International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 06 | June 2019 www.irjet.net p-ISSN: 2395-0072

A REVIEW OF SOLAR WATER HEATER PERFORMANCE FACTORS

Selvam S[1], Prathap A[2], Dr. C. Sivarajan[3]

[1]PG Student ME Thermal Engineering, Annamalai University, Chidambaram.
[2]PG Student ME Energy Engineering, Annamalai University, Chidambaram.
[3]Associate Professor, Mechanical Engineering, Annamalai University, Chidambaram.

Abstract: *This review article deals with performance factor of the flat plate solar water heating system to obtain hot water for the domestic and industrial applications. Fins are helping us to enhance heat transfer rate by extending the area of heat flow. According to Fourier's law, heat transfer is directly proportional to the finite temperature difference, cross sectional area and thermal conductivity of the conducting material as it is many researchers were working on the extended surface. Fluid velocity has been dominating heat transfer rate in convection by the way of Newton's law of cooling. Here, our review is analysis different factors that affect heat transfer rate such as number of fins, glassing, number of passes, geometry of fins and site selection. Selection of materials and absorber plate coating is crucial things when we are going to perfect design for flat plate collectors because it is one of the promising technologies to absorb the solar energy.*

Keywords: Thermal conductivity, Convection, Absorber plate, Flat plate solar collector, Finned tube.

INTRODUCTION

Finned tube heat exchangers can effectively transfer the heat energy from one object to another in many engineering applications. The simplest form of solar energy absorption is a flat plate solar water heater shown in figure-1. It is directly converting the solar radiation into the heat energy without any instruments like solar photo voltaic system. Currently, solar flat plate collector has a fixed set of components that is glass cover, absorber plate, and insulation then raiser tube to perform. Here the glass cover act as a heat wave protector and Selection of material is always based on the thermal conductivity. A higher thermal conductivity material has a better heat absorption as well as provided better results. In an engineering application many types of fins have been utilized to faster heat transfer rate than that of plain tubes due to fins are exposed to the inner surface of riser tube and have direct contact with water. Fluid flow through the internally finned tube never considers as a circular flow and flow have not laminar even at lower velocity.

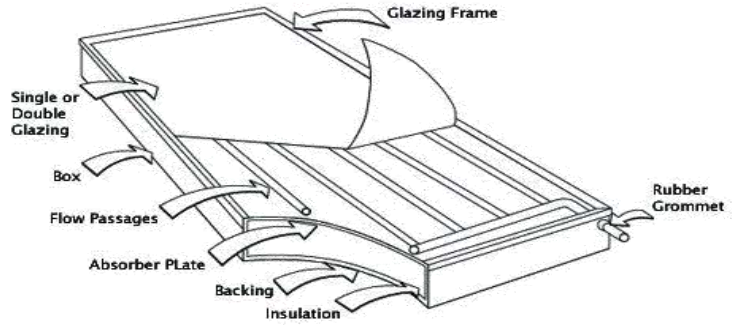

Figure-1

A flat plate solar collector performs with all modes of heat transfer such as conduction, convection and radiation. Initially, energy received from sun in the form of light and heat waves with considerable potential, that the radiation directly hit on the absorber plate and share their energy with the same. Absorber plate is diffusing heat into the riser tube after that their heat capacity. During the operation, increasing Fourier's number provide the best heat exchange between the riser tube and absorber plate with the mode of conductive heat transfer. Typically, water entering temperature has

been always lesser than the raiser tube temperature beside according to the second law of thermodynamics ''heat is always travel from higher temperature to lower temperature'' as it is heat flow from riser tube to water by the way of forced convection.

LITERATURE REVIEW

(P.P.Patil et al, 2015) deals with design consideration of the solar water heaters to obtain hot water for the domestic and industrial applications. Design of solar water heating system is important to assure maximum benefit to the users, so they concentrate and analyze absorber plate materials, absorber and glazing coating along with the changes in the design. Designing a solar water system involves appropriate selection of each component of the desired capacity and location of installation for solar water heater to produce hot water. Various factors and correlations for design of collector, storage tank and insulating material are briefly discussed. Constructional element of a flat plate solar collectors and operational characteristics are clearly defined and shows its importance to get better thermal performance.

