Computerized Study of Flat Plate Collector and its Installation

Rohitash Singh[1], Avinash Kumar Sharma[2]

[1]Assistant Professor, Hindu College Moradabad, UP, India
Email: *rohitsinghnbd[at]gmil.com*

[2]Assistant Teacher SLMD HSS, Harirampur, Aligarh , UP, India
Email: *avi1380[at]yahoo.co.in*

Abstract: ***The sun, which is the largest member of the solar system with other members revolving around it is a sphere of intensely hot gaseous with a diameter of 1.39×10^{9} m and, on an average, at a distance of 1.5×10^{11} m from the earth. With an effective black body temperature Ts of 5777K, the sun is, effectively, a continuous fusion reaction the reaction is as follows $4({}_1H^1) \rightarrow {}_2He^4$ + 26.7 MeV. This energy is produced in the interior of the solar sphere, at temperatures of many millions of degrees. The produced energy must be transferred out to the surface and then be radiated into space. The intensity of solar energy on a surface oriented perpendicular to the sun's rays above the earth's atmosphere (known as the solar constant) has been measured by satellite to be between 1,365 and 1,367 W/m^2 (NASA 2003).***

Keywords: flatplate collector, Solar Still, absorption coefficient, solar intensity

1. Flat Plate Collector

Solar energy is widely used by human being in different manner. Solar collectors are helpful to convert solar energy into thermal energy. The solar collector is the essential element of a thermal-solar installation. This is widely used for house water heating. In the summers, installation could fully cover the adequate quantity of energy. In whole year, the solar installation delivers up to72% of the necessary of energy for house water heating[1].At the falling of the solar radiation on a certain surface, this radiation could be absorbed, transferred through the matter or reflected.

2. What are solar collectors, and how do they work?

The sun gives us energy in two forms, light and heat. For many years, people have been using the sun's energy to make their homes brighter and warmer. Today, we use special equipment and specially designed homes to capture solar energy for lighting and heating are known as solar collector. Solar collectors trap the Sun's rays to produce heat. Most solar collector are Boxes, Frames, or rooms that contains these parts

1) Clear Covers that let in solar energy
2) Dark surface Inside called absorber plates that soak up heat
3) Insulation materials to prevent heat from escaping and carry the heated air or liquid from inside the collector to where it can be used.

3. The Flat Plate Collector efficiency

The basic principle of flat plate collector working is based on the absorption surface heating under the action of the solar radiation. The heat passes to the fluid that comes in thermal contact with the absorption surface, & then the circulation of this fluid transfers the heat transferred to other elements of the installation that integrates the solar collector. The performance of any solar collector is described by its own energy balance. This has the role to point out the way in which solar incident energy is distributed in useful energy and different losses.

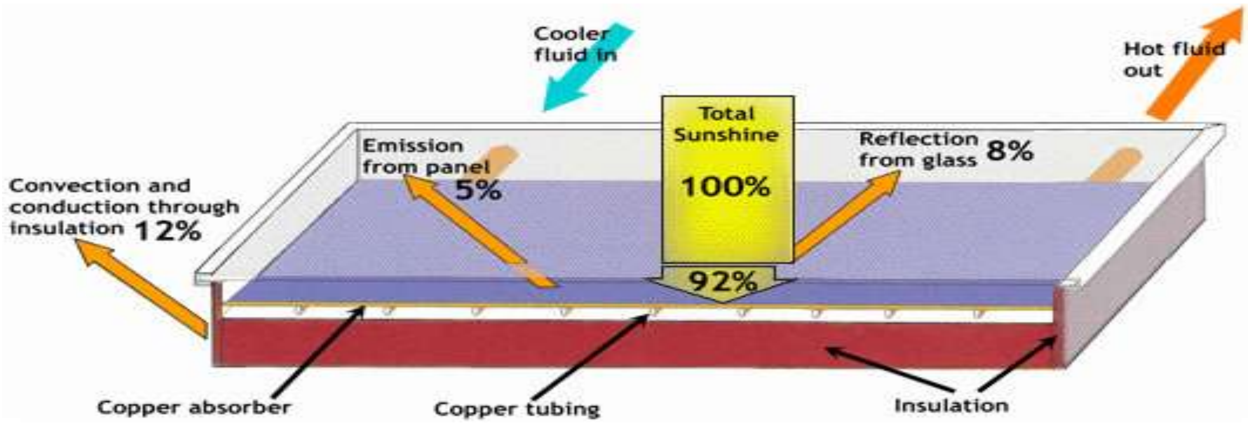

Figure 1: The heat losses of the flat plat solar collector

Due to the sun light reflection on the transparent surface and also due to the solar radiation absorption in the transparent material, a part of the solar radiation doesn't reach the absorbing surface. If the heat losses through solar radiation reflection are dependent on the angle on which the radiation drops (at angles higher than 45° the losses are highly Increasing).The heat losses through transparent material absorption can be estimated by τ (transmission factor)

4. Type of Material Transmittance

Table 1: Transmission factor values for different materials

Material Type	Transmittance
Glass(ordinary type) for window, 6mm	0.80
Floating glass(6mm)	0.87
Low content of Ferro oxide glass	0.91
Polycarbonates	0.70
Polyethylene membrane	0.82
Plexiglas(4mm)	0.80
Tedlar	0.86

