NUMERICAL ANALYSIS OF TWISTED TAPE ABSORBER TUBE OF SOLAR PARABOLIC TROUGH COLLECTOR

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Abstract – *In this work, Numerical analysis has been conducted for the fluid flow in twisted tape absorber tube of a parabolic trough collectors. This project aims to improve the efficiency of the heat transfer rate from the absorber tube wall to the working fluid by using twisted helix fin. 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 and also to compare the results with different velocity profile.*

***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, Compound parabolic concentrator. 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. Thus the air pollution rate and global warming can be reduced.

2. DESCRIPTION OF SOLAR COLLECTOR

Solar energy is converted into thermal energy using a special kind of heat exchanger known as a solar collector. Solar collectors can be classified into two general categories: (i) non-concentrating and (ii) concentrating. In the non-concentrating type, the collector area (the area that intercepts the solar radiation) is the same as the absorber area (the area that absorbs the radiation). Flat plate collectors (FPC) and evacuated tube collectors (ETC) are non-concentrating type collectors. These collectors are mainly designed for solar hot water and industrial process heat applications which require energy delivery at temperatures in the range of 60-250°C. These collectors use both diffuse and beam solar radiation and do not require tracking of the sun. They are mechanically simpler than concentrating collectors and require less maintenance. The different types of non-concentrating and concentrating type collectors are shown in Figure 3.1. In the concentrating type solar collector, various types of mirrors, reflectors or concentrators are used to concentrate the solar energy and they provide higher temperatures.

3. PARABOLIC TROUGH COLLECTOR

PTC system is a renewable energy technology, which converts solar radiation that strikes earth daily to useful thermal energy. The Parabolic trough collector are found suitable in tropical climate where the proportion of diffuse solar radiation is high. Usually a parabola has a focus point. All the radiations (sun rays) which strikes the parabolic collector will concentrate at the focus point. It is constructed as a long parabolic mirror with an absorber tube running its length at focal point. Sunlight is reflected by the mirror and concentrated on the absorber tube. Water passes through the absorber tube is heated due to transfer of heat primarily by means of convection with the absorber tube wall. The size of the parabolic trough used varies depending upon the applications, required focus temperature.

FIG 2.1. Parabolic Trough Collector

4. THERMAL FLUID

Parabolic trough solar collectors utilize a heat transfer fluid (HTF) that flows through the receiver collecting and transporting solar thermal energy to the power block. The choice of the thermal fluid or heat transfer fluid (HTF) can affect the kind of storage technologies that can be used in the plant. Several HTF options may be used in PTC solar plants. The selection of the HTF is related to the required temperature and further options like storage. Thermal oils are commonly used as the working fluid in PTC plants for temperature above 200˚C because the use of water can raise the price of the solar plant since it would produce high pressures inside the receiver tube and piping. Biphenyl-diphenyl-oxide, known by trade names Therminol VP-1 and Dowtherm A is widely used and has shown excellent stability. Although it is flammable, safety and environmental protection requirements can be satisfied with reasonable effort.

5. MATERIAL SELECTION

5.1. 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

5.2 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

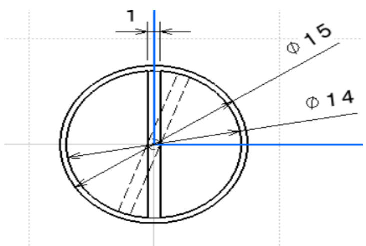
Wall temperature –333k

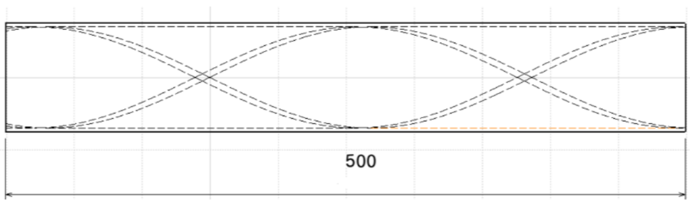
All the above properties of water and copper are constant.

6. INTRODUCTION OF FIN

A fin is a surface that extends from an object to increase the rate of heat transfer to or from the environment by increasing convection. The fins increase the effective area of the surface thereby increasing the heat transfer by convection. The amount of conduction, convection, or radiation of an object determines the amount of heat it transfers. Increasing the temperature difference between the object and the environment, increasing the convection heat transfer coefficient, or increasing the surface area of the object increases the heat transfer.24 Sometimes it is not economical or it is not feasible to change the first two options. Adding a fin to an object, however, increases the surface area and can sometimes be an economical solution to heat transfer problems.

