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Design and Heat Transfer Analysis of a Parabolic Shaped Solar Dish Collector

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ABSTRACT:

The paper focuses on solar parabolic dish collector with truncated cone shaped helical coiled receiver made up of copper and coated with nickel chrome at focal point, which is designed and modeled using 3D modeling software Pro/Engineer. The present model has 15 coils for solar receiver. To investigate the performance of the collector, a 20 coiled receiver is also studied. Heat transfer analysis is done on the dish collector by applying different temperatures effecting in a particular day. Comparison is done between the two models. CFD analysis isalso done to determine the outlet fluid temperature, mass flow rates etc. Heat transfer analysis and CFD analysis is done by using CFD ANSYS 14.5.
Key wards:Solar Parabolic Dish Collector; Helical coil receiver collector; 20Turns; 15Turns. Heat transfer

I. NTRODUCTION:

Parabolic dish is a point focusing collector; it is used for the applications, where temperature requirements are very high like in steam generation. This collector requires two axes tracking for to focus the radiations on the absorber Solar Dishes use a parabolic mirror to concentrate solar energy at its focal point. Then a receiver, mounted at the focal point, converts the energy of the sun's rays into heat. The heat gained produces a temperature of between 125 °C to 250 °C and this is used to drive a micro-Steam Turbine or small Sterling Engine that generates electricityA parabolic dish concentrates only the direct radiation that enters the system parallel to its optical axis. So, the solar dish has to be oriented always towards the Sun. As it is a point-concentrating system, it requires a two-axes trackinglike other point-concentrating systems it reaches very high concentration ratios, which are much higher than the ones of line-concentrating systems these high concentration ratios result in high receiver temperatures realized systems have reached temperatures above 750°C. Such high operating temperatures allow a high thermal-mechanical energy conversion efficiency and, consequently, high solar to electric efficiencies.We know that our sun is actually a very large and hot star emitting lots of power in its rays. How do we go about harnessing that power effectively, so it can help generate electricity, which is an important part of modern life? The sun's rays transmit both heat and light. The heat is used in thermal systems to produce hot water and hot air for commercial and residential heating use, as well as power generation with steam or sterling engines.

2. METHODOLOGY:

2.1 Modeling Helical coil for receiver solar collector:

Modeling starts with the describing of the boundary and initial conditions for the dominion and leads to modeling of the entire system. Finally, it is followed by the analysis of the results conclusions and discussions .CFD modeling of a simplified solar collector (Helical Coil for receiver) was to be investigated by using model of helical coil has15 turns for receiver solar collector. In this development of the model,a simplified helical coil for receiver of solar collector by increasing the number the turns of helical coil to 20 turns for solar receiver and also working fluid used as water; then Comparison is done between the two models to obtain the best heat transfer with increased surface area of helical coil and increased the efficiencyof helical coil for receiver solar collector.

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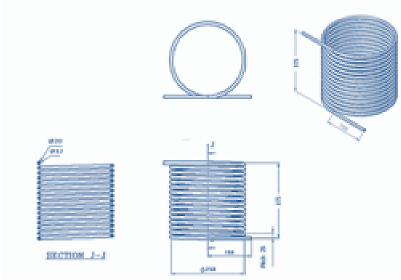

Fig2.1Helical coil 15 turns

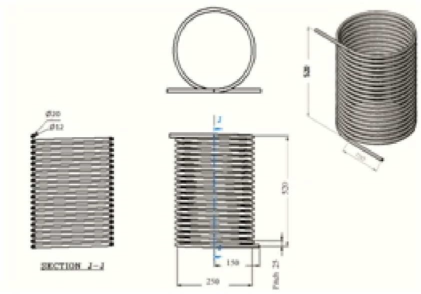

Fig 2.2Helical coil 20 turns

Table 2.1. Dimensions of 15 turn Helical coil

Coil parameter	value
Outer Diameter of the coil	250 mm
Inner tube	12 mm
Outer tube	20 mm
Thickness	4 mm
Length	375 mm
Pitch	25 mm

Table 2.2. Dimensions of 20 turn Helical coil

Coil parameter	value
Outer Diameter of the coil	250 mm
Inner tube	12 mm
Outer tube	20mm
Thickness	4 mm
Length	520mm
Pitch	25 mm

2.2CFD Meshing:

The three dimensional computational domain is modeled using (Tetra/Hydro) mesh as shown in Figures shown below. Then after making model by using ANSYS Work beach 14.5 Export to Influent CFD with extension (ANSYS ICEM CFD tetrahedrons) after that , import to Influent make boundary mane input coil (inlet water) outlet coil to (out water).

