World Applied Sciences Journal 4 (6): 808-811, 2008
ISSN 1818-4952

Solar Geyser cum Distiller for Domestic Use

[1]S.H. Sengar and [2]A.K. Kurchania

[1]Deptment of Electrical and Other Energy Sources,
College of Agricultural Engineering and Technology, DBSKKV, Dapoli, Dist: Ratnagiri-415712
[2]Department of Renewable Energy Sources, College of Technology and Engineering, Maharana Pratap University of Agriculture and technology, Udaipur-313001

Abstract: Solar Geyser cum Distiller (SGD) device, having a capacity of 100 litre was designed and developed and its performance evaluation was carried out. Overall efficiency of SGD for winter and summer was found to be 36.70 and 27.48% respectively. The yields of distilled water were 5007 ml/m^2 day in winter and 5275 ml/m^2 day in summer respectively. The total cost of SGD device was Rs 8930.

Key words: Solar geyser . Solar distillation . Solar composite

INTRODUCTION

The first detailed study of the performance of the flat plate collector was made by Hottel and Woertz [1] later and modified by Tabor [2]. Many researchers have made performance evaluation as well as component wise studies. After that [3] studied the storage tank and two flat plate solar collectors integrated with basin type solar still. [4] too made extensive performance study of integrated solar water heater having solar collector and storage tank as separate unit.

SYSTEM DESCRIPTION

The SGD device consisted of a flat plate collector with net effective area was 2 m^2 shown in Plate 1. It was fundamentally based on two processes i.e. evaporation of water through the application of solar energy and subsequently condensation of vapors naturally and thus getting potable water.

The SGD unit consisted of solar collector (front glazing), metallic absorber, back insulation and collector box, insulated storage tank, water trough and piping. Water was heated with the solar energy and the same unit also distilled water. Evaporation took place from the water inside the storage tank that was heated through the solar collector. Conical cover (Plate 2) with cold water on the top of the storage tank was provided for maintaining the temperature difference for condensing the inside vapors of storage tank. This temperature difference produced convection currents in the air, which was trapped inside the enclosure. These currents brought the humid air into the contact with relatively cool cover and resulted in condensation of some of the humidity on the surface of cover. This condensation slid down the slope and collected in the distillation bowl (Plate 3) and drained out of the enclosure through the piping depicted in Fig. 1. The collector frame was mounted on steel angle bars, grouted on the roof having 40^0 inclinations from the horizontal, facing towards south.

EXPERIMENTAL OBSERVATION

The study was conducted in the month of February and April 2004. Temperature corrected electronic sensors with 0.1°C accuracy were used to measure the water temperature at different points of the SGCD. Insolometer was used to measure the instantaneous solar radiation on the surface of collectors. All measurements were made during the period of constant insolation.

PERFORMANCE CALCULATION

Solar water heater efficiency

$$\eta_{overall} = \frac{ms\,(Tf - Ta)}{\sum I\,A_p \Delta t} \qquad (4)$$

Where, $(T_f - T_a)$ is difference in temperature of water in the evening and ambient temperature at the subsequent morning, m is mass of water in storage tank, s is Specific heat of water, I is solar radiation, W/m^2 of aperture area, A_p is Aperture area, Δt is Time
Distillation efficiency

Corresponding Author: Dr. S.H. Sengar, Deptment of Electrical and Other Energy Sources, College of Agricultural Engineering and Technology, DBSKKV, Dapoli, Dist: Ratnagiri-415712

