Case Study of Solar Flat Plat Collector

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Abstract - - *Solar is the free source of energy available in the nature, now days most of the gadgets are electric, likely vacuum cleaner to electric vehicle. In general, it had found that, the energy utilization in the residential home and industrial applications for heating the water for other applicational use is usually developed by flat plate solar collectors. Even though there are verities of solar water heater equipment's with different configurations and cross-sections for the enhancement of the collector efficiency. This paper analyzes the implications on thermal performance when different paths and cross-sections & materials are adopted for the tubes (zigzag, u-bent double parallel etc.) of absorber plate.*

The comparison criteria will be adopted were constant area of cross section along flow path and constant perimeter of the tube flow path for different designs will be adopted in the analysis. This overall study envelopes the design parameters required for the enhancement of the flat plate solar collector using ANSYS CFD post processer to solve the model under transient mode.

Key Words - **Solar flat plate collector, Cross-sections, path, collector efficiency, Zig-Zag, parallel & U bent, ANSYS & CFD Analysis.**

1.INTRODUCTION

A Flat Plate Collector is another type of heat exchanger which converts the radiant solar rays or energy from the sun (natural resources) into the heat energy using greenhouse effect. As the rays directs over the plate, it gets hotter this heat is conducted by the risers and absorbed heat is transferred to the working fluid flowing inside the tube. Flat plate collectors are the best accessories to raise the temperature of the water through a collector.

A flat plat solar collector consists of the solar glass or tempered glass, copper tubes, absorber plate, collecting area or collector, water pump etc. As the heat directs over the tempered glass due to high radiant effects the rays are imposed on to, absorber plate and water inside the collecting area gets heated and this water can be used for domestic as well as automobile or any other aspects

Types of flat plate solar collector

There are two variations available in the collectors based on the working medium.

dependent on the type of heat transfer fluid, flat plate collectors are further classified in to two types and they are as follows

- Liquid Heating Collectors and
- Air or gas heating collectors.

1.1 Principle of Flat Plate Collector

The main principle behind the solar collector is simple and natural of habitats. Radiant energy of the sun is converted into useful heat energy. If a sheet metal is directed or exposed to a radiant sun the temperature on the plate rises until the rate at energy is received is equal to the heat loss from the plate. Which termed as equilibrium temperature. If the backside surface of the plate is supported by insulating material to protect from radiant remedies, if the plate is painted black colour and is covered by one or two glass then the temperature will be much higher compared to normal sheet exposed to the sun.

2.Problem Statement

If an electric water heater is not producing hot water, it could be a simple problem like a blown fuse or tripped circuit breaker. Additionally, some electric water heaters have a circuit-style safety switch located near or on the thermostat. For gas water heaters, it could be as straightforward as being out of gas. For heating water nowadays most of the electric Gizar, coils & electric water heater are in market, which requires a potential energy for operation in the form of electricity. More the use more the power source, also most of the solar products are also available but because of cost most of them not buy.

So, in order to overcome these problems, being a design engineer our proficiency is to reduce time, cost & effort. So, this project explains the design consideration for different path for tube, cross-section & parameter of flat plate solar collector will be varied and studied. To minimize the weight as well as cost selection of material play a vital role.

1. Over heating
2. Consumptions of electricity
3. Discolored water – Rusty water can indicate corrosion of your tank's inner lining, often caused by a failing anode rod while heating in a Gizar.

4. Not cost effective.

Maximizing temperature can affect in leaks, loose heating elements and can produce cracks as well

3. Objectives

1. To utilize free & natural renewable source of available energy.
2. To heat the water without any aid of power source or gas source applications.
3. To enhance the heat transfer rate by changing the flow path and comparing with thermal materials.
4. To study the CFD of solar flat plate collector.
5. To develop cost effective system.
6. To make use of lightweight materials for easy handling.

4. Current Approach

1. To study the online literature papers to know feasibility of the project.
2. To make material selection criteria for low weight, thermal application & enhanced heat transfer usage.
3. To analytically prepare heat conduction in collector.
4. To design a 3D model using CATIA v5 software with suitable parameters.
5. To simulate the prepared model in CFD post in ANSYS workbench.
6. To vary the flow path by changing the tube variations and solving for FEM to know whether system can produce higher efficiency.
7. To purchase the material according to the designed parameters and material selection.
8. To fabricate the work and test for the efficiency.