(Chii-Dong Ho et al, 2007) Investigated and theoretically studied on the double pass sheet and tube solar water heater with attaching internal fins on tube walls internally. Also discussed the number of fins, recycles ratio, incident solar radiation and mass flow rate on the collector efficiency. To improve fluid temperature distribution and collector efficiency, to developed flow element diagram with energy balance equitation as shown in figure-2.

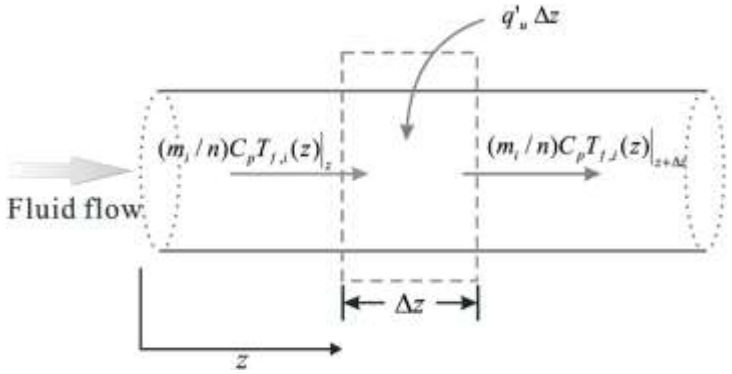

Figure-2

To predict the overall heat loss co-efficient with the help of average absorber plate temperature, the procedure for finding collector efficiency is to assume an initial guess for absorber plate temperature and iterate the calculation until the convergence by using trial and error method. The collector efficiency improvement is illustrated by calculating the percentage increments in collector efficiency of re-cyclic operation based on a single-pass device with the same water mass flow rate and working dimensions. From their conclusion, double pass internally finned collector perform better than single pass without internal fins under I = 1.0 kJ $m^{-2}s^{-1}$, m = 9 kg s^{-1}, R = 1, n = 4 and Nf = 2 instead of using the single-pass device without recycle.

(L.Chilambarasan et al, 2018) worked on helical internal grooved solar flat plate collectors to enhance their conversion efficiency by reducing heat loss from the collector surface. In an experiment conducted in three ways, case-I: plain tube, case – II: internal groove with 0.43 pitch and case-III: internal grooved with 0.44 pitches. Every case analyzes with two identical mass flow rates of 0.01 Kg/sec and 0.015 Kg/sec. According to their conclusions

- ✓ For plain tube, efficiency increased with the increasing mass flow rate. At the same, efficiency is to be increased 7% for increasing solar intensity by 5% at a higher mass flow rate.
- ✓ For grooved tube (pitch-0.43) increasing efficiency from 8% to 20% than that of plain tubes.
- ✓ For grooved tube (pitch-0.44) increasing efficiency from 8% to 22% with increasing mass flow rate.

From the above mentioned work grooved absorber tube collectors, always produce more outlet water temperature than that of plain tubes. Changing internal grooved pitch makes the changes on the efficiency.

(Mr. Ganesh et al, 2017) conducted experimental investigations on solar flat plate collectors by changing the geometry of the fin. To improve the heat transfer rate, different kinds of fins were used such as standard fins (900 area of contact), inverted riser tube with standard fins, riser tube with modified fins (2700 area of contact) and inverted riser tube with modified fins. To compare the thermal performance between the plain and finned tube absorber plate the experimental investigations conducted over the system.

Figure-3

Results shown that the finned tube absorber plate given more outlet water temperature than that of plain tubes. Standard fins provide more outlet water temperature that that of plain tubes, but lesser than the modified raiser tube fins. Inverted modified raiser tube given more outlet water temperature compares all over. Here by extending are always given more thermal performance.

(Vikas Reddy Chittireddy et al, 2018) studied flat plate solar collector with an air conditioning radiator as a heat absorber for a domestic Water heater. The receiver plate was constructed from an air conditioning radiator shown in figure-4. Efficiency of the collector is to be a function of glazing as it is efficiency, changing with respect to glassing and the number of layers.

