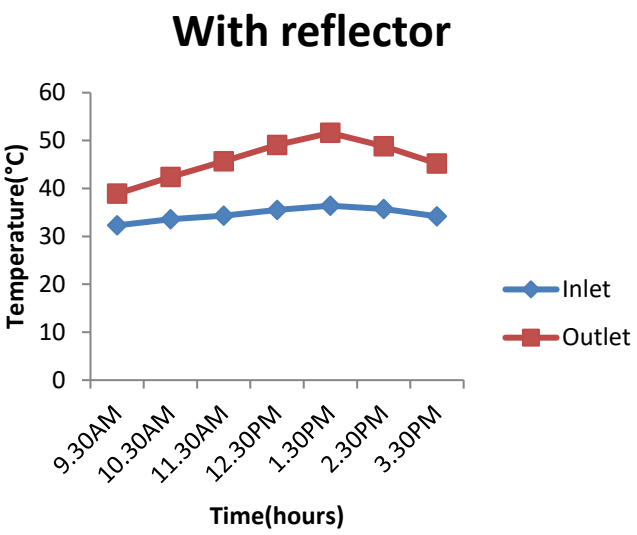

Fig. 1.4(b) Time Vs Water Temperature [With Reflector] for 120 liters/hr

The water inlet temperature has been observed around 30°C to 35°C commonly in the entire experimental work at average. This temperature is directly related to solar radiation level. If the inlet of the system is considerable, the rise in outlet temperature is by an every hour limited at 4 °C to 12 °C rising temperature is credible flow rate that is 1 liter per 1 minute. The effect of outlet water temperatures depends upon collector system. The maximum outlet temperature was observed by 76°C on high intensity climatic conditions. While the lowest outlet temperature was obtained at 59°C at evening time for flow rate of 60 liter/hr. The maximum temperature is 59 °C for 120 liter/hr. The lowest outlet temperature is while obtained for both 60 liter/hr and 120 liter/hr at 3.30pm to 4.30pm.

1.5 Time Vs Copper plate Temperature [With &Without Reflectors]

The performance of the bin model solar instant water heating systems depends largely on the performance of copper plate collector and particularly important for researchers to know how well a copper plate performed. The measurements of copper plate efficiencies has been shown to require temperature sensors if it is to be performed accurately. The obtained results are suitable standards for the bin model solar instant water heater.

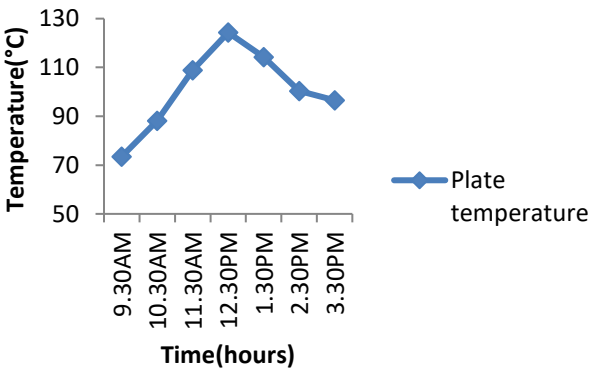

Fig. 1.5 Time Vs Copper plate Temperature [With Reflectors]

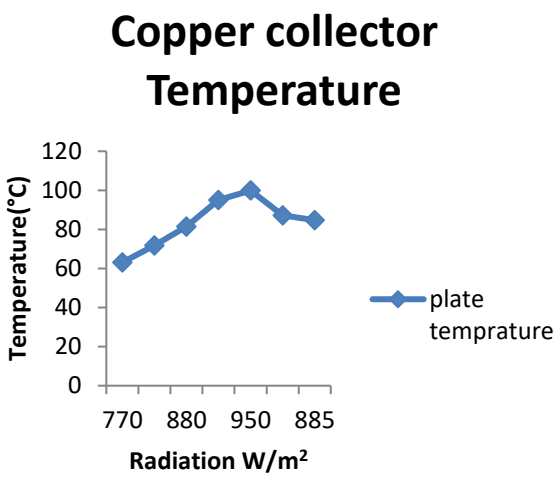

Fig. 1.6 Time Vs Copper plate Temperature [Without Reflectors]

To study the copper plate temperature in bin model solar water heater system operation, experiments were conducted during the time period 9.30 am to 3.30 pm. The variation of copper plate temperatures of absorber plate during sunny days is shown in above figure. The measured highest value is noted around 12.30 to 1.30.The performance of maximum radiation absorption, that is the maximum copper plate temperature achieved was studied separately with and without reflectors along with water load. The above Fig.1.6 shows the Time Vs radiation Vs copper plate's maximum temperature with and without reflectors. From the graph it is concluded that we obtained the maximum temperature of **127°C** with reflectors **110°C** without reflectors between the time 12.30 to 1.30 pm for the water flow rate of 60 liters/hours. From the above results it is concluded that if the copper collector temperature reached to **127°C.** We received the water outlet temperature of 76°C for 60 liters/hour flow rate and 59°C ,120 liters/hour flow rate. It may due to fast heat transfer directly to the water area. Since our design is a unique characteristics as the collector area is equal to heat transfer area to water, even with low temperature obtained as 127°C for collector temperature, the maximum heat transferred to water[5-7].So we received the maximum temperature of 76°C for 60 liters/hour flow rate and 59°C 120 liters/hour flow rate. The effect of wind speed on instantaneous efficiency as we are resulted lightly affect the bin model solar systems efficiency decreased with increased wind speed. This is due to overall little heat loss occurs surroundings of bin model solar instant water heater. Effect of wind speed is around 3 to 4.5 km/h. This small variation may affect little amount the efficiency of copper collector with respect to wind speed.