The optical losses can be minimized by taking certain selective collector surfaces e.g. Ferro oxide masking. The quantity of heat caught by the absorption surface, results in rising its temperature, over the surrounding temperature. The thermal conduction losses are due to this difference of temperature the heat losses unit is closely connected with the solar collector constructive thermal characteristics & the temperature difference b/w the surrounding temperature and that of the absorption surface. The efficiency of solar radiation transforming into heat is defined by the absorption surface factor α

Table 2: Absorption of certain materials and absorption surface

Types of material or cover surface	*Absorption α*
Normal materials &surfaces	
Iron	0.44
Copper	0.35
Pure aluminum	0.10
Oxide steel sheet	0.74
Black panted steel	0.95
Graphite	0.95
White paint	0.66
Selective surface	
Nickel	0.95
Copper oxide on a copper surface	0.90
Ceramics on a steel surface	0.96

The thermal losses can be reduced by improving the isolation (increasing the number of transparent surfaces and using quality materials suitable for the isolation).Only a part of the global solar radiation will be converted into heat. The global solar radiation E is defined by the properties of the transparent surface materials and those of the absorption surface too.

$$Q_a = (\alpha\tau).E = A_0.E \ [W/m^2]$$

Q_a – the heat derived from the absorption surface,[W/m^2];
A_0 – optical factor – percentage from solar radiation intensity E that converts into heat on the absorption surface.

The solar collector optical losses represent the difference b/w solar radiation intensity and the absorbed solar radiation intensity by the absorption surface

$$q_{opt} = E - Q_a [W/m^2]$$

The thermal losses are directly related to the temperatures difference T_m between the absorption surface and the environment T_a:

$$q_t = k\cdot(T_m - T_a) \ [W/m^2]$$

k – Global losses factor, [W/m2·°C], varies from 1 to 30W/m2·°C.
T_m – average temperature of the absorption surface, [°C];
T_i – thermal factor temperature at the collector entry,[ºC].
T_e - thermal factor temperature at the collector exit, [ºC].

The usable heat derived from the catcher Qu is the heat transferred by the mentioned thermal factor and it actually represents the heat derived from the absorption surface and thermal losses from the collector.

$$Q_a = (\alpha\tau)\ E - k\cdot(T_m - T_a) \ [W/m^2]$$

the collector specific heat, the heat losses trough the transport of the thermal factor & the angle adjustment under which the solar radiation drops are being neglected.

The thermal efficiency is defined as the ratio between the resulted usable energy and the radiation intensity[10]:

$$\eta = Q_u/E = (\alpha\tau)\ E - k\cdot(T_m - T_a)/E$$
$$= \alpha\tau - k\cdot(T_m - T_a)/E$$

The heat absorbed by the thermal factor is:

$$Q_t = (dm/dt)c\cdot(T_e - T_i) \ [W/\ m^2]$$

dm/dt - thermal flow rate factor, [kg/s·m^2]
c - Thermal capacity, [J/kg·ºC].

Because the heat absorbed by the thermal factor is equal to the usable heat derived from the solar collector we can write (figure 3):

$$(dm/dt)\ c\ \cdot(T_e - T_i) = E - k\cdot(T_m - T_a) \quad (8)$$

as a result the flow rate factor becomes :

$$(dm/dt) = Q_u/c\Delta T[kg/s\cdot m^2]$$

Very low differences b/w the incoming temp & the outgoing temp from collector implies high flow rate factor that runs through the collector. If the flow rate factor is low, it results a high temperature differences b/w the entry and the collector exit. If the heat derived from the absorption surface is not absorbed by the thermal factor, the temp of the absorption surface rises to the value T_{max}, if the solar collector heat losses will be equal to the absorbed from the solar radiation for a certain solar collector the temperature at null weight flow is determined by the relation:

$$T_{max} = \frac{E_{max}\cdot A_0}{k}$$

These temperatures impose conditions upon materials used to build the solar catcher, but also the thermal factor selection and overpressure protection for thermal factor circuit

5. Conclusion

The flat plate collector is a technical installation characterized by a global efficiency that is used in way to choose and dimensioned for the thermal-solar installation. Using the computerized Parameters (values) as given in Table 3 it can be observed a better influence upon the efficiency based on the radiation intensity, the absorption factor corresponding to the absorbent Surface material and the gradient temperature between the o/p and i/p thermal agent temperatures. The equipment producers offer the methodology according with the technical principles and the equipment constructive characteristics. Two-positional tracking can be recommended as an economical method for increasing the solar energy yield**.**

References

[1] Al. Dănescu, S. Bucurenciu, St. Petrescu, UtilizareaEnergieiSolare, EdituraTehnică, Bucureşti, 1980.
[2] G. Kelemen, Alternativaenergetică: Energiasolară, Partea a-III-a Principiul de funcţionare al captatorului plan, Tehnicainstalaţiilor, Anul IV.1/2004.
[3] Visual Basic 6.0 (http://www.microsoft.com).
[4] www.powerfromthesun.net.
[5] www.utm.md/master/curs/sre.html (Surseregenerabile de energie, Sobor Ion, Dinov Daniela, ş.a.)
[6] Rommel, Matthias: *Medium Temperature Collectors for Solar Process Heat up to 250°C*. Estec 2005
[7] Wagner & Co. (Hrsg.): *So baueicheineSolaranlage. Technik, Planung und Montage.*Cölbe:
[8] Wagner & Co Solartechnik GmbH, 1995
[9] Henning, Hans-Martin: *Solar-assisted Air-conditioning in Buildings – A Handbook for Planners.*
[10] SpringerVerlag Wien New York, 2005

Paper ID: SR21929191827 DOI: 10.21275/SR21929191827