International Journal of Advanced Engineering &Innovative Technology (IJAEIT)
ISSN: 2348 7208
IMPACT FACTOR: 1.04

Analytical Analysis on Influence of Heat Transfer in the Solar Panel of Solar Domestic Hot Water Storage Tank

Mainak Bhaumik[1]*& Bhavesh Pasi [2]

ABSTRACT: The work is an analytical analysis of heat transfer on solar panel of solar domestic hot water (SDHW) storage tank and indeed into the tank for storage and utilization. The analytical calculations have been carried out with the heat transfer formulae. The three modes of conduction, convection and radiation heat transfer has been taken under consideration for analysis. The hot water pipe is either placed under the solar panel or directly exposed under the solar light with the fitted inbuilt solar cells to capture the solar radiation heat and to transfer the heat into the water to heat the water to serve the utilization of solar energy to heat hot water to serve the domestic service or for industrial utilization. Hence this analytical analysis is to draw some conclusion about the absorption of thermal radiation energy from the Sun light. The temperature has been assumed for the calculation and analysis. The pipe under solar panel or directly exposed pipe is the main centre of attraction for analysis purpose.

Keywords: SDHW (Solar domestic Hot water), solar panel, solar pipe, heat transfer, radiation, conduction and convection.

1. INTRODUCTION:

The free renewal sun light radiation heat has been utilized in the different purpose. Solar energy utilization is versatile in different fields. To produce electricity the solar cells are developed and solar energy has been stored and utilized to get electricity without paying anything for combustion. Here the study is about the sun light energy utilization to; heat the water for the domestic utilization purpose. The different analysis has been carried out about the storage and utilization of solar energy.

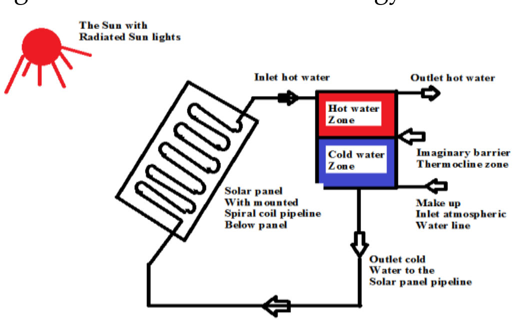

Fig. 1: The SDHW storage system with the spiral tube embedded under the solar panel.

****

Mainak Bhaumik[1], Bhavesh Pasi[2]
[1]*Assistant Professor, M.G.M's College of Engineering and Technology, Kamothe, New Mumbai – 410209, India*
[2]*Assistant Professor, Vishwaniketan College of Engineering and Technology, Khalapur, Panvel, Raigad, New Mumbai – 410206, India bnpasi@vishwaniketan.edu.in*
(This paper is presented in National Conference ETAT-2019 held at VIMEET, Khalapur)

The SDHW storage system requires a storage tank to store the solar energy in the form of hot water and later on to utilize the same for the domestic purpose or for industrial purpose. An analysis to be carried out about the heat growth in the solar panel pipelines to store the radiation energy in the form of hot water. Initially the sunlight falls on the black dark solar cells or on the pipe lines embedded with solar cells.

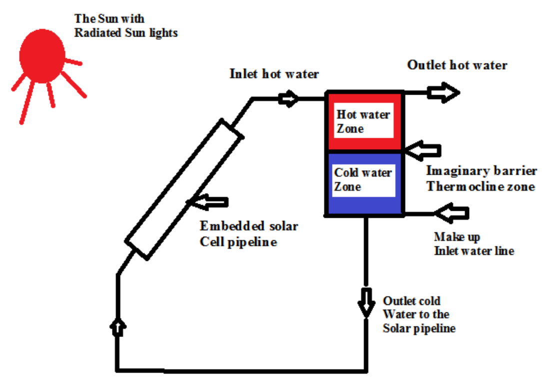

Fig. 2: The SDHW storage system with the embedded solar cells on the pipeline.

