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DESIGN AND ANALYSIS OF ABSORBER TUBE OF SOLAR PARABOLIC TROUGH COLLECTOR

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Abstract – *In this work, Computational Fluid Dynamics analysis has been conducted for the fluid flow in absorber tube of a parabolic trough collector with and without insertions. This project aims to improve the efficiency of the heat transfer rate from the absorber tube wall to the working fluid by using various types of inserts and internal fins. Some of the methods of increasing the efficiency of the heat transfer rate to the working fluid are: - (1) increasing the contact area of fluid with absorber tube, (2) using some obstacles such as insertion which increases the residual time of fluid and thus reducing pressure across the tube, (3) decreasing the velocity of the working fluid. The analysis has been carried out to study the effect of heat transfer in absorber tubes with various types of insertion profile and also to compare the results with absorber tube without insertion.*

***Key Words*: CFD, Heat Transfer, Solar Panels, Solar Energy, 3D VIEW.**

1. INTRODUCTION

Nowadays, improving the efficiency of collection and conversion, lowering the initial and maintenance cost, increasing the reliability and applicability make significant progress. Energy conversion system that is based on renewable energy technologies appeared to be cost effective compared to the projected high cost of oil. Further, renewable energy system can have a beneficial impact on the environmental, economic and political issues of the world. India can utilize the solar energy for some of the basic household needs. The roof top solar panels (solar cells) can generate electricity which can be used for lighting low capacity bulbs, solar oven, solar cooker, solar water heater and many solar powered appliances can be used to minimize the electricity utilization. A remarkable revolution or change can be made in India if every woman in the house uses solar appliances for household needs. As a result the energy demands can be reduced.

The solar to thermal energy conversion is the most efficient method for utilizing the solar energy. Some of the solar thermal storage methods are solar ponds, phase change material, solar collectors etc. Some of the solar collectors are Flat plate collector, Evacuated tube collector, parabolic trough, solar tower, Dish collector, Advantages of solar concentrating collectors includes its higher temperature and performance efficiencies, its low cost design due to utilization of available components like mirrors, metal sheets etc., its reliability as a secure and inexhaustible source of energy. The Australian National University solar concentrator dish of 500m^2 is currently producing super-heated steams up to 550^{0}C at 5Mpa is the world's largest dish. The largest solar thermal power plant using PT technology include the 354MW SEGs plants in California. Harmful gases coming out from Thermal power plant where coal is used as a fuel can be minimized. Coal plants are the largest producers of carbon emissions, which contribute to global warming. Oil hurts the planet too. Each year in America alone, over one million gallon petroleum spill into waterways, oceans and groundwater. That's why solar power is so important. It can reduce pollution and harm to environmentWe ask that authors follow some simple guidelines. In essence, we ask you to make your paper look exactly like this document. The easiest way to do this is simply to download the template, and replace(copy-paste) the content with your own material. Number the reference items consecutively in square brackets (e.g. [1]). However the authors name can be used along with the reference number in the running text. The order of reference in the running text should match with the list of references at the end of the paper.

2. SOLAR CONCENTRATING POWER

Solar radiation arriving at the Earth's surface is a fairly dispersed energy source. The photons comprising the solar radiation can be converted directly to electricity in photovoltaic devices or in concentrating solar power (CSP). In the latter case, the solar radiation heats up a fluid that is used to drive a thermodynamic cycle. Opposed to photovoltaic cells or flat plate solar thermal collectors, the diffuse part of the solar irradiation which results from the scattering of the direct sunlight cannot be concentrated and can therefore not be used in CSP power plants. In the CSP technology, concentration of sunlight using mirrors or optical lenses is necessary to create a sufficiently high energy density and temperature level. Solar concentrating systems enable the thermal conversion to be carried out at high solar flux and with relatively little heat loss.

3. LITERATURE REVIEW

R. Thundil Karuppa Raj et al. [1] done experimental and numerical analysis using CFD Technique of the performance of the absorber tube of a solar parabolic trough collector with and without insertion. They performed their experiment in Renewable Energy Laboratory at VIT University. The Dimensions of SPTC in which they performed the experimental performance are as follows:- Width of the collector is 0.91m, Length of the collector and absorber tube are 1.5m, Rim angle is 90°, Absorber tube outer and inner diameter are 15mm, 14mm respectively. The experimental result that is the mass flow rate of the fluid for which the maximum inner-outer temperature difference occur is used for analysis. They performed CFD analysis for both absorber tube without insertion and absorber tube with cylindrical insertion and they found that the presence of insertion in the absorber tube gives a higher temperature rise of 0.5°C when compared with the absorber tube without insertions.

Syed Ameen Murtuza et al. [2] in their work made an effort to evaluate the performance of a designed 5m length Parabolic Trough Solar Collector model. Heat collecting element was made of stainless steel with water as working fluid. The length and width of the collector are 5m and 1.5m respectively. The authentication of the proposed model is justified based on the results obtained on a yearly scale with respect to average inlet and outlet temperature, surface temperature and thermal efficiency for the climatic conditions of Ramanagaram. They observed that March to May yield better outlet temperature ranging from 93°C to 103°C. They found that February to May gave good surface and outlet temperature as compared with other months while the flow is laminar.

