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Development And Experimentation Of Cost Effective Parabolic Solar Concentrator

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Abstract

This paper present an overview of the use of solar energy for heating medium and exchange heat to the utility. The result of the preliminary research to develop a cost effective parabolic solar concentrator for heating medium using solar energy. The amount of heat gain in the concentrator is 8316KJ/kg. The amount of heat gain in the utility is 3930KJ/kg.

The efficiency of the solar concentrator is 55% and the effectiveness of the heat exchanger is found to be 0.6. The result obtained indicates that the system have the potential to exchange heat to the utility to meet the requirement.

The main objective of this attempt is to replace the total dependence on fossil fuel energy to the solar energy. To overcome the problem of electricity in rural area this system is developed for the pasteurization of the milk

Introduction

Energy is the basic need of human being in modern society. The primary energy resources available have been used since past to convert then in to useful form of energy. The proper use of energy resources requires consideration for technology and social impact with its economical growth as well as quality improvement. The use of fossil fuel have created serious environmental problems and pollution, which is now and will in the future lead to undesirable consequences such as the depletion of the ozone atmospheric layer, water, and air pollution and global warming.

These problems have promoted numerous attempts and research that will lead to the utilization of alternative green sustainable energy sources. These sources such as wind energy, solar heat, energy form sea waves etc, exist in adequate quantities, environmentally safe [1]. Solar energy is rich, green, safe and low cost comparing with conventional energy sources. It is used widely as well as grown constantly for power generation, heating water supply to variety of solar power plant. Solar water heaters are common in daily life making use of solar energy devices, which use collectors to absorb sunlight, convert light to energy and store hot water in storage tank by the insulation.

Solar water heater collector orientation and inclination angle of the water heating performance has an important effect, because the collector will directly affect the direction and angle of the collector can receive astronomical amount of radiation. By adjusting the position and angle of collector is the key to improve the efficiency of water heating [2].

Rural electrification is still incomplete due to electrical constraints and practical difficulty in electrical power transfer to remote rural areas through grid connectivity which are usually form conventional sources. Rural electrification can be achieved predominantly if one harnesses the locally available renewable sources, namely, bio-mass, biogas and solar power. Exploiting these resources will eliminate the requirement of electricity transfer to remote rural areas and improve living standards and also ensure a clean environment. These non-conventional or renewable sources of energy can supply of in some cases more than meet the demand, without creating environmental hazards. So, this option is more suitable to cater to the problem of rural energy requirements, as these sources are abundantly available in rural areas in India[3]. The intermittent nature of energy and the energy requirements of buildings necessitates the storage of thermal energy. Most solar energy storage systems use sensible heat storage (SHS), though using latent heat storage (LHS) systems have been considered too. There are many types of SHS for different applications. Water or stones usually are used in low temperature solar energy systems. In some technologies thermal storage in sand bed with working fluid of air has been used. Concrete is a suitable medium for heat storage in passive solar energy houses[4].

Experimental Set Up

Present device is capable to convert the abundant low grade solar energy in to high grade solar energy by concentrating beam radiation, at small segment of outer tube curvature. The system consists of parabolic collector, concentrator with lenses, heat exchanger, temperature sensors.

concentrator with lenses for absorbing the radiations heat exchanger exchanges the heat to the utility Pump for recirculation of medium. Thermocouple for measuring temperature at various points.

Specification

Collector

length=1000mm

height=260mm

width=930mm

collector reflector material = magnifying glass,aluminum sheet

concentrating pipe =copper pipe

lens diameter=50mm

Heat exchanger

shell and tube heat exchanger

length=330mm

coil length=320mm

diameter=210mm

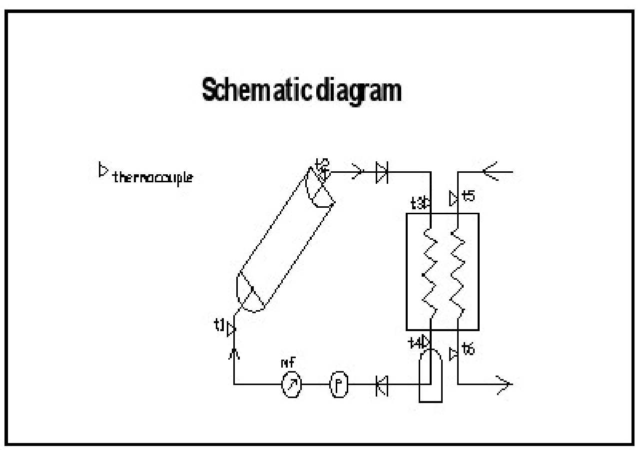

Figure.1:Schematic diagram showing experimental setup

Experimentation

The following parameters were measured. Temperature at various point with temperature indicator efficiency of the solar concentrator by observations and calculations effectiveness of the heat exchanger heat gain at the utility.