The solar cells are responsible to absorber more radiation energy and to transfer the same radiation energy into the pipelines internal conduit fluid. Then such absorbed radiation energy is being transformed in the form of conduction and convection to generate hot water to serve the purpose. Of course the radiation energy varies throughout the period of full day of available sun light ray condition. For analysis the average day time midday section temperature has been paid an important role. The

Fig. 1 and Fig. 2 shows the two basic system of SDHW storage system with the phenomena of storing hot water into the storage tank and releasing and make up of water from the storage tank and into the storage tank. The generation of hot water using radiation sun light is atmospheric environment and throughout year weather and location of city oriented while storing of heat energy is not exactly like so. In the insulated storage tank the hot energy in the form of hot water can be stored for few days and for a week as per the size and capacity of the storage tank. Hence the generation of and utilization of thermal radiation energy is important for study and analysis.

2. PROBLEM DEFINATION:

Here the defined problem is about the heat generation by the solar cells and embedded solar cells of the pipelines. In case of the solar panel with solar tubes, it has been considered that the copper tube of size 12 mm internal diameter or 15 mm internal diameter is going to absorber the radiation energy via the black solar cells. Then embedded spiral coil tube is going to transfer the heat into the flowing atmospheric water to generate hot water. The size of the solar panel considered under study as 3 meters of length and 1.5 meters of width. So the overall area of the solar panel becomes 4.5 m2.

In case of single or multiple pipes embedded with solar cells, it has been considered that stainless steel tube of size 25 mm to 50 mm of internal diameter and length of 2 meters of each pipe has been taken under study and analysis to find the influence of heat absorption and transformation of same into the flowing atmospheric water.

Also it has been considered that the atmospheric water is going to develop temperature within the range of 600C to 1000C.

.

3. ANALYATICAL ANALYASIS:

For the study and thermal analysis purpose starting from the radiation energy transform the Stephen Boltzman's theorem has been taken under consideration to know the radiation heat utilization by the black body solar cells. The rate of radiation heat energy analysis has been done using the following relation,

Qrad. = ε σ As (Ts4 – T4surr)

Where, Q = Radiated heat generation in watts.

ε = emissivity of the solar cells, which is taken as = 0.98

σ = Stephen Boltzman's constant = 5.67 x 10- 8 in w / m2 k

As = Surface area in m2

Ts = Surface temperature in deg. C

Tsurr = Surrounding atmospheric temperature in deg. C

To find out the conduction heat energy transformation from the solar panel or outer diameter of the tubes or pipelines to the available atmospheric flowing water inside the tube or pipeline has been utilized the following conduction relation as,

Qcond. = m cp ΔT = m cp (Thot – Tatm.)

Where, Qcond = Conduction heat transfer in w.

m = Mass flow rate of water through the tube or pipe, which is taken as 0.025 kg /m3

cp = specific heat of water= 4187 j / kg K

Thot = Hot temperature of the tube or pipe surface in deg. C

Tatm. = Considered and available atmospheric water temperature = 25 deg. C

The convection current heat transform also been calculated. The relation utilized for the convection current heat transformation is as,

Q conv. = h As ΔT = h As (Thot – Tatm.)

Where, Qconv. = Convection heat transfer rate in w.

h = Convection heat transfer rate = 50 w / m2 k

As = Surface area of tube or pipeline = πD2 / 4 in m2

T hot = Hot water temperature in deg. C

Tatm. = Atmospheric temperature in deg. C

The calculated data values are being plotted in terms of graph. In the following result and discussion section the same has been shown for better visualization and understanding purpose.

4. RESULTS:

In radiation heat transfer rate calculation the hot surface temperature taken in the range of 600C to 1000C for the purpose of calculation and analysis. The considered average surrounding temperature is 300C. The other constant values are defined in earlier analytical analysis part. The temperature has been varied and calculations are carried out. Such values are being plotted and shown in Fig. 3 radiation heat v/s temperature. There is increase in the radiation heat transfer with the increase in surface temperature of solar panel due to continuous falling of sun light and of over of certain period of time. The surface temperature development on the solar panel depends on the absorbity of the solar cells and the duration of time.

