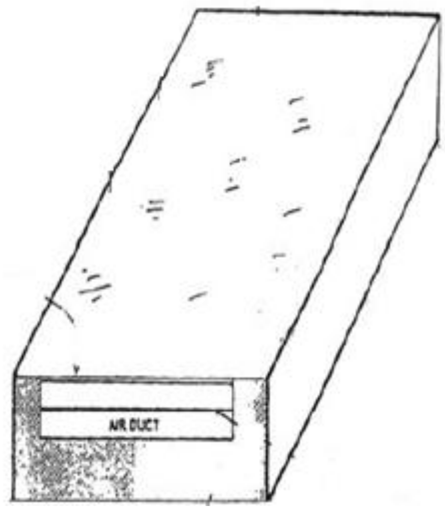
Insight Solar



Experiment Manual
Solar Air Heater

Ecosense Sustainable Solutions Pvt Ltd,C-131, Flatted Factory Complex,Okhla Phase 3, New Delhi – 110020Tel: 011 46016794
Email:info@ecosenseworld.com

Theory

In general, solar air heaters are flat-plate collectors (FPCs), consisting of absorber, a transparent cover and insulation. In most cases, solar air heaters are operated in the open-loop mode.
The performance of solar air heaters is mainly influenced by meteorological parameters such as direct and diffuse radiation, ambient temperature, wind speed etc. and design parameters like type of collector, collector materials. It also depends upon flow parameters like air flow rate and mode of flow. The principal requirement of a solar air heater is a large contact area between the absorbing surface and the air.
Rigorous heat transfer method can be used to analyze the performance of a solar air heater. However in this manual we are covering the simple instantaneous thermal efficiency formula for the said purposes.

The instantaneous thermal efficiency of the collector is given as

$$\eta_t = \frac{\dot{m} c_{air}(T_{fo} - T_{fi})}{A_{ap} I_t} \quad (1)$$

Where,
$\dot{m}$: Air mass flow rate through collector (kg/sec)
c_{air} : Specific heat of the air (J/kgK)
T_{fo} : Temperature of the output air (^{0}C)
T_{fi} : Temperature of the inlet air (^{0}C)
A_{ap} : Collector aperture area (m^2)
I_t : Radiation falling on the collector (W/m^2)

Experimental setup:

The experimental setup has been design to analyze the performance of a solar air collector in natural and force mode of air flow.
The dimensions of the collector used in the experimental setup are 1m length 1 m width. The inlet of the collector is an open structure whereas special arrangement has been made in the out let of the collector. To generate the force mode of operation some fans are mounted in the outlet of the collector.
To measure the inlet and outlet air temperature, temperature sensors are there in the respective position. Digital meters are there to read the output of the temperature sensors. Special arrangements have been made in the outlet side of the collector to measure the air flow rate. Instruments such as hot wire anemometer, radiation meters are also supplied with the system to determine the air flow rate and radiation level respectively.

Specifications of different component:

Component	Specifications	Remark
Solar air collector	Dimension: 1 m^2 Aperture area : 0.912 m^2 Air duct area: 0.037m^2	The aperture area is used in the efficiency calculation
Radiation meter	Range: 0 to 1999 W/m^2 Power supply: DC	To measure the radiation level receives by the still
Thermometers	Sensor: Class A sensor Range: -200 to 650 ^{0}C Accuracy : ± 0.15 +0.002*(t) Where t is absolute value of temperature in deg C Display: Range -100 to 200^{0}C Supply Voltage: 230AC	Sensor is RTD based platinum probe. Works on the principle of variation of resistance with temperature. To measure the air temperature at the inlet and outlet of the collector
Hot wire anemometer	Flow rate: actual velocity is a function of actual velocity and duct size. Velocity range: 0 to 30 m/sec	To measure the air flow rate at the outlet of the collector
Fan	4 ac fans Size: 120*120*38mm Power: 18/17 W Air flow: 95/102cfm	To produce the force mode operation

Experiment No. 1

Performance evaluation of a solar air heater in natural mode of air flow

Methodology:

1. Placed the system under the open sky in the morning 6 o'clock
2. Start the observation around 7 o'clock
3. Measure solar radiation by using the radiation meter at different location of the collector after every hours
4. Note all the reading shown by the meters
5. Measure the air flow rate by using the hot wire anemometer
6. Repeat the above steps after every hours

Observation:

Table -1: Experimented values of different parameters during natural mode of air flow

Time of the day	I_t $(\frac{W}{m^2})$	T_a(^{0}C)	T_{fi}(^{0}C)	T_{fo}(^{0}C)	Air flow rate $(\frac{m^3}{sec})$			
					1	2	3	4
7:00								
8:00								
9:00								
10:00								
11:00								
12:00								
13:00								
14:00								
15:00								
16:00								
17:00								
18:00								

Calculation:

Calculate the instantaneous efficiency of the collector by using the equation (1) for every hour

Table-2: Calculated results of solar air heater in natural mode of flow

Time of the day	Air flow rate $(\frac{m^3}{sec})$	Density $(\frac{kg}{m^3})$	Air mass flow rate, $\dot{m}$, $(\frac{kg}{sec})$	air specific heat c_p(J/kg K)	I_t $(\frac{W}{m^2})$	T_{fo}-T_{fi}(^{0}C)	Efficiency (η_t)
7:00							
8:00							
9:00							
10:00							
11:00							
12:00							
13:00							
14:00							
15:00							
16:00							
17:00							
18:00							