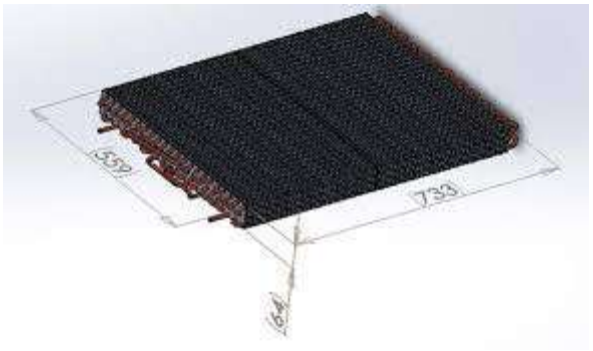

Figure-4

Major component of system

- Receiver plate
- Water storage tank
- Casing for collectors
- Insulation
- Double layer glazing actuator to control the inclination
- Water circulating pump
- Temperature sensor
- Mass flow rate sensor
- Data acquisition system

He took reference from Benslama, found that the efficiency is 42% for double glazing, whereas, 30% for single glazing. Kalidasan et al, examine the efficiency with function of the number of cover plate. The flat plate collector efficiency is 51.5%, 61.7% and 56.5% for one, two and three covers plate respectively. The thermal performance of the flat plate collector developed and described by numerical model. The energy balance approach used to predict the heat transfer of the water. To solve the unknown receiver and cover plate temperature used newton-Rapson method.

(Esdras nshimyumuremyi et al, 2019) analysis thermal efficiency and cost of solar water heater made in Rwanda shown in figure-5. The thermal efficiency of the system based on the absorber plate with high thermal conductivity therefore galvanized iron sheet replaced by aluminium. Year round experimentation conducted different region of Rwanda such as Kigali, Kinigi and Tampa and then a variation of monthly average temperature based on every month shown in fig-6

Figure-5

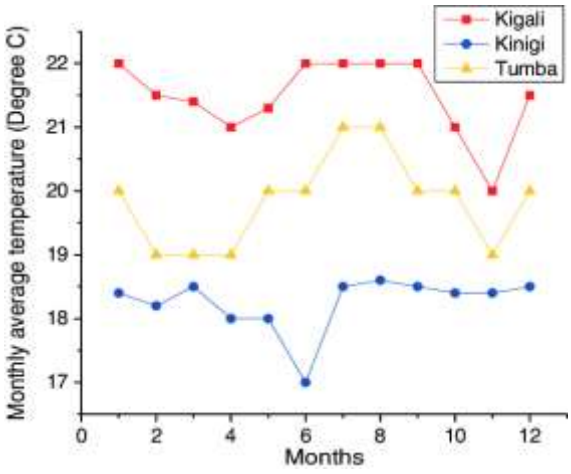

Figure-6

At Kigali recorded maximum temperature was 29^{0}C while ambient temperature 16^{0}C. Maximum registered temperature is 24^{0}C while ambient temperature is 11^{0}C at musanze. In rulindo, minimum ambient temperature is 13^{0}C while the maximum temperature is 26^{0}C. According to his conclusion, better solar radiation always provide higher thermal efficiency with high thermal conductivity absorber plate. The payback period also analyzed, according to that payback period also depend on radiation availability of the system.

(K.Balaji et al,2015) focused on thermodynamics analysis of a solar flat plate water heater using an extended surface absorber tube. He studied the effect of with and without extended surface by using a data acquisition system. Fluid flow parameter factor such as friction factor and non- dimensional numbers are analyzed. Open loop solar collector with and without extended surface are constructed same frame and orientation towards the south with tilt angle of 13^{o}C according to the topographical conditions. To resist the heat loss provided insulation material. The selection of fins geometry based on circumference and the contact surface.

Assumption

- ✓ Properties of absorbent remain constant at all point.
- ✓ Heat transfer process is to be a steady state
- ✓ Potential and kinetic energies are neglected
- ✓ The system always be a chemical equilibrium
- ✓ There is no mass loss inside the system

