

Design and Development of Wire Mesh Type Solar Air Heater Unit

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Abstract

The Wire mesh type solar air heater is constructed and investigated experimentally for thermal efficiency. The highest daily solar radiation obtained at 12.30 p.m. which was 780 W/m^2 . At the mass flow rate of 0.00811 kg/s . The highest ambient temperature was obtained at 1.00 p.m. i.e. 33.4°C . In general, the input temperature was found to be increasing from the morning to afternoon and then it is decreasing with little fluctuation during evening. The maximum temperature difference ΔT was 40°C at 2.00 p.m. The maximum efficiency i.e. 82.81% was achieved at ambient temp. of 31.3°C during the time of 1.30 p.m. with solar radiation of 658 W/m^2 .

Keywords: Solar Air Heater, Solar Radiation, Thermal Efficiency, Mass Flow Rate

I. INTRODUCTION

Solar energy is available freely, and an indigenous source of energy provides a clean and pollution free atmosphere. The simplest and the most efficient way to utilize solar energy are to convert it into thermal energy for heating applications by using solar collectors. Solar air heater is a device which converts solar energy in to heat energy. Solar air heaters, because of their inherent simplicity are cheap and most widely used collector devices. Solar air heaters are being used for many applications at low and moderate temperatures. Some of these are crop drying, timber seasoning, space heating, etc.

The air heater absorb large amount of heat energy and converted into hot air and this air is used for many purposes like Environment degradation. With use of fossil fuels is a danger to life in this earth. In view of world's depleting fossil fuel reserves and environmental threats, development of renewable energy sources is important. Among many renewable energy sources, solar energy is huge energy source for meeting the demand. The large amount of area is available for solar energy. The purpose of this research is to design a solar air heater to heat the air, a system that is relatively cheap, portable and depends only on renewable solar energy.

II. MATERIALS AND METHODS

A. Experimental Location:

Talsande has diverse climate. It is exceptionally hot and dry during summer with temperature reaching as high as 40°C . Talsande receives about 1140 mm rainfall during monsoon, which is followed by pleasant temperature in winter. Talsande is situated at Latitude: $16^\circ 51' 46.2672'' \text{ N}$ and Longitude: $74^\circ 14' 19.77'' \text{ E}$ and Altitude of 605 m above sea level.

III. COMPONENTS OF SOLAR AIR HEATER

A. Cover Plate:

The passage from where irradiation occurs on the surface of basin is top cover. The glass used having thickness of 4mm and size is $1000 \times 550 \text{ mm}$.

B. Insulation:

For a proper insulation the silicon glue was used to stop the leakage of hot air.

C. Duct:

Duct is the part of the system in which the air is to be heated. It is therefore essential that it must absorb solar energy. Hence it is necessary that, the material have high absorptivity and very less transmissivity. The material used for duct was galvanized iron and it was black painted to increase its absorptivity. The area of the basin was 1000×550×150 mm.

D. Wire Mesh:

Wire mesh is the main part of the system which absorbs the solar radiations and heats the air. Wire mesh is placed in duct above bottom insulation and below glass cover. Wire mesh, i.e. wire diameter 0.795 mm, pitch 2.50 mm and 2 numbers of layers.

E. Blower:

It is just like a small fan consists of 5-6 blades having low rpm. Its purpose is to suck & circulate the air in proper manner. It also used for exhaust purpose. The hot air from the wooden box is exhaust to dryer.

F. Solar Photovoltaic Panel:

The solar panel is used to run the blower fan. The 12 Volts solar panel is to be used.

G. Air Outlet:

To convey hot air from the air heater.

H. Air Inlet:

To allow the air to flow in air heater duct.