4. METHADOLOGY

4.1.MATERIALS SELECTION AND PROPERTIES

Fluid Medium: Water. The water is selected as the fluid medium and the properties of water are

Density – 1000 kg/m^3.
C_{pw} (Specific Heat) – 4185.5 j/kg-K.
Thermal Conductivity – 0.6 W/m-K.
Viscosity– 1.793×10^{-03}kg/m-s.
Mass flow rate of water –0.023611kg/s

4.2 Absorber Tube and Fin Material: Copper. The copper is selected as the absorber tube and fin material and the properties of copper are
Density – 8940 kg/m^3.
C_p (Specific Heat) – 376.812 j/kg-K.
Thermal Conductivity – 401 W/m-K.
Outer diameter of the tube –15mm
Inner diameter of the tube –14mm
Length of the tube –500mm
Inlet temperature –307K
Ambient pressure – 101325 Pascal
Wall temperature –333k
All the above properties of water and copper are constant.

5. INTRODUCTION OF CFD

Computational fluid dynamics modelling was developed to predict the characteristics and performance of flow systems. Overall performance is predicted by breaking the flow system down into an appropriate number of finite volumes or areas, referred to as cells, and solving expressions representing the continuity, momentum, and energy equations for each cell. The process of breaking down the system domain into finite volumes or areas is known as mesh generation. The number of cells in a mesh varies depending on the level of accuracy required, the complexity of the system, and the models used. Equations solve for flow (x, y, and z velocities), energy (heat fluxes and temperatures) and pressure based on various simplifications and/or assumptions.

5.1. SEQUENTIAL STEPS FOR ANALYSIS

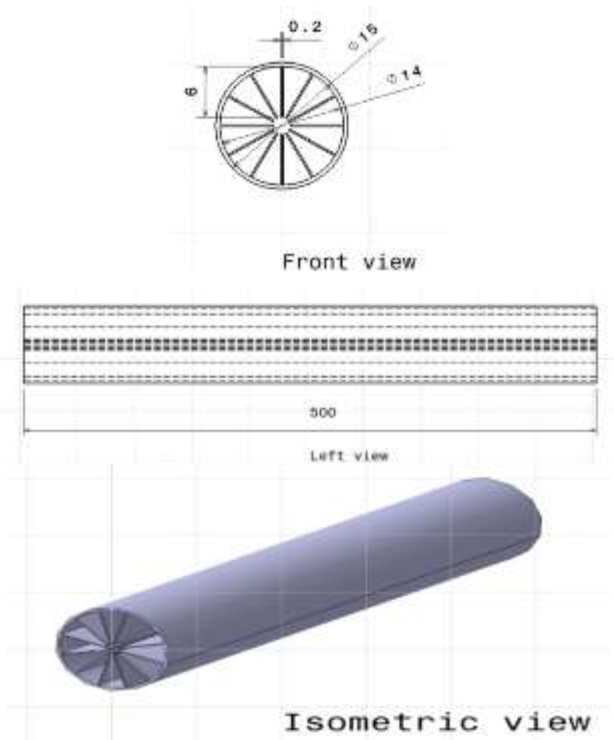

Fig 1. Views of rectangular tube

5.1. MESHING

Fine meshing with high smoothing is done. The size of the mesh can also be defined. In this analysis we use minimum mesh size as 0.0001 m and the maximum mesh size as 0.001 m. Immediately after meshing the named selection is done for the meshed model which will be helpful in applying boundary conditions. In this we gave inlet, outlet and wall as named selections.

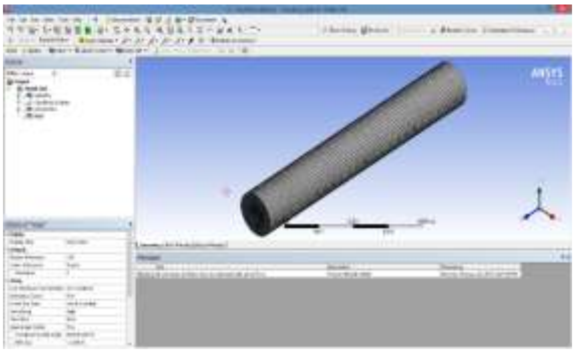

Fig 2. Mesh of the absorber tube with insertion

5.3. BOUNDARY CONDITIONS SETUP

The wall material is selected as copper and the working fluid as water. Steady state analysis is done. The ambient temperature and pressure are given as 307 K and 101325 Pa respectively. The following boundary conditions remain the same for all absorber tube

Inlet: The inlet temperature of the water is 307 K. The velocity of the water flowing inside the absorber tube is varied from 0.1 to 1.2 m/s up to which the outlet temperature of the water is approximately equal to the inlet temperature.