A. Determination of Efficiency

The efficiency of the bin model solar instant water heater is calculated by using the below equation for the flow rate of60 liters / hour, 120 liters/hour separately. The time taken for water flow calculated by using equation of continuity. The water outlet temperature for 120 liters/hour flow rate as peak value at 59°C, is low value compared to the peak value as 76°C for 60 liters / hour flow rate, this is

due to receiving double the amount of water outlet in same time, so efficiency achieved as 77%.

The 60 liters/hour and 120 liters/ hour flow rates concluded due to increasing flow rate the efficiency raises nearly double the value. It is high output even though the raise in water temperature as 59°C at peak time. So, this bin model solar instant water heater is suitable for 120 liters/ hour flow rate to achieve nearly 60°C at peak time. This output will give more energy saving criteria for home and industrial sectors. The collector efficiency is measured by the input-output method, it consists in letting the collector warm up during all the day, each hour, we measure the water temperature on three levels (low, medium and high) and the incidental solar flux.

$$\text{Efficiency} \qquad \eta = \frac{m.C_p.\Delta T}{S.\Sigma IN.\Delta t}$$

With:

m: mass of water, C_P: specific heat of water, S: absorber surface.

Δt-time taken for water flow

IN: incidental solar flex

ΔT-Temperature difference between inlet and outlet water.

Efficiency $\eta = 41\%$ for 60 liter / hour

Efficiency $\eta = 77\ \%$ for 120 liter / hour

Efficiency for the flow rate of 60 liter/hour is calculated, its value is 41% and for the flow rate of 120 liters / hour is determined value is 77%. The efficiency calculated for the maximum intensity of the solar radiation at 1.30 pm. The experimental results are in below table.

Table-I: Experimental results in tabular form

Time in hours	Radiation W/m²	Water temperature °C (without reflectors)	Water temperature °C (with reflectors)	Copper plate temperature °C	Efficiency in %
9.30 am to 3.30 pm	786 without reflectors	65	76	127 with reflectors	41 % for 60 liter / hour
	1490 with reflectors	51	59	110 without reflectors	77 % for 120 liter / hour

IV. CONCLUSION

The bin model solar instant water heater setup was applicable for domestic and larger industries, particularly for rural areas. Our Bin model solar instant water heater does not need storage tank, and the sun tracker, it is an instant water heater type. The main research aim is to analyzing the performance of this system like efficiency, heat harvesting region in system, reflecting area increases, wind velocity analysis, angle, water flow, temperature factors, energy savings and developments. Efficiency of the system decreases slightly with the increase of wind velocity due to small heat loss in encircles. Bin model solar instant water heater is converting 60 liters / hour, normal water into hot water at 76°C maximum temperature and for 120 liters/hour flow rate the maximum temperature obtained as 59°C. Bin model solar instant water heater was examined at 9.30 to 3.30pm each and every day continuously in 30 days. It is determined that the simple system but given more efficient during good climatic conditions obtaining hot water continuously in long time sessions. The solar radiation has received 1490 W/m^2, when adding reflectors, and without reflectors it is around 1020 W/m^2.

- The bin model solar instant water heater has been constructed successfully and the performance of the water heater also studied with various parameters.
- The unique characteristics of this bin model solar instant water heater is heat transferring area to water equal to heat harvesting area.
- The following overall conclusions determined for the work presented in this thesis. The bin model setup was applicable for domestic and larger industries, particularly rural areas. This Bin model solar instant water heater does not need storage tank, and the sun tracker, it is an instant water heater type.
- The solar radiation has achieving 1490 W/m^2, when adding reflectors, we have 470 W/m^2 are increased. The converted and consolidated solar radiation obtained is 1490 W/m^2.
- The position for reflectors with the effect of angle relation of time, between 12.45pm to 2.30pm, received the maximum yield radiation at the range of 45° angle with increase of above 40% of reflecting radiation along with direct radiation.
- Efficiency of the system decreases slightly with the increase of wind velocity due to small heat loss in encircles. Effect of wind speed is around 3 to 4.5 km/h. This speed may give small variation in the efficiency of copper collector.
- The maximum temperature of copper plate is 127°C with reflectors 110°C without reflectors achieved between 12.30 to 1.30 pm of a good sunny day.
- Bin model solar instant water heater was examined at 9.30 to 3.30pm each and every day continuously in 30 days. The system achieved maximum temperature of 76°C for 60 liters/ hour flow rate and 59°C for 120 liters / hour flow rate at the time of 12.30 to 1.30pm in sunny days.
- The efficiency of the bin model solar instant water heater is calculated and the value is 41% (maximum) for 60 liters/hour water flow rate and 77% (maximum) for 120 liters/hour water flow rate.

This system helps to reduce electricity cost in solar water heating needers. It is determine that the simple system but giving more efficient during good climatic conditions obtaining hot water continuously in long time sessions. This bin model solar instant water heater is environment friendly, simple maintenance. In our modern world most of the hot water requirements are in schools, hospitals, hostels, colleges, in that area these needs can be met through our Bin model solar instant water heater.

FUTURE WORK

If we want to increase the efficiency and more hot water from of this system, we have to increase the size of the collector area from (1 m x 1m) to (2 m x 1 m) or (2 m x 2 m) with the same construction materials.

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