5. Scope

Because of dense land India is one of the major resources in solar because of high heat interaction during the summer season. Solar is a free powered source, about 25 % of total electricity in the world needs solar PV cells.

Because of electric era in transportation solar will become the no 1 generation of electricity for commercial and industrial applications.

6. Facility Required

Pre-Processing

- Geometry Modeling (using CATIA v5)
- Meshing (ANSYS)
- Material and Contact Definition (ANSYS library or self-material propagation from online survey)
- Loading and boundary condition (ANSYS)

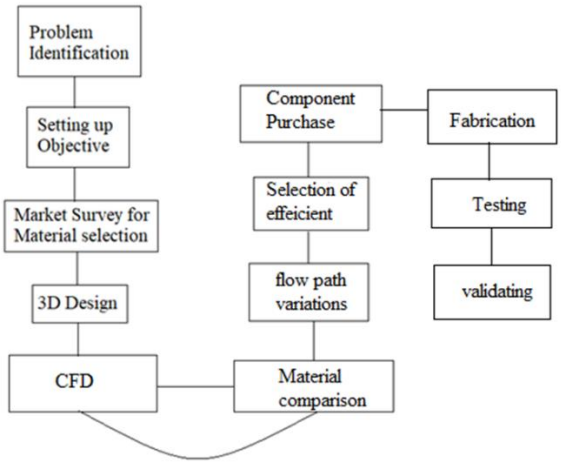
Solution & Post-Processing (ANSYS)

- Pressure
- Velocity stream line
- Temperature distribution in let, out let
- Transient CFD post processing

Facilities Required

- CATIA v5 design tool
- Surface designing or wireframe design – To create the 3D model of cabin mounting bracket.
- CFD system
- Material comparison of tubes
- Flow path variation of tube from parallel to u bent

7. Methodology



Flow chart No. 1 - Methodology of the project

Step 1: - I have started the work of this project with literature survey. Gathered many research papers which are relevant to this topic. After going through these papers, we learnt about

topology optimization, CFD post & pre-processing of the alternator project of our aim.

Step2: - After the study, material selection criteria are surveyed in the market according to availability and cost of material.

Step 3: - After deciding the materials, the 3 D Model and drafting will be done with the help of CATIA software.

Step 4: - FEM solution will be evaluated 1st using CFD post.

Step 5: - Material comparison.

Step 6: - varying tube cross-section.

Step 7: - Material Purchase.

Step 8: - fabrication.

Step 9: - testing

Step 10: - validating

Step 11: - thesis writing

8. Literature Review

In this project author had changed the cross section of tube from circular to semicircular to ellipse and solved using integrated technique. Following details can give us a brief idea.

Sr. No.	Author & title	Summary
1	Design and CFD Analysis of Solar Flat Plate Collector by Using CREO M.ALEKHYA	In this project cero software is used to simulate the FEA CFD post the heat transfer rate for depends on the working medium the author had solved the solution with 3 working mediums.
2	Design And Analysis of Flat Plate Solar Air Collector Mr.Arunprasad S, Dr.Saravanan P, Mr.Arulraj R	In this project author had consider working medium as air and different insulation material for the enhancement of the performance.
3	CFD Analysis Of Triangular Absorber Tube Of A Solar Flat Plate Collector Basavanna S And S Shashishekar	In this paper the author had changed the tube shape from circular to triangle to know the performance
4	Mathematical modelling and performance analysis of single pass flat plate solar collector Mohd Irshad, Anshul Yadav, Rajnish Singh, Anil Kumar	Inn this paper Various effective heat loss coefficient, and the efficiency of the collector was found to be 72.7 %, 8.422 W m- ^{2} K-1, 36.73 % respectively.