In case of the embedded solar cell circular pipe type the surface area is the peripheral area of the pipe which is As = π D L. For "n" numbers of pipes the surface area relation is As = π D L X n The Fig. 4 and Fig. 5 shows the calculated radiation values v/s temperature of 10 numbers of pipes with the considered effective peripheral surface area of all 10 pipes for the pipe size of 25 mm and 50 mm respectively. The conduction heat transfer for the same mass flow rate of 0.025 kg/sec has been calculated. The data has been plotted in the form of graph and is as shown in Fig. 6. Also the convection heat transfer rates for different surface area of the solar panel type and for pipe type solar system has been calculated. The data plotted in the form of graph. The Fig. 7shows the convective heat transfer rate in the solar panel type system. While the Fig. 8 and Fig 9 is about the convective heat transfer rate plots in pipe type solar water heating system of pipe size 25 mm and 50 mm respectively.

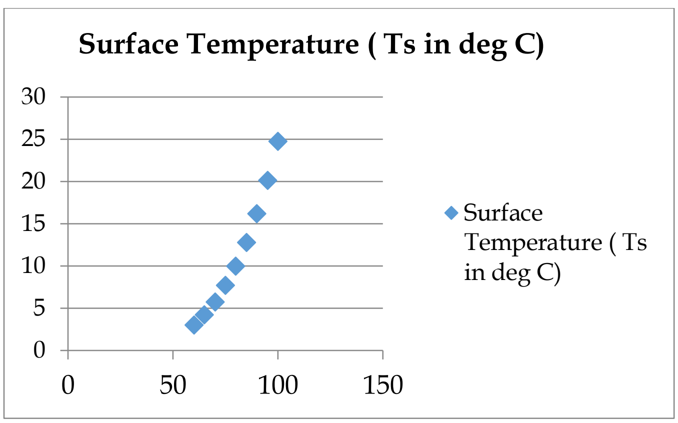

Fig. 3: Radiation heat transfer (Qrad.) v/s surface temperature (Ts) plot of solar panel tubes of SDHW

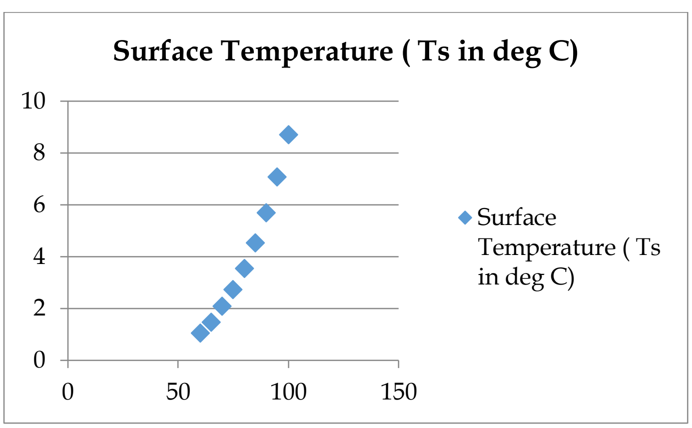

Fig. 4: Radiation heat transfer (Qrad) v/s solar water heating 10 Nos of pipe of diameter of 25mm.

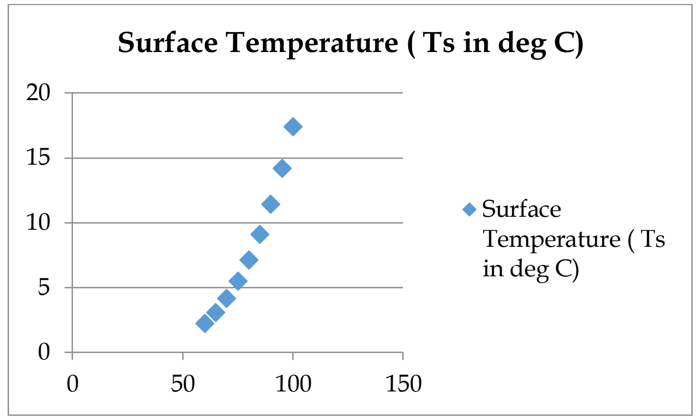

Fig. 5: Radiation heat transfer (Qrad) v/s solar water heating 10 Nos of pipe of diameter of 50mm.