6.1. SEQUENTIAL STEPS FOR ANALYSIS





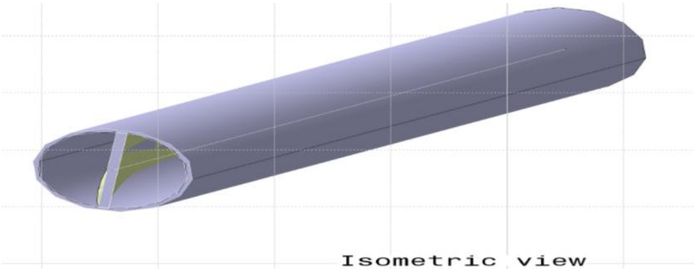


Fig 1. Views of Twisted Tube Insert

6.2. MESHING OF OUTER TUBE

The named selection of the model is important in applying boundary conditions. The named selection can be done by right clicking on the model and it should be done after meshing. The surface of the absorber tube is named as wall and is shown in the figure 2. The back face of the absorber tube is named as inlet, through which the water enters the absorber tube whereas the front face of the absorber tube is named as outlet.

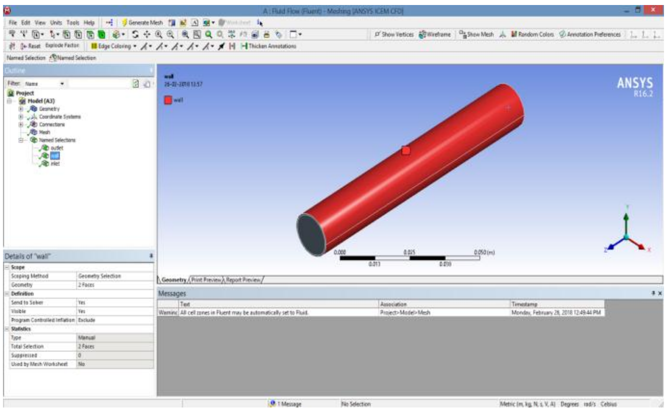


Fig 2. MESHED TUBE

6.3. 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 remains 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 0.1 and 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.

7. RESULTS AND DISCUSSION

The outlet temperature of the water are found for twisted tube for different velocities such as 0.1m/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.

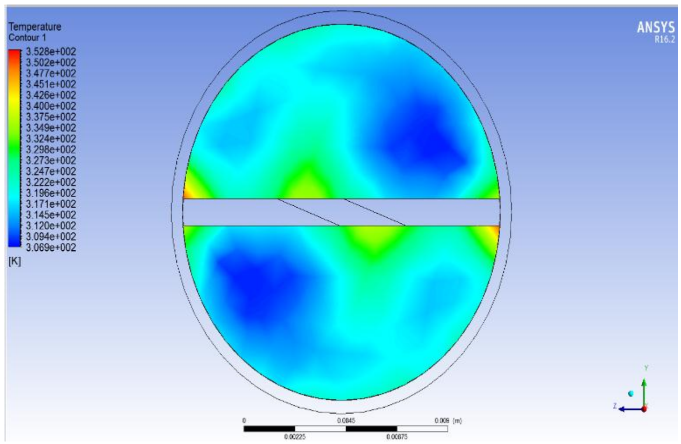


Fig 3. Outlet temperature distribution of Twisted tube at 0.1 m/s velocity

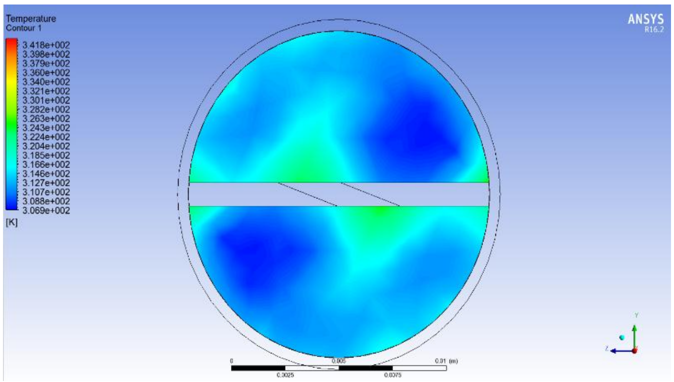


Fig 4. Outelt temperature distribution of Twisted tube at 1.2m/s velocity

From fig 4 and 5 indicates outlet temperature contour and results for the twisted tube. The outlet temperature of twisted tube is 322K and 309K.

8. CONCLUSION

From fig 3 and 4 indicates outlet temperature results for twisted tube insert. The prescence of the insertions in the absorber tube gives a higher temperature at 0.1 m/s velocity which is 322k whreas at 1.2m/s the temperature is 309k. From the comparison, it was inferred that the absorber of with twisted tube fin insertion exhibits superior performance at minimum velocity.

9. REFERENCES

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