8.1 Literature Gap

After going to similar research papers, I have seen only cross section change of tube from square, circular, semi etc. and many had worked on the different fluids with parameter change. We can go for modification of project with different material for tube its cross section, path from parallel to zigzag, U- bent etc. as shown below

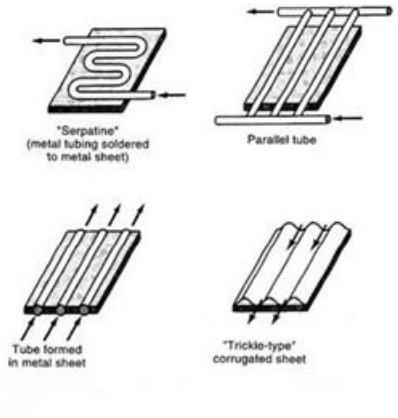


Fig No.1 – Patterns

9. Analytical Analysis of Solar Flat Plate Collector

Formulations :

Parent section Design parameters

1. Case dimension

Shell or thickness = 5mm = 0.005 m

Length of the case = 2000 mm = 2m

width of the case = 1000 mm = 1m

depth of the case = 30 mm = 0.03m

$Area$=4.329m^2

Assume total weight on collector including tube, Glazzing glass & absorber plate =10Kg

σ=$Force/Area$= (10∗9.81)/4.329=22.66$N.m$^2

2. Tube

Tube max diameter = 8mm

Tube min diameter = 6.35 mm

Length of the tube = 1900 mm

Area=$\pi XDminXL=\pi*6.35*1900=37903.31 mm$^2=0.037$m$^2

3. Header pipe

Pipe max diameter = 14 mm

Pipe min diameter = 12.7mm

Pipe length = 1050 mm

4. Collector glass

Length of the Thermal glass = 2000mm

Width of the thermal glass = 1000mm

Depth of the thermal glass = 3mm

A = 2((L*B) +(B*D) +(L*D))

= 2((2*1) +(1*0.003) +(2*0.003))

= 4.018m3

5. Absorber plate

Length of the absorber plate copper = 1950mm

Width of the absorber plate copper = 950mm

Thickness of the absorber plate copper = 0.16 mm

Water velocity is a measure of the speed of water flowing through a closed pipe system. Water velocity can be determined using a simple formula:

V = Q/A

Where,

• V = velocity

• Q = Flow rate

• A = cross-sectional area of pipe

The cross-sectional area of a pipe can be determined using the formula:

A = πr^2

r = radius of pipe mm = 6.35 mm $A=\pi*6.35^2$

= 126.67 mm2

Q = let us assume that the total water to be discharge is of 25 LPM

10 litre/minute = 0.0001666667 cubic meter/second

Q = 0.0004166667m^3/sec

= 0.41 kg/sec

V=0.0004166667126.67= **3.2896e-6 m3/sec**

Parameter Value

- Solar radiation = 1200 W/m2
- Mass flow = 0.41 kg/s
- Assume outlet temperature = 317.55 k
- Water inflow temperature = 295 K
- Velocity of the water = 3.2896e-6 m/sec
- The specific heat capacity of water is 4184 J·kg−1·c−1.
- Collector area = 4.18m2

The efficiency of the solar collector is determined by,

The analysis was carried out based on the following assumptions:

- The physical and thermal properties of the absorber plate, pipe and water are independent of the temperature.
- Water is a continuous and incompressible.
- The flow is stable and has characteristics of laminar flow.
- The heat loss from the bottom of the plate and the tube is by convection, which depends upon wind speed.

A constant heat flux (solar radiation) is applied to the upper part of the plate, whilst the lower part is established as a convective surface where the convective heat transfer coefficient is obtained by Gunjo.

$\eta=micp(To-Ti)IAc$

$=0.41X418.4X(317.55-295)1200X4.18$

$=0.771*100=\mathbf{77.1}\%$

Where:

m = Mass flow of fluid, kg/s

Cp = Specific heat of the fluid, J/kg-K

Ti = Fluid inflow temperature, K

To = Fluid outflow temperature, K

I = Solar radiation, W/m2

Ac = Effective area of the collector, m2

Heat gained through radiation

$Qt=\sigma eA(T24-T14)$

where σ = 5.67 × 10−8 J/s · m2 ·

K4 is the Stefan-Boltzmann constant,

A is the surface area of the object, and

T is its absolute temperature in kelvin.

The symbol e stands for the emissivity of the object, which is a measure of how well it radiates. An ideal jet-black (or black body) radiator has e = 1, whereas a perfect reflector has e = 0. Real objects fall between these two values. Take, for example, tungsten light bulb filaments which have an e of about 0.5, and carbon black (a material used in printer toner), which has the (greatest known) emissivity of about 0.99.