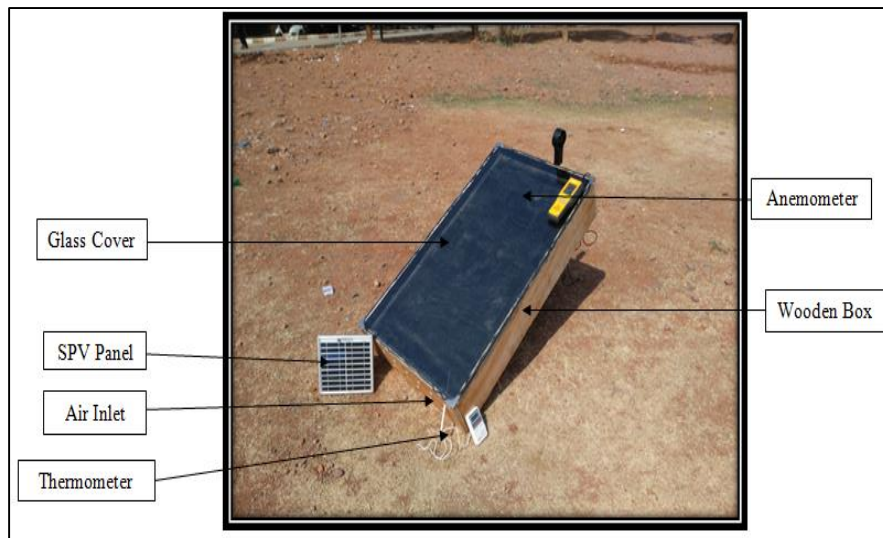


Fig. 1: Plate No. 1.1(a): Experimental Setup of Wire mesh type solar air heater

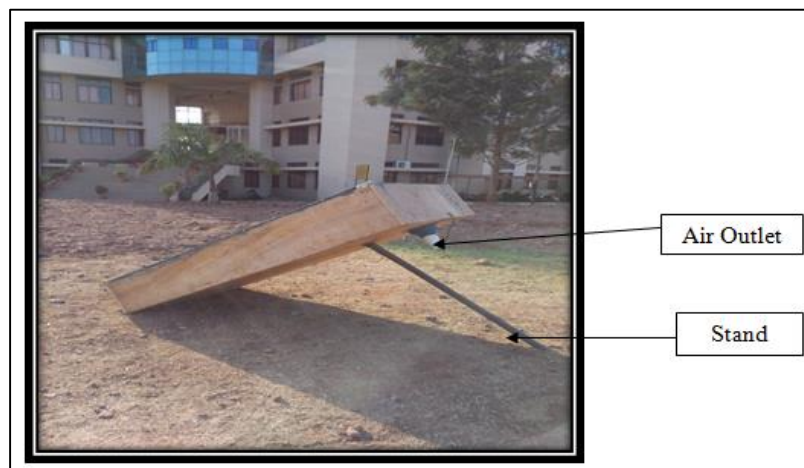


Fig. 2: Plate No. 1.1(b): Experimental Setup of Wire mesh type solar air heater

IV. INSTRUMENTATION AND PARAMETER MEASUREMENT

The following parameters was measured before and after during evaluation / testing period.

- 1) Initial temperature of air, °C
- 2) Ambient temperature, °C
- 3) Solar radiations
- 4) Temperature of air inside and outside of the air heater.
- 5) Wind velocity, km/ hr
- 6) Final air temperature
- 7) Humidity

A. Determination of Efficiency of Solar Air Heater:

The useful gain by the solar collector to solar radiation with measured values of fluid inlet (Ti) and outlet temperature (To) and the fluid mass flow rate (m) is given as follows

$$Q_u = m \times C_p \times (T_o - T_i)$$

$$\eta = \frac{Q_u}{S \times A_c} \dots \dots \dots \text{(Dr. R. P. Sharma et.al 2012)}$$

Where, Ac is the area of the collector, S is the solar radiation incident on the collector.

V. RESULT AND DISCUSSION

The performance analysis of the solar air heater is done experimentally. Results are summarized in Table 1. The performance analysis of the wire mesh type solar air heater is done experimentally in the Talsande. The thermal efficiency of the solar air heater with wire mesh layers as absorber plate and small duct of diameter 4 cm, at different mass flow rates is studied. The mass flow rate of the air was varied from 0.00426 to 0.00811 kg/s.

The solar radiation versus time is shown in Fig 3. The highest daily solar radiation obtained at 12.30 p.m. which was 780 W/m². At the mass flow rate of 0.00811 kg/s. The mean solar intensity is calculated and it is found that all mean averages are within the close range and it shows that a stable amount of solar radiation measured. The average solar radiation intensity of experiment was about 587.9 W/m².