Table 2.3The mesh details view gave us the following information

Helical coil 15turns	Helical coil 20turns
Relevance Centre: fine meshing	Relevance Centre: fine meshing
Smoothing: high	Smoothing: high
Nodes: 1201902	Nodes: 1614264
Elements: 832032	Elements:7389082

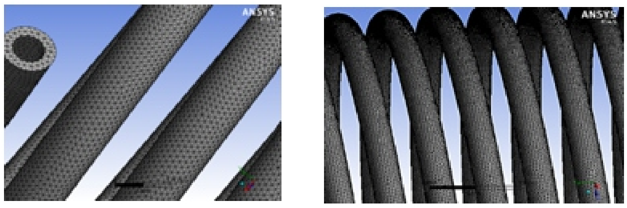

Figure 2.3Meshed model.

2.3BOUNDARY CONDITIONS:

Boundary conditions are used according to the practical situation. The inlet and outlet conditions are defined as velocity inlet and pressure outlet. After completing the mesh by CFD fluent 14.5 imported the mesh to CFD-Work bench 14.5 to inter the boundary condition inter the inlet condition water mass flow rate 0.11304 Kg/s. initial Temperature of water is 308K and take material from library is water at 100 with initial properties Material Description = Water (saturated liquid) at 100 Density = 958.4 kg/m^3, Molar Mass = 18.02 kg/kmol, specific Heat Capacity = 4215.7J/kg K, specific Heat Type = Constant Pressure. Reference Pressure = 1.014 bar, Reference Specific Enthalpy =1.5552049E+7 J/kg, Reference Specific Entropy = 4.8215097E+03 [J/kg/K], Reference Temperature = 100, Dynamic Viscosity = 2.817E-4 kg/m s, Thermal Conductivity = 0.6791 W/m K, Absorption Coefficient = 1.01/m, Scattering Coefficient = 0.0 1/m Thermal Expansively = 7.4E-04 1/K.

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Table 2.4 The Properties of the (copper)

Copper Parameter	value
Density(copper)	8978kg/m³
Specific heat(copper)	381J/kg-K
Thermal conductivity(copper)	387.6W/m-K

Table 2.5The Properties of the water

Water Parameter	value
Density (water)	1000 kg/m³
Viscosity (water)	0.008 kg/m s
Specific heat (water)	4.187kJ/kg-K
Thermal conductivity (water)	0.6 W/m-K

Assumptions:

- Water is a continuous medium and incompressible.
- The flow is steady and possesses turbulent flow characteristics.
- The thermo-physical properties of the absorber dish collector and absorber tube are constant with respect to the operating temperature.
- The bottom portion of the absorber tube and bottom face of the absorber dish collector is assumed to be adiabatic.

2.4Analysis:

Thepapercontains a detailed description of the analysis and results which were obtained for the concentrating solar energy. Starts with an overview of the solar calculations needed for the solar concentrator to get the heat flux solar energy. An analysis to get the results for the receiver of solar concentrator in CFD fluent to get the temperature of steam from outlet of receiver. its performance and increase the heat transfer rate between the absorbing the helical coil of the solar collector receiver and working fluid.

So that The purpose of this study is to investigate the theory behind solar water collectors and the potential techniques available in order to find ways to enhance its performance and increase the heat transfer rate between the absorbing the helical coil of the solar collector receiver and working fluid. Analysis has completed of the helical coil of the solar collector the goal is to improve the efficiency of the helical coil of the solar collectors. The main focus was on the helical coil of the solar collectors which are commonly used. A modified shape of the helical coilwas created with the aim to examine how the heat transfer intensification technique using the taken are 20 turns in the receiver with the helical coil(copper) medium in the receiver the use of Computational Fluid Dynamics (CFD) was a very important tool to obtained detailed numerical data on heat and mass flow transfer in the proposed design solution.

3. RESULTS AND DISCUSSION:

The result contains analysisfor testing performed of the helical coil for receiver had applied in both of the modeling (modified and simple).The first thing should be complete the mesh of model by using CFD work bench 14.5 and open the result in the CFD fluid flow (fluent), the inlet data used is for 1st May 2015 between the time 7:00 AM to 7:00 PM day in year the temperature distribution in XYZ plan in define the cross section area of receiver as show the temperature of water increase from 308K to 411K for helical coil 15turns and the temperature of water increase from308K to 468k helical coil 20 turns.