The sunrays incident directly to the centre of concentrator. Keep valve open, fill the water in the pipe with the help of funnel. Start motor for 5 minutes to recirculation of medium throughout pipe. Take readings in the temp indicator with the help of thermocouple. After one hour again move the concentrator according to the sun & take readings at various points in the temperature indicator. Take each reading by moving concentrator according to the sun in every one hour, starts from 9.00am to 4.00pm., because sun moves by 15^0 for each hour.

Observation

Sr. no.	Time	Temperature (in ^{0}c)					
		T_1	T_2	T_3	T_4	T_5	T_6
1.	09.00 am	40	36	36	36	36	36
2.	10.00 am	40	54	44	49	48	54
3.	11.00 am	41	62	50	54	53	62
4.	12.00Noon	43	70	57	62	62	70
5.	01.00 pm	44	74	62	67	67	74
6.	02.00 pm	45	80	68	72	73	80
7.	03.00 pm	46	85	74	79	79	85
8.	04.00 pm	45	92	86	89	89	92

Table 1:Observation

Where,

T_1 – Atmospheric temp

T_2 – Heat exchanger inlet temp

T_3 – Utility outlet temp

T_4 – Heat exchanger outlet temp

T_5 - Concentrator inlet temp

T_6 – Concentrator outlet temp

Calculation

for efficiency of solar concentrator

$$\text{Efficiency} = \frac{\text{solar energy absorbed}}{\text{heat gain in the concentrator}} \times 100$$

Graph

For combined gain in temperature in concentrator and utility

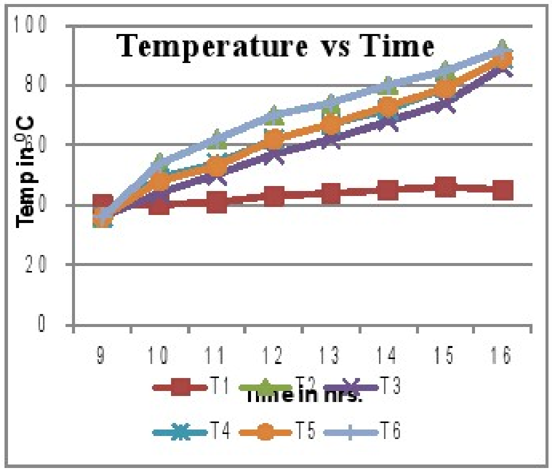

Figure 2:The combined graph for the utility temperature, concentrator temperature and atmospheric temperature

In the concentrator temp the temp rises by 6-7^{o}c each hour. Temp gain at the utility temp rises 4-5^{o}c. The temp obtained by the concentrator outlet at 12.00 noon is 62^{0}c and utility temp is 57^{0}c. Maximum temperature is shown at 4.00 pm, the concentrator outlet temp is 92^{0}c and utility temp is 89^{0}c.

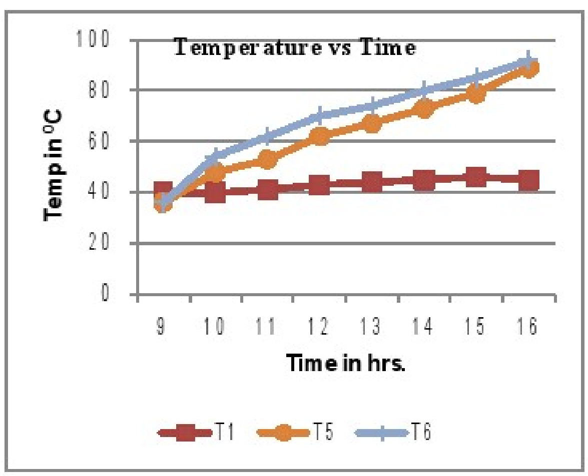

Figure 3:The combined graphs showing Temperature at T1, T5 and T6

The rise in temp T5 is less as compare to the temp. at T6. The difference between T6 and T5 is gain in water temperature passing through concentrator

Graph For Utility Temperature (Time vs temp)

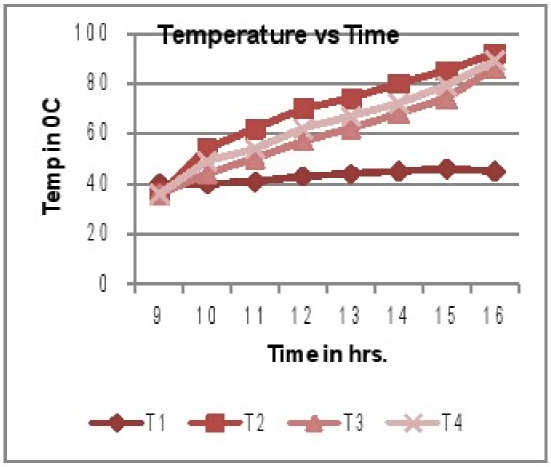

Figure 4:The combined graphs showing Temperature at T1, T2, T3 and T4

Fig. 4 shows the temperature T_4 is less than T_2. The difference between the T_4 and T_2 is the gain in temperature at utility. The fall in temperature T_4 as compare to the temperature T2 shows the gain in temperature at utility.