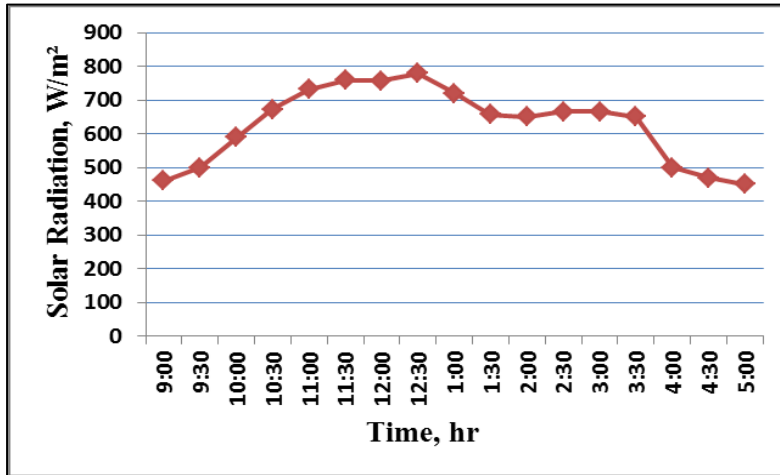


Fig. 3: Solar Radiation Vs Time

The ambient temperature, versus time of the day in which the experiment was carried out is presented in Fig. 4. Variations of ambient temperature were found in between 26°C to 33.4°C. The highest ambient temperature was obtained at 1.00 p.m. i.e. 33.4°C. In general, the input temperature was found to be increasing from the morning to afternoon and then it is decreasing with little fluctuation during evening. The temperature differences, ΔT = Tout - Tin, versus time of the day are depicted in Figure 5. The maximum temperature difference was found to be 42°C at 12.30 p.m. The temperature difference was increasing from morning to a peak value at noon and then was decreasing in the afternoon until sun sets, in a similar manner as the solar radiation. The maximum temperature difference was about 40°C at 2.00 p.m.

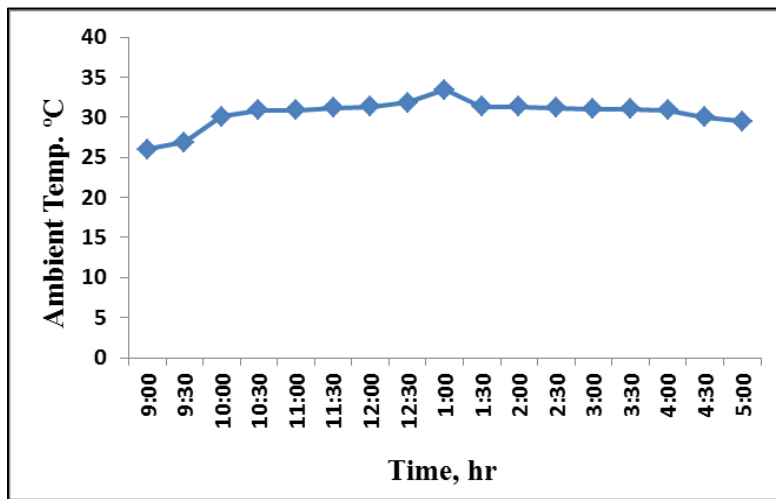


Fig. 4: Ambient Temp. Vs Time

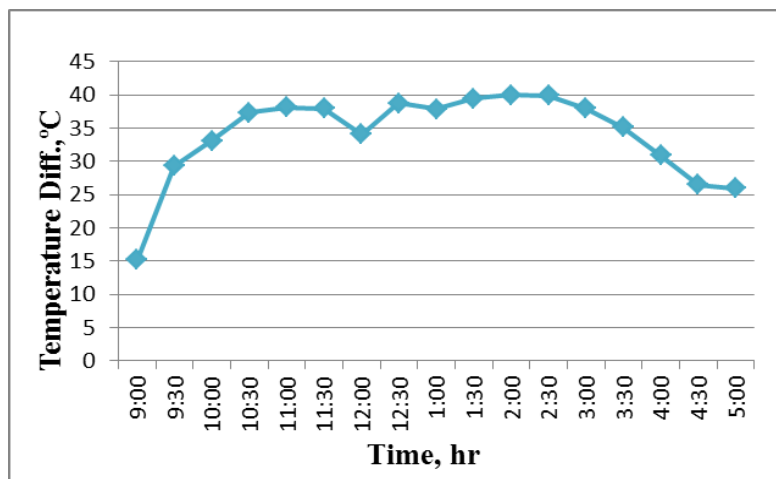


Fig. 5: Temp. Difference Vs Time

Efficiency versus time of the day at different solar radiation of the wire mesh air heater is shown in Fig. 6. The efficiency for most of the cases was found to be increased with the standard local time of the day from morning until 13:30 p.m. with slight decrease in the afternoons. The average efficiency for the wire mesh type solar air heater is 64% at the mass flow rate of 0.0064 kg/s. Generally the thermal efficiency increased as the air mass flow rate was increased.

