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Comparative Study of Solar Flat Plate Collector with Circular Tube using different Nano Fluids

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Abstract: Solar energy is one the most popular renewable energy sources that can be used in a Thermal or Photovoltaic system. Solar collectors Play a key role in solar thermal systems. They convert solar radiation into heat and transfer the heat to working fluids Such as water or air. Flat-plate collectors are the most common type of solar collector and are typically used as a water heater or air heater. These collectors have a low efficiency and low outlet temperature. Recently, many researchers have attempted To enhance the efficiency and performance of flat-plate collectors via different methods. One of the methods For improving the performance of flat-plate collectors involves Using nano fluids instead of common fluids in solar collectors. Nanofluids are suspensions comprising base fluids such as water and nano particles 1–100 nm in size. These types of working fluids have more thermal properties than their base fluids. Solar liquid collectors are potential candidates for enhanced heat transfer. The enhancement techniques can be applied to thermal solar collectors to produce more compact and efficient energy collection/storage mechanism. Those collectors can be induced for simplest and most direct applications of energy conversion of solar radiation into heat. The present study examines and compares the heat transfer characteristics of different fluids for solar plate collectors for increasing the performance and efficiency SFPC. From CFD Simulation results we can conclude that among the four nano fluids which we have used in the current study for increasing the heat transfer characteristics of the solar collector, CuO + Water nano fluids have a great heat transfer rate as compared to others. Absorbing Temperature and Reynold Numbers are much higher in case of CuO + Water nano fluids than the other nano fluids we used.
Key words: Solar collector, Nano fluids, Radiation model, Numerical Simulation, CFD, Experimental Analysis, Fluent , etc.

I. INTRODUCTION

Nanofluids-Nano fluids demote to a solid-liquid mixture or suspensions produced by dispersing tiny metallic or nonmetallic solid Nano particles in liquids. Nanofluids are a new class of fluids engineered by dispersing nanometer sized materials (Nano-particles, Nano-fibers, Nano-tubes, Nano-wires and Nano-rods) in base fluids. The size of nanoparticles (usually less than 100nm) in liquids mixture gives them the ability to interact with liquids at the molecular level and so conduct heat better than today's heat transfer fluids depending on Nano particles. Nanofluids can display enhanced heat transfer because of the combination of convection & conduction and also an additional energy transfer through γ-particles dynamics and collisions. Metallic nanofluids have been found to possess enhanced thermo physical properties such as thermal conductivity, thermal diffusivity, viscosity and convective heat transfer coefficients compared to those of base fluids like oil or water. In current years, nanofluids established greater potential in many fields like solar collector and solar thermal storage. Even though some review articles involving the progress of nanofluids investigations were published in the past several years most of the reviews are concerned with the experimental and theoretical studies of the thermo physical properties or the convective heat transfer of nanofluids.

A. Classification Of Nanofluids

Nano fluids can be normally classified into two categories metallic nanofluids and non-metallic nano fluids. Eastman et al, [16] theoretically studied the atomic and micro scale-level characteristic behavior of nano fluids. The result shows that the enhancement of thermal conductivity, temperature dependent effects and significant raise in critical heat flux. Metallic nanofluids often refer to those containing metallic nano particles such as (Cu, Al, Zn, Ni, Si, Fe, Ti, Au and Ag), while nano fluids containing non-metallic nano particles such as aluminum oxide (Al_2O_3), copper oxide (CuO) and silicon carbide (SiC, ZnO,TiO_2) are often considered as non-metallic nanofluids, semiconductors (TiO_2), Carbon Nanotubes (SWCNT, DWCNT and MWCNT) and composites materials such as nano particles core polymer shell composites. In addition, new materials and structure are attractive for use in nano fluids where the particle liquid interface is doped with various molecules.

