Experiment 6: Natural circulation flat plate solar hot water system

Aim: To find out efficiency of Natural circulation water heating system.

Apparatus: Solar water heating system, pyranometer, thermocouples, selector switch and DC voltmeter.

Theory:

The laboratory set up for this experiment has a collector connected to tank. The level of tank is higher than that of collectors. The efficiency of the flat plate collector and tank system is given by,

$$\eta_{sys} = Q_u|_{over\ \Delta t} / [A_c\ (I_T * \Delta t)] = M\ C_p\ (T_f - T_i) / [A_c\ (I_T * \Delta t)] \quad (1)$$

And the characterizing equation is,

$$\eta_{sys} = A - B\ X_c \quad (2)$$

where, A and B are characteristic system constants,

and X_c is given by

$$X_c = \frac{\sum_i \left[\left(\frac{\sum_{j=1}^{m} T_{sj}}{m} \right)_i - T_{a_i} \right] \Delta t_i}{\sum_i I_{T_i} \Delta t_i}$$

$M\ C_p$ = Mass and specific heat product for the tank fluid

η_{sys} = Efficiency over the period Δt

T_f = Final tank temperature

T_i = Initial tank temperature

I_T = Mean Solar Intensity

A_c = Collector area

Δt = time interval

$\left(\frac{\sum_{j=1}^{m} T_{sj}}{m} \right)_i$ Mean tank temperature over the period Δt_i

m = Number of locations

T_{ai} = Ambient temperature at i^{th} time step

I_{Ti} = Solar Intensity at i^{th} time step

Δt_i = i^{th} time interval

Solar intensity,

$$I_T = I_b r_b + I_d r_d + r_r\ (I_b + I_d) \quad (3)$$

where,

I_b = Beam radiation, I_d = Diffuse radiation, r_b, r_d, r_r = Tilt factors

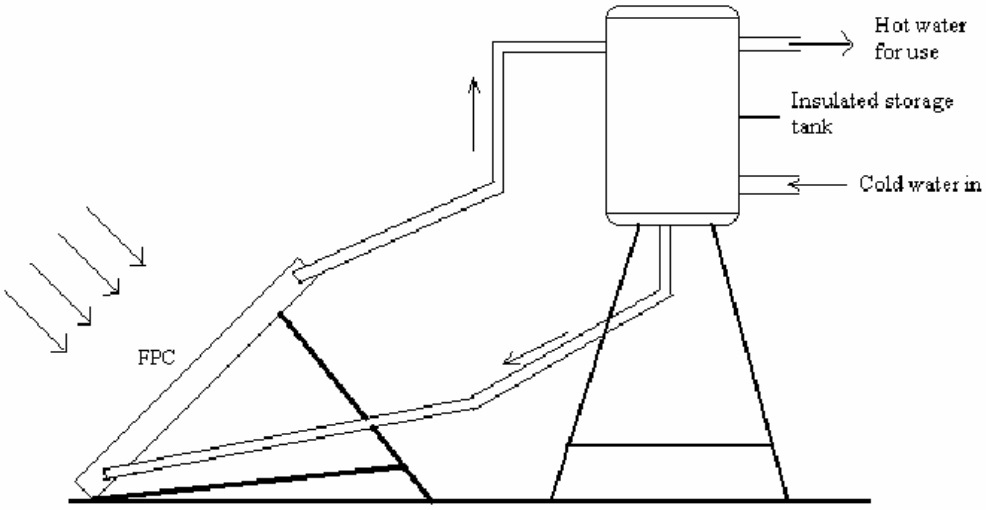

Figure 1. Schematic of the Natural circulation water heating system

Procedure:

1. Fill the storage tank to its full capacity, measure the tank capacity.
2. Measure the area of the collector.
3. Note down the readings for inlet fluid temperature, outlet fluid temperature at collector and tank temperature at different locations.
4. Note down the readings for solar radiation (global and diffuse) at the same instant.
5. Note down all readings in interval of 15 minutes. Take about 9-10 set of readings.
6. Calculate the efficiency.

Solar Radiation data

Sr. No.	Time (IST) h	Diffuse radiation I_d (W/m^2)	Global radiation I_g (W/m^2)
1.			
2.			
…			
8.			

Readings for determining characteristic parameter

Sr. No.	Time (h)	Flow rate (LPM)	Inlet temperature T_{fi} (mV)	Outlet temperature T_{fo} (mV)	Mean tank temperature (mV)	Ambient temperature (mV)
1.						
2.						
…						
8.						

Precautions:

1. Note that N sets of readings will give you N-1 sets for calculation.
2. Water withdrawal from tank should be stopped (i.e. close the inlet and outlet of tank) before starting the experiment.
3. Do not shadow collector as well as pyranometer during the experiment