Shape of the graph

The shape of the graphs for different parameters will be of the following type

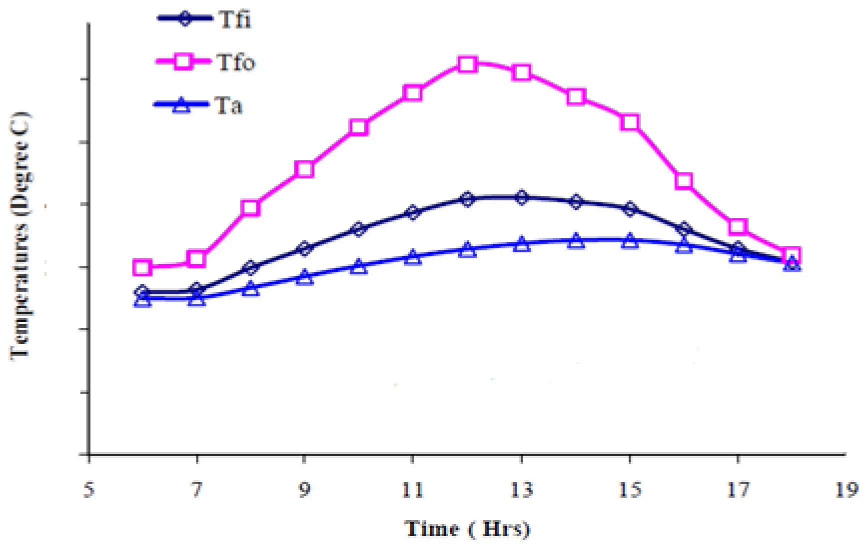


Fig:-1: variation of ambient temperature, inlet air temperature and outlet air temperature with time of the day

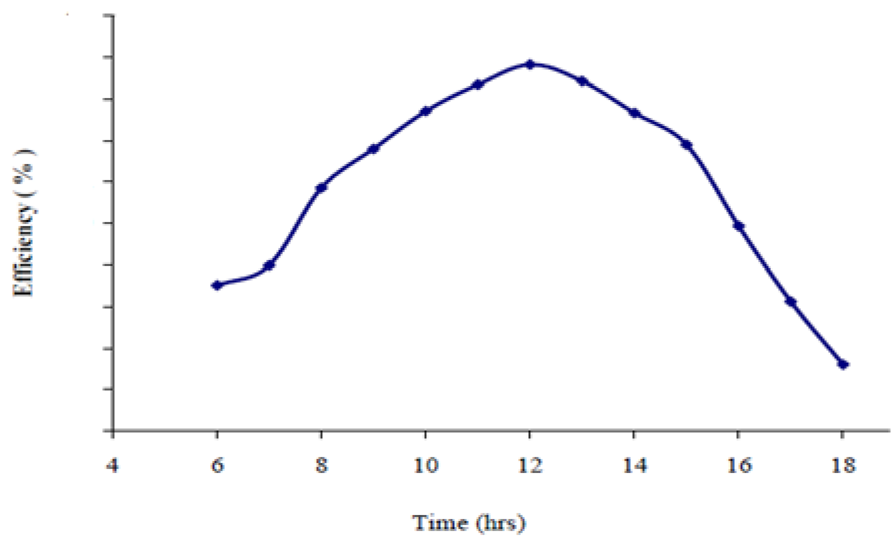


Fig-2: variation of efficiency of the collector with time of the day

Experiment-2

Performance evaluation of a solar air heater in force mode of air flow

Methodology

1. Switch ON the fan to produce the force mode of air flow
2. Measure the air flow rate by using the hot wire anemometer
3. Set the fan regulator for the desire air flow rate
4. Follow all the steps of experiment as in experiment 1.

Observation

Table -3: Experimental values of different parameters during force mode of air flow

Time of the day	I_t ($\frac{W}{m^2}$)	T_a(^{0}C)	T_{fi}(^{0}C)	T_{fo}(^{0}C)	Air flow rate (($\frac{m^3}{sec}$)			
					1	2	3	4
7:00								
8:00								
..								
..								
18:00								

Calculation:

Calculate the instantaneous efficiency of the collector by using the equation (1) for every hour

Table-4: Calculated results of solar air heater in force mode of flow

Time of the day	Air flow rate ($\frac{m^3}{sec}$)	Density ($\frac{kg}{m^3}$)	Air mass flow rate, $\dot{m}$, ($\frac{kg}{sec}$)	air specific heat c_p(kJ/kg)	I_t ($\frac{W}{m^2}$)	T_{fo}-T_{fi}(^{0}C)	Efficiency (η_t)
7:00							
8:00							
..							
..							
17:00							
18:00							

Shape of the graphs:

The shape of different graphs will be similar to the above experiment. The main difference will occur in values only.

Experiment-3

Performance evaluation of a solar air heater in force mode of air flow at different mass flow rate

Methodology:
This experiment is similar to experiment number 2. The only difference is in the air mass flow rate. The air mass flow rate can be changed by adjusting the fan regulator.

Observation and calculations:
Same as experiment number 2.

Shape of the graph
The shape of the efficiency curve vs air flow rate will be of the following type

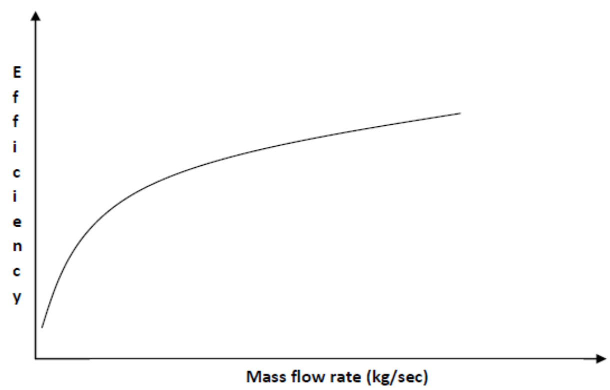


Fig-3: Variation of efficiency of the collector with air mass flow rate