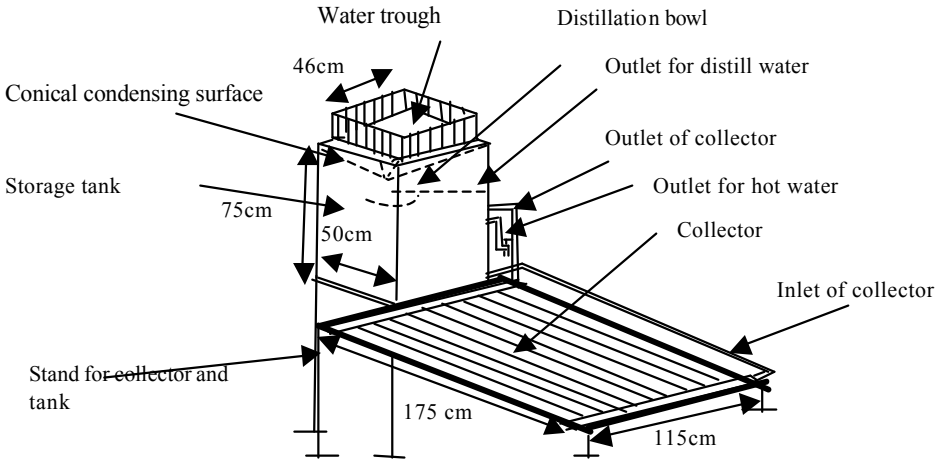

Fig. 1: Solar water geyser cum distillation

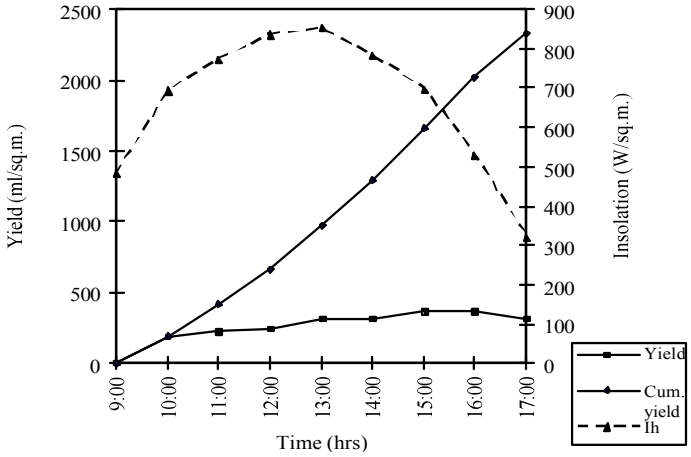

Fig. 2: Performance of SGD for distillation during winter

Table 1: Thermal performance of Solar Geyser (SG) in SGD for winter

Time (hrs)	Ambient Temp. (°C)	Inlet Temp. (°C)	Outlet Temp. (°C)	Storage Temp. (°C)	Insolation (W/m^2)	SG Efficiency (%)
9:00	22.81	32.23	38.56	37.00	234.00	
9:30	23.80	33.06	40.70	37.39	399.33	
10:00	24.00	33.75	43.31	34.95	415.00	
10:30	24.13	34.33	49.65	36.99	535.18	36.70
11:00	25.14	34.31	43.15	38.75	586.91	
11:30	26.19	34.95	42.66	40.47	638.82	
12:00	26.99	35.78	45.41	41.88	697.91	
12:30	27.45	36.53	49.13	42.63	713.82	
13:00	28.27	38.21	49.80	44.75	733.27	
13:30	28.27	39.95	51.56	46.35	711.00	
14:00	28.52	41.11	52.83	46.72	680.00	
14:30	28.79	42.75	53.91	47.69	630.00	
15:00	28.47	44.00	56.41	48.29	547.91	
15:30	27.69	44.93	58.50	48.59	494.27	
16:00	26.15	45.75	60.33	48.50	407.00	
16:30	25.09	46.33	59.00	48.00	290.10	
17:00	24.05	46.91	53.75	48.00	182.55	

Plate 1: Solar geyser cum distillation unit

Plate 2: Conical water trough

Plate 3: Bowl inside storage tank

$$dist = \frac{Q_e}{Q_t} \quad (5)$$

Where

Q_e = Me x f

Me = Daily output of distilled water in kg $m^{-2}day^{-1}$

f = Latent heat of vaporization of water in Wkg^{-1}

Q_t = Energy available, Wm^{-2}

RESULTS AND DISCUSSION

Experimental observations have been shown in Table 1. Variation of solar radiation on collector surface during the measurement period was noted as 234-734 W/m^2 on 12 February 04 and 451-860 W/m^2 on 12 April 04 respectively. Overall efficiency of SGD for winter and summer was found to be 36.70 and 27.48% respectively. Temperature coming out from tank was 15-20°C more than the ambient temperature. Total distilled water in 24 hours produced from SGD in February 2004 and April 2004 were 5007 ml m^{-2} day^{-1} and 5275 ml m^{-2} day^{-1}. During winter, the temperature in water trough decreased while the temperature inside storage tank was more due to insulation but in summer temperature in water trough was more due to more ambient temperature. Hence there was more condensation in February and consequently distillation was also more. The output of the SGD was greater in February as shown in Fig. 2.

ELECTRICAL ENERGY SAVED

Calculation of the electrical energy, saved by the SGD, was made during the observation. Temperature of cold water in storage tank rose by about 24°C, which showed that the total gain in heat was about 3.02 kWh (6) and 3.40 kWh energy was required to evaporate the 5.17 kg of water. If electricity unit charge was taken as Rs. 3.00, then the cost of unit equivalent of electrical backup would be Rs. 19.00. Hence per day saving of SGD would be Rs. 19.00.

CONCLUSIONS

The maximum temperatures of hot water in winter and summer were 48.68 and 52.28°C respectively.

The yield of distilled water in SGD device was found 5007 ml m^{-2} day^{-1} in winter and 5275 ml m^{-2} day^{-1} in summer.

Composite unit performed well and per day savings of SGD was observed as Rs.19.

ACKNOWLEDGEMENTS

Authors are highly thankful to Ministry of Non-conventional Energy Sources for providing the financial

assistance to carry out the research work. They are also thankful to the Department of Renewable Energy Sources, College of Technology and Engineering, Udaipur for providing all sorts of required facilities for the study.

REFERENCES

1. Hottel, H.C. and B.B. Woertz, 1992. Performance of flat plate solar heat collectors. Transaction of the American Society of Mechanical Enginering, 64: 91 Journal of Energy Research, 16 (5): 365-372.
2. Tabor, H., 1958. Radiation, Convection and conduction coefficients in solar collectors. Bulletin of research Council of Israel, 6C: 155.
3. Tiris, C., M. Tiris, Y. Erdalli and M. Sohmen, 1999. Experimental studies on a solar still coupled with a flat plate collector and a single basin still. Teri Information and Energy Digest, Vol: 9 (3).
4. Singh, P., S.S. Dhaliwal and Singh Sukhmeet, 2004. Evaluation and development of integrated solar water heater. Annual Report-2002-2003, Thirteenth annual workshop at spreri vallabh vidya Nagar, Gujarat, January 7-10, 2004-IV1-IV14.
5. Sinha, S., G.N. Tiwari and M.S. Sodha, 1992. Techno-economic analysis of solar distillation system. International Journal of Energy Research, 16 (5): 365-372.
6. Garg, H.P., P. Avanti and G. Datta, 1998. Development of monogram for performance prediction of Integrated Collector Storage (ICS) solar water heating systems. Renewable Energy: An International Journal, 14 (1-4): 11-16.