Qt=5.67e−8$X1X$4.18(317.54−2954) Qt=**613.50W**

Heat transfer in a parallel tube

Area of parallel tube = 0.037m^2

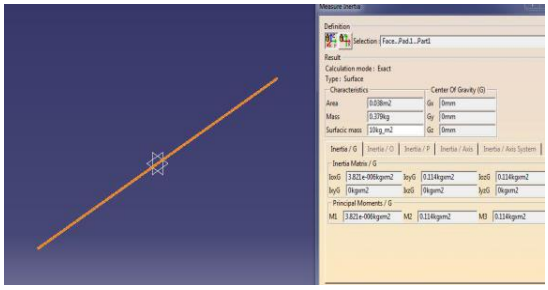


Fig-2: Straight Tube for calculation Purpose

$Q=\varepsilon\sigma A(T24-T14)$

Where,

Q = heat transfer through radiation

ε = $emissi\quad ity\ factor$=1

A = Area tube

T1 & T2 = temperature difference

Q=1∗5.67e−8∗0.037(317.554−2954)=**5.44395w**

10. Design

Procedure for 3D Development of model.

- Take tracing 2D drawing of any car model with standard dimensions available, and download.
- Open CATIA software, select sketch tracer from shape designing, select the downloaded 2D drawing and extract all the views on required plane, using create an immersive sketch.
- Now the importation part is over, after importation trace the sketch using free style section using desired plane. (Tracing involves creating of spline on a 2D drawing).
- Create nodes and join nodes using curvature.
- Extract the are to surface,
- Add material
- Offset thick surface to the required value.
- Convert to IGS or STP file for ANSYS import.

Parent section

Absorber plate

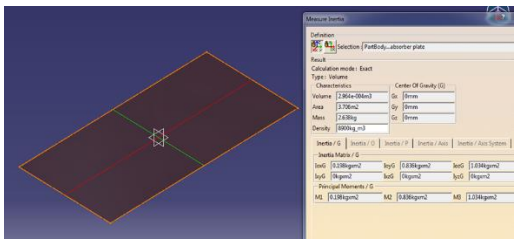


Fig-3: absorber plate

Assembly

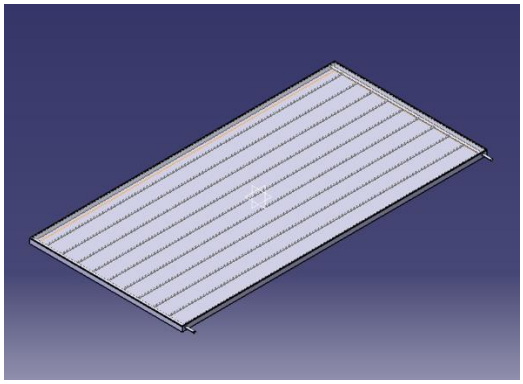


Fig-4: assembly of all sub parts

1. Tubes
2. Absorber plate
3. Glass
4. Collector
5. Black paint

Proposed design

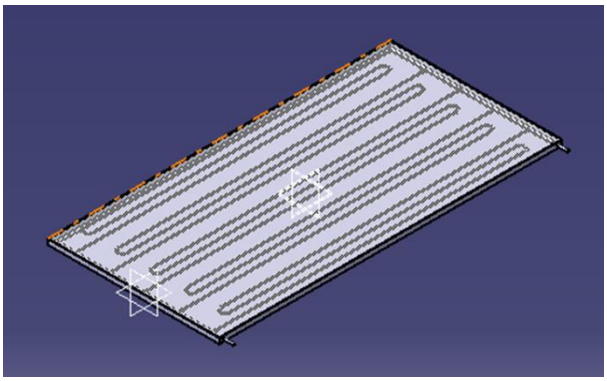


Fig-5: ISO view of proposed system u tube bent

Parameters

- Pitch between two parallel tube is 50 mm curve module is 50mm & length of u bent tube at one side is 1800mm and overall length of the tube from fixed to foxed is1900 mm.
- 5 number of tubes are used, diameters are same as per the parent section, we will convert this file into IGS or STP and use to solve the FEM solution.

11. Conclusion

Until now preparation of analytical calculation has been done parameters of the design has been set, also studied about the flat collector its working, terminology, materials and so on. We had given a list of materials that can be used to make the collector and performance enhanced.

Acknowledgement

The preferred spelling of the word

—acknowledgment‖ in American English is without an —e‖ after the —g.‖ Use the singular heading even if you have many acknowledgments

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BIOGRAPHY

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