The inlet boundary conditions are given to the fluid flowing inside the absorber tube. The figures 4.10 and 4.11 shows the inlet boundary conditions (Temperature and Velocity) that are given to the water.

6. RESULTS AND DISCUSSION

The outlet temperature of the water are found for rectangular absorber for different velocities such as 0.1m/s, 0.3m/s, 0.5m/s, 0.7m/s, 0.9m/s and 1.2m/s. The results are found for wall temperature at 333K.The fin which produces maximum temperature difference (T_{out}-T_{in}) is found.

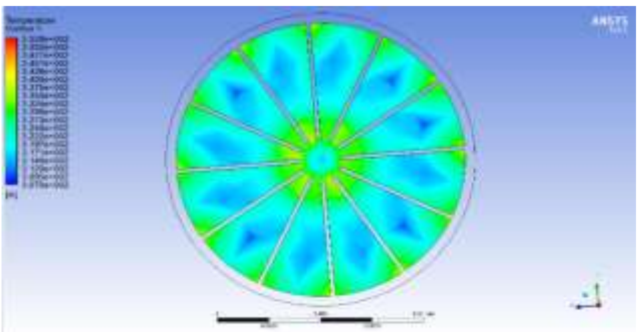

Fig 3. Outlet temperature distribution of Rectangular tube (with insertion)

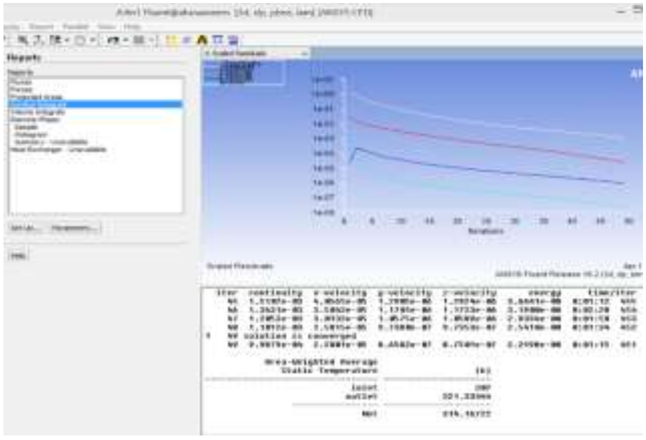

Fig 4. Outlet temperature of Rectangular tube

From fig 3 and 4 indicates outlet temperature contour and results for the rectangular tube. The outlet temperature of rectangular tube is 321.3K.

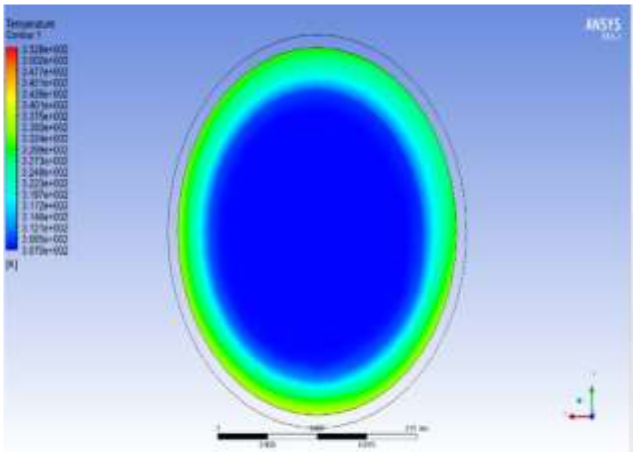

Fig 5. Outlet temperature distribution of normal tube (without insertion)

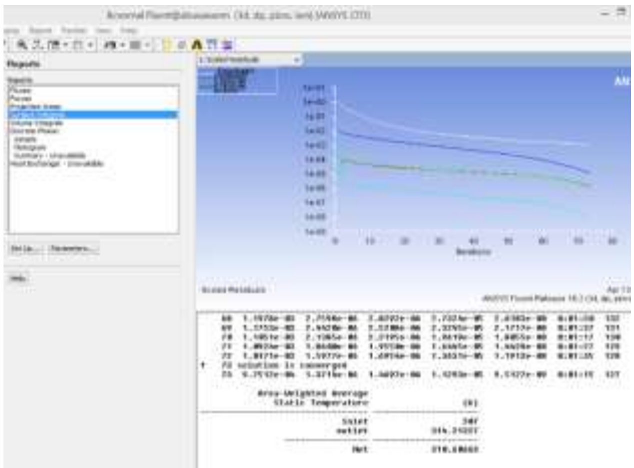

Fig 6. Outlet temperature of normal tube

From fig 5 and 6 indicates outlet temperature contour and results for the normal tube. The outlet temperature of rectangular tube is 314.2K.

7. CONCLUSION

From fig 4 and 6 indicates outlet temperature results for rectangular and normal tube. The prescence of the insertions in the absorber tube gives a higher temperature rise of 7.1K when compared with the absorber tube without insertions. From the comparison, it was inferred that the absorber of with rectangular fin insertion exhibits superior performance than without fin.

8. REFERENCES

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