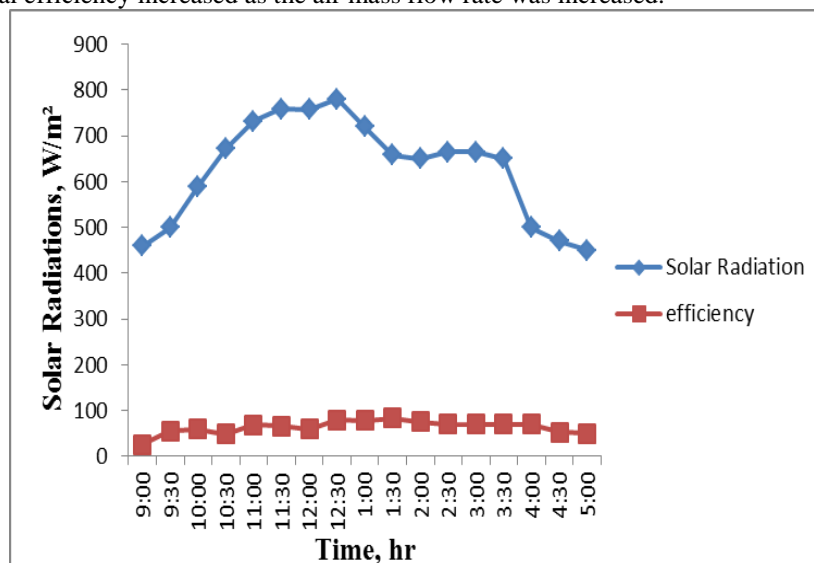


Fig. 6: Efficiency Vs Time of the day at different solar radiation

Table – 1
Experimental Data for the Performance of the solar air heater:

Sr. No.	Time, hr	Temp of air, °C		Ambient Temp. of air, °C	Air Velocity, Km/hr	Solar Radiation, W/m ²	Humidity, %	Velocity at Duct, m/s	Mass Flow Rate, Kg/s	Efficiency %
		Inlet	Outlet							
1	09:00	36.0	51.2	26.0	2.4	460	62	2.77	0.00426	25.71
2	09:30	37.1	66.4	26.9	5.0	500	60	3.32	0.00511	54.69
3	10:00	40.9	74.0	30.1	8.2	590	59	4.15	0.00477	58.84
4	10:30	41.5	78.9	30.9	8.0	672	55	4.15	0.00477	48.48
5	11:00	42.0	80.2	30.9	7.0	732	51	4.70	0.00723	68.92
6	11:30	44.3	82.3	31.2	7.5	759	50	4.70	0.00723	66.13
7	12:00	44.3	78.4	31.3	5.5	758	46	4.70	0.00723	59.41
8	12:30	40.3	82.2	31.8	7.0	780	45	5.27	0.00811	79.50
9	01:00	41.3	81.2	33.4	7.2	720	45	5.00	0.00769	77.86
10	01:30	41.0	80.5	31.3	5.0	658	47	4.98	0.00766	82.81
11	02:00	40.1	80.1	31.3	10.0	650	48	4.72	0.00726	75.79
12	02:30	40.0	79.9	31.2	10.5	665	48	4.15	0.00638	70.00
13	03:00	39.8	77.8	31.0	6.5	665	49	4.15	0.00638	70.00
14	03:30	39.3	74.5	31.0	7.5	650	50	4.15	0.00638	70.10
15	04:00	35.5	69.4	30.9	10.5	500	52	4.15	0.00638	70.02
16	04:30	37.0	63.5	30.0	8.0	470	53	3.32	0.00511	52.16
17	05:00	36.0	62.0	29.5	9.0	450	55	3.04	0.00467	49.29

A. Efficiency of Wire Mesh Type Solar Air Heater:

The useful gain by the solar collector to solar radiation with measured values of fluid inlet (Ti) and outlet temperature (To) and the fluid mass flow rate (m) is given as follows

$$Q_u = m \times CP \times (T_o - T_i)$$

Where CP is the specific heat of the air. The density of the air was assumed to be constant i.e 1.225 Kg/m³.

The efficiency of the collector is given by the formula,

$$\eta = Q_u / S \times A_c$$

The maximum efficiency i.e. 82.81% was achieved at ambient temp. of 31.3°C during the time of 1.30 p.m. with solar radiation of 658W/m².

VI. CONCLUSION

From the graph, we can conclude that the highest daily solar radiation obtained at 12.30 p.m. which was 780 W/m². At the mass flow rate of 0.00811 kg/s. The highest ambient temperature was obtained at 1.00 p.m. i.e. 33.4°C. In general, the input temperature was found to be increasing from the morning to afternoon and then it is decreasing with little fluctuation during evening. The maximum temperature difference ΔT was 40°C at 2.00 p.m. The maximum efficiency i.e. 82.81% was achieved at ambient temp. of 31.3°C during the time of 1.30 p.m. with solar radiation of 658W/m².

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