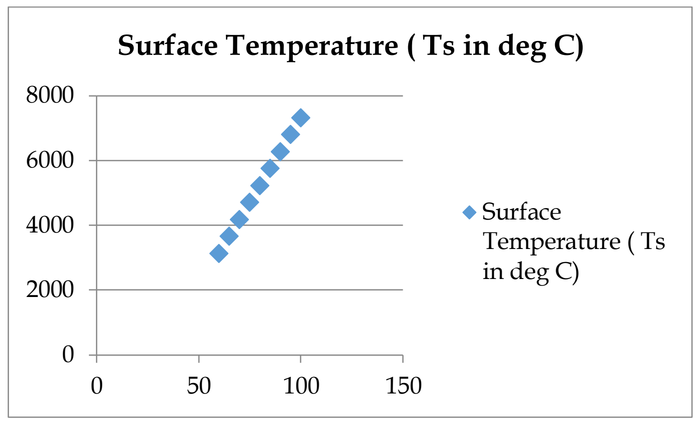

Fig. 6: Conduction heat transfer (Qcond.) v/s surface temperature (Ts) plot of solar panel tubes and pipe type water heating system by captured sunlight for the same mass constant mass flow rate.

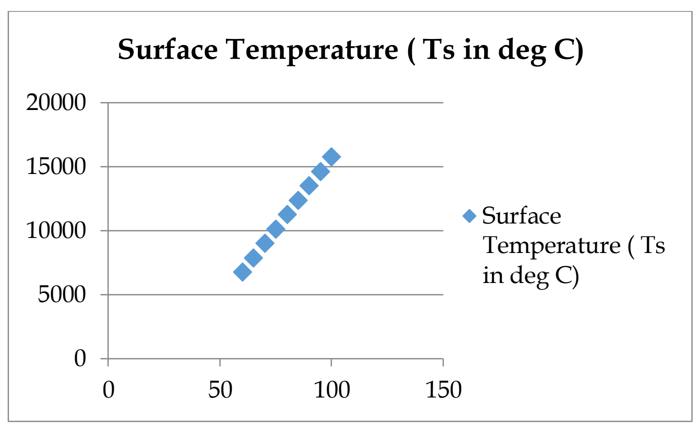

Fig. 7: Convection heat transfer (Qconv.) v/s surface temperature (Ts) plot of SDHW solar panel system.

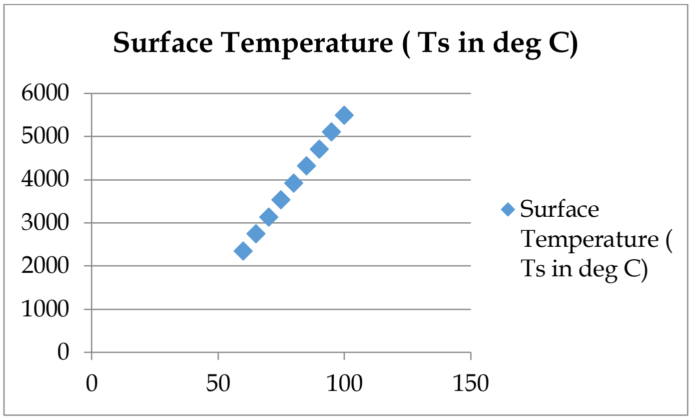

Fig. 8: Convection heat transfer (Qcon) v/s solar water heating 10 Nos of pipe of diameter of 25mm.

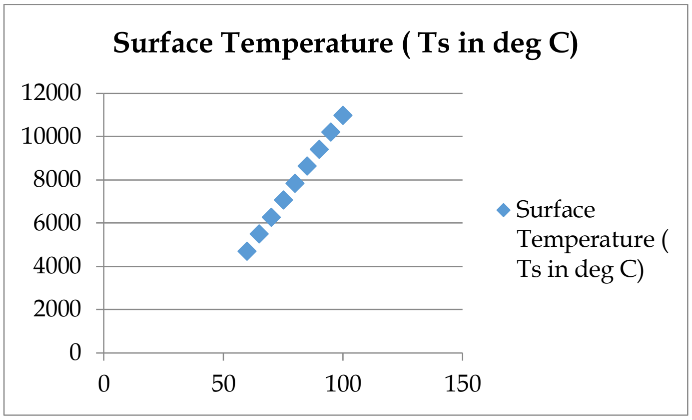

Fig. 9: Convection heat transfer (Qcon) v/s solar water heating 10 Nos of pipe of diameter of 50mm.