Energy Balance Equation And Efficiency Calculation

Energy Balance and mathematical modeling of the system is based upon following assumptions:

Total Aperture area A_a : Length of the collector X Curve portion of the collector

= 1.0 x 0.6

= 0.6 m^2

The solar constant is 1.367 kW/m^2 when measured at satellite station, but at the surface of earth

I_{sc} : 1.0 kW/m^2

All the lenses are focused at designed heat absorbing points all time.

No leakages and heat loss from the storage occurred.

No water is withdrawn during the experiment.

Let the efficiency of solar concentrator is : η

By equating the energy absorbed in the collector during the day to the enthalpy change of the water we have Solar radiation incident on the collector per unit area x No. of hours x 3600 x Aperture area of Concentrator x Concentrator efficiency $= I_{sc} \times 7 \times 3600 \times A_a \times \eta$

$= 1.0 \times 7 \times 3600 \times 0.6 \times \eta$

$= 15120\eta$ .....(i)

Heat gain in heat exchanger (utility) =

Q_{HE} =Mass of milk to be heated x Specific heat of milk x Rise in temperature

$= m_m \times Cp_m \times \Delta t_1$

$= 10 \times 3.93 \times 50$

= 3930KJ/sec .....(ii)

Heat gain in concentrator =

Q_{Conc} = Mass of water to be heated x Specific heat of water x Rise in temperature

$= m \times 4.186 \times \Delta t_2$

$= 10 \times 4.186 \times 198.66$

=8316KJ/sec ... (iii)

From equation (i) and (iii)

$15120\,\eta = 8316$

$\eta = 55\%$

The effectiveness of the heat exchanger,

$$\varepsilon = \frac{T_2 - T_4}{T_2 - T_3}$$

$$= \frac{92-72}{92-62}$$

$\varepsilon = 0.66$

Result And Disscussion

Fig. 1 shows the combined graph for the utility temperature, concentrator temperature and atmospheric temperature.

In the concentrator temp the temp rises by 6-7^{o}c each hour. Temp gain at the utility temp rises 4-5^{o}c.

The temp obtained by the concentrator outlet at 12.00 noon is 62^{0}c and utility temp is 57^{0}c.

Maximum temperature is shown at 4.00 pm, the concentrator outlet temp is 92^{0}c and utility temp is 89^{0}c.

Fig. 2 the rise in temp T5 is less as compare to the temp. at T6. The difference between T6 and T5 is gain in water temperature passing through concentrator

Fig. 4 shows the temperature T4 is less than T_2. The difference between the T_4 and T_2 is the gain in temperature at utility. The fall in temperature T_4 as compare to the temperature T2 shows the gain in temperature at utility.

For the system the energy absorbed in the collector during the day is found to be 15120η. The amount of heat gain in the concentrator is 8316KJ/kg. The amount of heat gain in the utility is 3930KJ/kg.

The efficiency of the solar concentrator is 55% and the effectiveness of the heat exchanger is found to be 0.6. The result obtained indicates that the system have the potential to exchanger heat to the utility to meet the requirement.

Conclusion

Where the electricity problem is faced like in rural area this device is used to pasteurize the milk. Solar energy is a good option than fossil fuel because fossil fuel like wood leads to pollute the environment and for this deforestization is take place. Hence solar energy is easily available and doesn't hazard to the atmosphere.

Reference

1. **Norlida Buniyamin** et al 'Low-Cost Solar Water Heater' 2011 International Conference on **Electronic Devices, Systems and Applications (ICEDSA), 978-1-61284-389-6/11/$26.00 ©2011 IEEE.**
2. **Deng Ji-**qiu et al 'The Optimal Installed Direction and Angle of Solar Collector' Central So**uth University Changsha, China, 978-1-4244-8039-5/11/$26.00 ©2011 IEEE.**
3. Amit Jain et al 'Sustainable Energy Plan for an Indian Village' 2010 International Conference **on Power System Technology, 978-1-4244-5940-7/10/$26.00©2010 IEEE.**
4. **Zaeem M. Moosavi & Hass**an Zohoor, 'Improving the Capability of Solar Thermal Energy Storage by Using a Hybrid Energy Storage System' 978**-1-4244-1888-6/08/$25.00 © 2008 IEEE.**
5. Solar Energy : 'Principles of Thermal Collection and Storage' by Dr. S.P.Sukhatme and Dr. **J.K.Nayak.**
6. **A te**xt book of 'NON-CONVENTIONAL ENERGY SOURCES,' by G.D. Rai.
7. A text book of 'NON-CONVENTIONAL ENERGY RESOURCES,' by S. Hassan Saeed & D. **K Sharma.**
8. A text book of 'NON-CONVENTIONAL ENERGY RESOURCES,' by S. K. Dubey & S. K. **Bhargav.**
9. Solar energy: 'Fundamentals and Applications' By Garg & Prakash, H. P. Garg