Figure-7

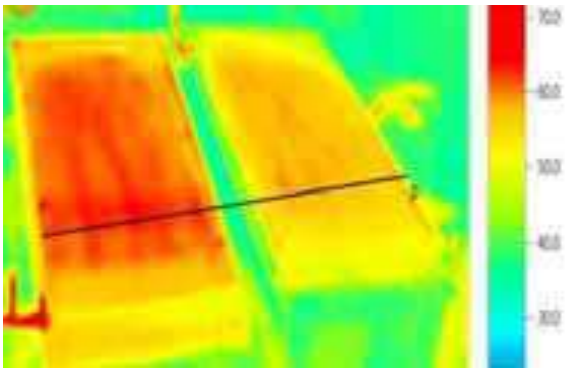

Figure-8

That the figure-7 and figure-8 shows the temperature of both the collectors and clearly implies the extended surface solar collectors recorded 8^{0}C more than that of plain absorbent. The Average temperature of both the system is 62^{0}C and 54^{0}C respectively. The friction factor is more for extended surface due to increasing contact area with water. The heat transfer rate is high at maximum solar intensity. Acccording to his conclusion, rod extended surface provided more heat transfer rate that the plain tube and extended surface do not have any thermal and viscosity boundary layer therefore it lead to more convective heat transfer. In an increasing efficiency of the extended rod collector is 22 ^{0}C more than the plain tube. The non- dimensional number and friction factor is more for extended surface.

(S saravanan et al, 2016) experimental investigation on the flat plate solar water heater with glass as an absorber material to check the thermal performance of difference absorbent such as absorber black painted clear toughened glass plate sandwich type (ABPCTG), absorbent tinted toughened glass plate sandwich type (ATTG) and absorber galvanized iron plate with pipe (AGI) were used as an absorbent material. performance of flat plate solar collector declines over the year due to scale formation in water passage and reduce the heat transfer probably It lead to poor system performance so toughened glass absorber is to be investigated to overcome this problem. Two toughened glass is used to make ABPCTG, clear glass placed top and bottom is frosted glass on one side for painting purpose has been used for investigation. Here, 2mm glass strip placed in between them to water flow passage. Clear and tinted glasses used to make ATTG. The three identical experimental set up with different absorber material are conducted the comparative analysis throughout maximum solar intensity.

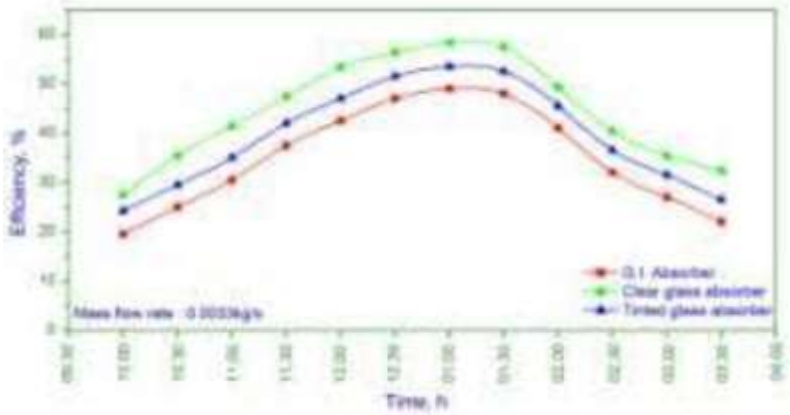

Figure-9

The performance analysis of three types of collector with three different mass flow rate of water is done. The thermal efficiency of absorber black painted clear toughened glass sandwich type (ABPCTG) is always higher than the other two and G.I absorber is lower efficiency among them. According to their conclusion, (ABPCTC) absorbent black painted clear toughened glass sandwich types provide maximum temperature of outlet water as shown in figure-9 as well as have highest thermal efficiency.

CONCLUSION

Flat plate solar water heater is a promising technique to collect the solar energy and many factors that affect its performance. Selection of material and geometrical modulations are crucial considerations to design solar collectors. Based on our studies, to improve the thermal performance, extended surfaces internally provided to absorber tubes. According to Mr.Ganesh et al work, inverted modified fins are given higher temperature different than the standard fins with proper pitch. The primary laws of heat transfer stated that the Heat transfer increased with time as it is known, multi passes given best outlet temperature with higher efficiency. During convective heat transfer, performance increased with the fluid velocity so we have to examine the proper mass flow rate. In a finned tube collector's friction factor and non-dimensional numbers are higher than the plain tube, especially Nusselt number, Fourier number and Prandle number is to be a main factor of higher heat transfer. From S. Saravanan et al work, absorber black painted clear toughened glass sandwich type (ABPCTC) perform better than the higher thermal conductive material like aluminium. From the Md.Imran studies, uniform velocity obtained by taper header tubes to improve thermal performance.