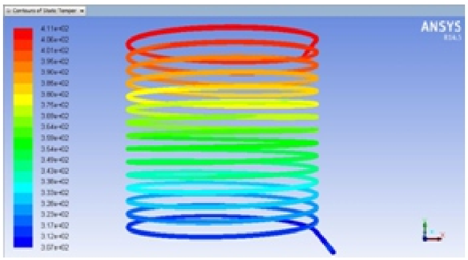

Figure 3.1 Temperature in oK for Simple helical coil 15 turn.

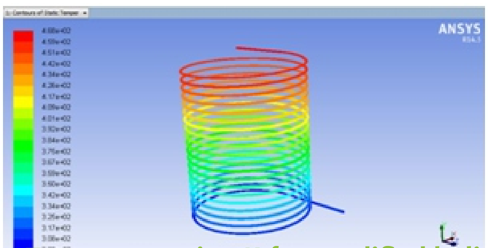

Figure 3.2 Temperature in oK for modified helical coil 20 turn.

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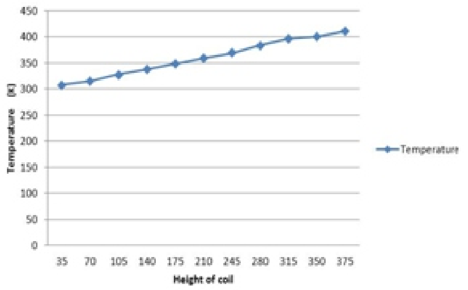

Figure3.3Temperature gradient of helical coil 15 turns.

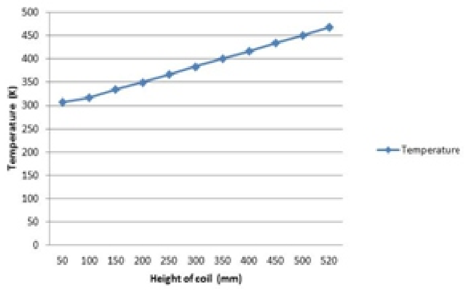

Figure3.4Temperature gradient of helical coil 20 turns.

Boundary condition had applied in both of the modeling (modified and simple) and will observe the different temperature. CFD simulation has performed of the helical coil receiver solar collector with increasing the number the turn's helical coil to up to20turns for extending the heat transfer area and enhancing the convective heat-transfer coefficient, resulting in improved device performance of coil receiver solar water heaters with water as working fluid. The modified has been completed on the simple helical coil. The temperature is improved around 57that means the heat transfer rate also increased; the goal to enhancement the performance and reduce the heat loses.

Temperature inlet = 308 oK
Mass flow rate = 0.114 Kg/s
Heat flux = 1353 KW/m2

A graphical representation of the temperature compared in K for both of the modeling (modified and simple) along the length of the heating tube is shown in Figure 3.5. The temperature (blue line) refers to the helical coil 15 turns and the temperature (red line) refers to the helical coil 20 turns. The temperature increase in the heating tube is higher all along its length compared to that of a conventional collector displayed by the (blue line).

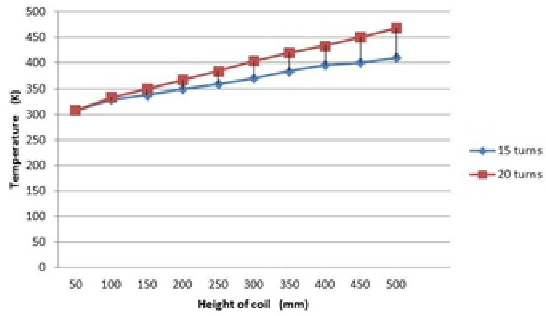

Figure 3.5Comparsion between different Temperatures for both of modeling in K along the length of heating helical coil tube.

Pressure distribution:

The pressure value increased in the helical coil pipe at same given boundary conditions in both cases, the pressure value of the coil 20turn increased up to 0.37MPa compared with the pressure value of the coil 15 turn0.277MPa, respectively. Due to do modified on the shape of the helical coil receiver the pressure of fluid became higher than the simple helical coil receiver.

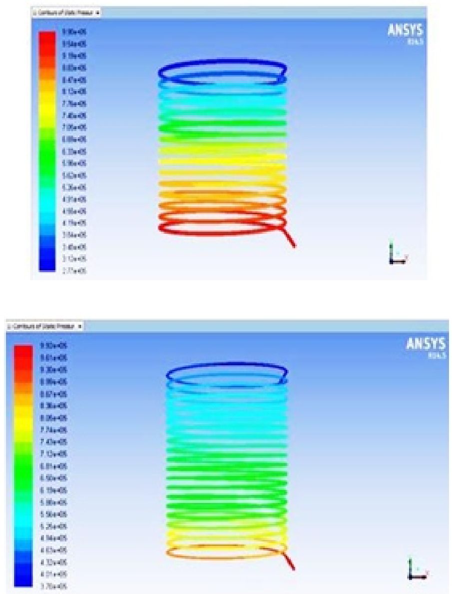

Figure 5.6 Pressure for both modeling (simple and modified).