5. CONCLUSIONS:

The continuous absorbed solar radiated sunlight with temperature has been utilized to generate heat. Due to continuous fall of temperature the surface temperature increased. With the basic temperature mood of heat transfers of radiation, conduction and convection the generated heat energy has been calculated analytically by assuming different temperature generation from the range of 600C to 1000C. It has been found from the calculation that with the increase in temperature surface temperature the heat generation has been increased. In case of conduction and convection current it has been observed that the intensity of heat generation in conduction and convection mood is much more than radiation. In solar panel system type the heat generation observed is much more than the pipe type solar panel heat generation. For same similar type of heat generation in the solar panel system and in the multiple type pipe system it is required to calculate the number of competent pipes required to serve the same type of purpose. Here in this analysis only ten numbers of pipes are considered and it has been observed comparative with lesser size of area of the pipe type solar panel system than the flat plat solar system the heat generation is quite lesser. So it can be advised to maintain equivalent area for flat plate solar panel system and pipe type solar system.

6. REFERENCES:

[1] Pinar MertCuce, Box type solar cookers with sensible thermal energy storage medium: AComparative experimental investigation and thermodynamic analysis, Solar Energy, Volume 166, 2018, pp. 432-440.

[2] Manuel et al.Figures of merit and their relevance in the context of a standard testing and Performance comparison methods for solar box – Cookers,Solar Energy, Volume 166, 2018 , pp. 21-27.

[3] Zied et.al.Thermal performance of a solar box cooker with outer reflectors: Numerical Study and experimental investigation,Solar Energy, Volume 158, 2017 , pp. 347-359.

[4] Amal et al. Review on solar cooker systems: Economic and environmental study for different Lebanese scenarios, Renewal and Sustainable Energy Reviews, Volume 81, 2018, pp 421– 432.

[5] ErdemCuce, Pinar MertCuce, A comprehensive review on solar cookers, Applied Energy, Volume 102, 2013, pp. 1399 - 1421.

[6] SuhailZakiFarooqui, An improved power free tracking system for box type solar cookers, Solar Energy, Volume 120, 2015, pp. 100-103.

[7] ServínCampuzanoHermelinda, González Avilés Mauricio, Development of the solar cooker jorhejpatarnskua: thermal standardanalysis of solar cooker with severalabsorber pots, Energy Procedia, Volume 57, 2014, pp. 1573-1582.

[8] S.B. Joshi , A.R. Jani,Design, development and testing of a small scale hybrid solar cooker, Solar Energy, Volume 122, 2015, pp. 148-155.

[9] Kedar et al.Thermal Analysis of Parabolic Solar Cooker with BackReflection, Materials today Proceeding Volume 4, 2017, pp. 8035 - 8039.

[10] Nayak et al.Construction of Box Type Solar Cooker and Its Adaptability to Industrialized Zone, Materials today Proceeding, Volume 4, 2014, pp. 12565 – 12570.

[11] Nkhonjera et al. A review of thermal energy storage designs, heat storage materials andCooking performance of solar cookers with heat storage,

Renewal and Sustainable Energy Reviews, Volume 75, 2017, pp. 156 – 167.
[12] AbhishekSaxena, NitinAgarwal, Performance characteristics of a new hybrid solar cooker with air duct, Solar Energy, Volume 159, 2018, pp. 628 – 637.
[13] Manpreet Singh, V.P. Sethi, On the design, modelling and analysis of multi-shelf inclined solar cookercum-Dryer, Solar Energy, Volume 162, 2018, pp. 620 – 636.
[14]A. Soria-Verdugo, Experimental analysis and simulation of the performance of a box-type solar cooker, Energy and Sustainable Development, Volume 29, 2015, pp. 65-71.
[15] Terres et al.Mathematical Model to Study Solar Cookers Box-Type with Internal Reflectors, Energy Procedia, Volume 57, 2014, pp. 1583 –1592.