REFERENCES

1. Foued Chabane, Noureddine Moummi, Said Benramache. Experimental study of heat transfer and thermal performance with longitudinal fins of solar air heater(2014) 5, 183–192
2. *P. P.Patil, Dr.D.S.Deshmukh.* Design Considerations for Flat Plate Solar Water Heater System Vol. 3, No. 2, June 2015 ISSN (Print) 2277—7261
3. Chii-Dong Ho,Tsung-Ching ChenCollector Efficiency of Double-Pass Sheet-and-Tube Solar Water Heaters with Internal Fins Attached *323_334 (2007)*
4. L.Chilambarasan, G. Niranjan and Raja Sekhar Y Performance study of Flat Plate Collector with Internally Grooved tubes 2018, 4165-4174
5. Vikas Reddy Chittireddy, Ahmed ElSawy and Stephen Idem study of a flat plate solar collector with an air conditioner radiator as a heat absorber for a domestic water heater March 2018
6. Mr.Ganesh K. Badgujar, Prof.Sachin Nimbulkar and Prof. Rajesh Dahibhate Experimental investigation on solar flat plate collector by changing geometry of fin 2017
7. Esdras Nshimyumuremyi and Wang Junqi Thermal efficiency and cost analysis of solar water heater made in Rwanda 2019, Vol. 37(3) 1147–1161
8. Gang Pei, Guiqiang Li, Xi Zhou , Jie Ji and Yuehong Su Comparative Experimental Analysis of the Thermal Performance of Evacuated Tube Solar Water Heater Systems With and Without a Mini-Compound Parabolic Concentrating (CPC) Reflector($C < 1$) 2012, *5*, 911-924
9. S.S. Krishnananth, K. Kalidasa Murugavel Experimental study on double pass solar air heater with thermal energy storage(2013) 25, 135–140
10. A Hai, Qurat-ul-Ain To investigate the surface properties for increasing efficiency of solar water heater (2013)
11. Hussein ,M. S. Abd-Elhady, M. N. El-Sheikh and H. T. El-Metwally Improving Heat Transfer Through ParaffinWax, by Using Fins and Metallic Strips 2017
12. S. Saravanan1, N. Krishna Mohan Experimental investigation on the flat plate solar water heater with glass as absorber material *October 2016*
13. Sethuraman Ramasamy and Pakkirisamy Balashanmugam Thermal Performance Analysis of the Solar Water Heater with Circular and Rectangular Absorber Fins Vol. 2, Issue 1, January 2015
14. A.V.T.Shubhash, S.Karthick, S.Poornakumar, R.Vasanthakumar and Dr.P.Navaneethakrishnan CFD Investigation of Heat Transfer Enhancement in Flat Plate Solar Collector using Various Cross Sectional Inserts *Vol. 3, Issue 03, 2015*
15. K.Balaji , S.Iniyan and A.Idrish khan Thermodynamic analysis of a solar flat plate water heater using extended surface absorber tube *(2015)*
16. *Mr. M.V. Kulkarni, Dr. D. S Deshmukh* Design of Experiment for Solar Water Heater Performance Analysis
17. [1] Shkhair Mohammed M. and Dr.Sanke Narsimhulu (2015), "Solar flat plate collector heat transfer analysis in the raiser with helical fins", International journal of engineering & Science Research, Vol.5/issue-5,352-356
18. S. P. Sukhatme, J. K. Nayak ***Solar Energy*** Principle of Thermal Collection and Storage third edition The McGraw-Hill Companies
19. Chris Martin and Martin Watson.–Further testing of Solar Water Heating Systems. 2002 The Energy Monitoring Company Limited, U.K.

20. User's Handbook on Solar Water Heaters.–Ministry of New and Renewable Energy, Government of India. 2010 pp. 1-36.

BIOGRAPHIES

Selvam S received B.E- Mechanical Engineering degree in 2011 from skct, Coimbatore. Currently, M.E- Thermal Engineering student in Annamalai University, Chidambaram. He has four years experience in teaching at AVC polytechnic college, Mayiladuthurai. His research interest includes heat transfer and solar collectors. He has published international journal on finned tube solar water heating system.

Prathap A received B.E- Mechanical Engineering degree in 2016 from Annamalai university, Chidambaram. Currently, M.E- Energy Engineering student in Annamalai University, Chidambaram. His research interest includes heat transfer and gasification. He has published international journal on gasification.