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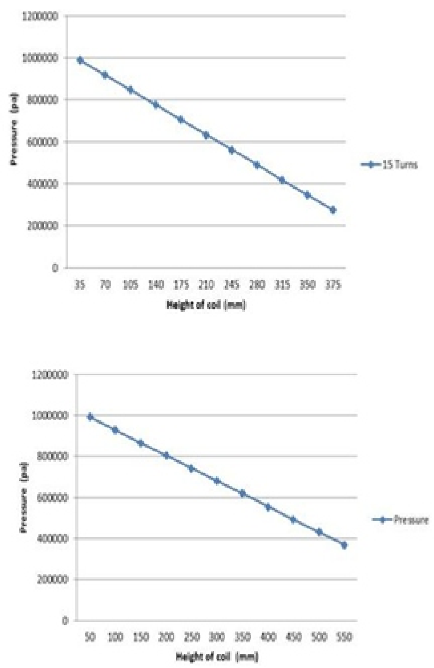

Figure 5.7 Pressure gradients for both modeling (simple and modified).

In this case pressure drop is increased due to change the shape of tube. In the straight flow with constant cross-sectional helical coil tubes, pressure increases from the entrance and the red line represents the pressure increases at inlet of the helical coil pipes and the blue line represents the pressure decrease at outlet of the helical coil pipes for both of the modeling due to momentum losses.

The pressure difference compared in Pa for both of the modeling (modified and simple) along the length of helical coil tubes presented in Graph 3.4. The red line represents the pressure of the helical coil 20turn and the blue line represents the pressure of the helical coil 15turn.

The pressure value increased in the pipe receiver at same given boundary conditions in both cases, the pressure value of the coil 20turn increased up to 0.37MPa compared with the pressure value of the coil 15 turn0.28MPa, respectively.

Due to do modified on the shape of the helical coil receiver the pressure of fluid became higher than the simple helical coil receiver.

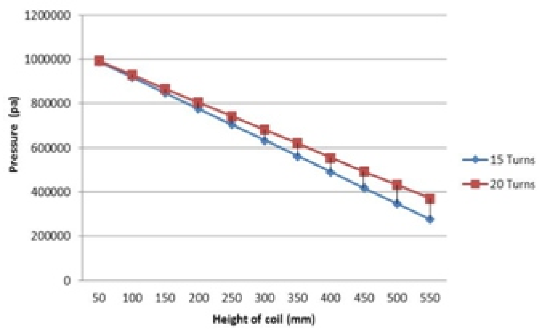

Figure 3.4 Pressuredistributions for both modeling (simple and modified).

CONCLUSIONS:

Parabolic dish concentrator and modeling of the helical coil receiver are created by using 3D modeling software Pro/Engineer, where the helical coil receiver is the most important part in the parabolic shaped solar dish collector system. The helical coiled pipe made up of copper. The helical coil pipe consists from 20 turns The diameter of the helical coil 250 diameter (mm). The inner tube 12 mm diameter. The outer tube 20 mm. The thickness is 4 mm .The length of the helical coil receiver 520 mm and the pitch between the helical coil tubes are 25 mm. The location of Hyderabad (India) is identified by latitude 17.4056 and longitude 78.45. The other parameters declination angle, zenith angle extraterrestrial solar radiation, atmospheric extinction of solar radiation, clearness index and insolation for the day considered and for different hours from7.00 Am to 7.00 Pm are used in the design and making the modal of dish, frame and receiver modal by software Pro/e. The model is investigated by using model of helical coil consisting of 15 turns for solar receiver and after that the model is modified by increasing the number of turns to 20 turns for solar receiver to obtain the best heat transfer and increased surface area of helical coil receiver and for increased efficiency of coil of solar collector. After that modification simulation is carried out by completing the mesh of model by using CFD work bench 14.5 and opened the result in the CFD fluid flow (fluent). The inlet data is used for the day on 1st May 2015 between the 7:00 AM to 7:00 PM. The outlet temperature of working fluid for the temperature distribution in XYZ plane is presented. The temperature of water increased from 308K to 411K for helical coil of 15turns and the temperature of water increased from 308K to 468K for helical coil of 20 turns. The temperature/heat of fluid can be used by micro-turbine to generate electric power in domestic steam power plant.

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