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B. Classification Of Solar Collectors

Solar radiation is converted into thermal energy in the focus of solar thermal concentrating systems. These systems are classified by their focus geometry as either point-focus concentrators (central receiver systems and parabolic dishes) or line-focus concentrators (parabolic-trough collectors (PTC) and linear Fresnel collectors). Most popular types of solar collectors are parabolic Dish, Parabolic Trough and Power Tower system.

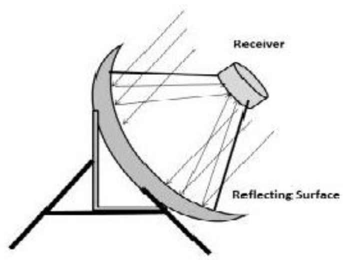

Figure 1.1: Parabolic Dish Collector

Firstly, the parabolic dish system Figure (a) uses a computer to track the sun and concentrate the sun's rays onto a receiver located at the focal point in front of the dish. Parabolic dish systems can reach 1000 °C at the receiver, and achieve the highest efficiencies for converting solar energy to electricity in the small-power capacity range.

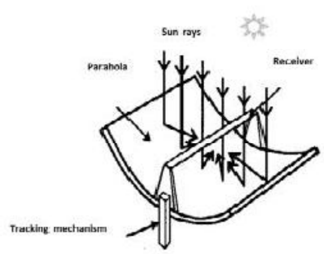

Figure 1.2: Parabolic Trough Collector

Secondly, the parabolic troughs concentrate sunlight onto a receiver tube that is positioned along the focal line of the trough Figure (b). Occasionally a transparent glass tube envelops the receiver tube to reduce heat loss. Parabolic troughs often use single axis or dual-axis tracking system which permits temperatures at the receiver can reach 400 °C and produce steam for generating electricity.

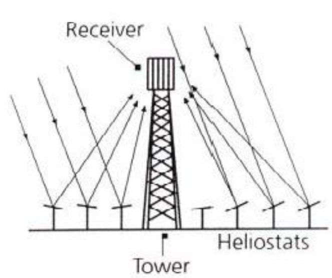

Figure 1.3: Power Tower System

Thirdly, the heliostat uses a field of dual axis sun trackers that direct solar energy to a large absorber located on a tower Figure (c). A solar power tower has a field of large mirrors that follow the sun's path across the sky. The mirrors concentrate sunlight onto a receiver on top of a high tower and computer tracks the mirrors aligned consequently the reflected rays of the sun are always aimed at the receiver, where temperatures reach above 1000°C and produce high pressure steam for generating electricity. Finally, this categories of collectors were used which reduces heat losses and increases efficiency at high temperatures and thermal detoxification.

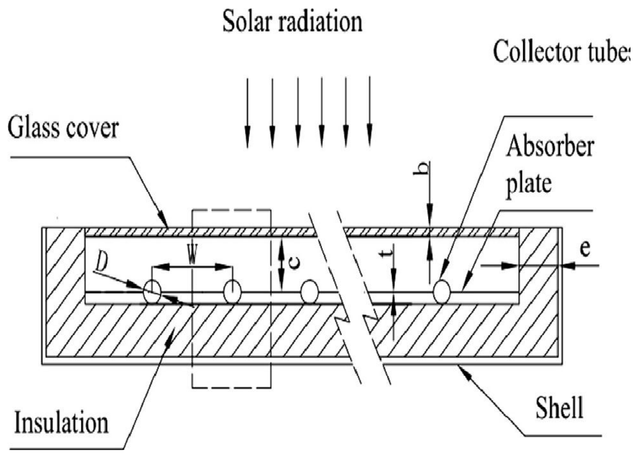

Figure 1.4: Sketch of a flat-plate solar collector

The flat-plate solar collectors are the non-focusing-light components which receive the solar radiation and transfer heat to the heat transfer fluid in the solar collector system. The structure of absorber is form of flat (Dhariwal and Mirdha, 2005), which is shown in Figure d. Its working principle is as follows: the sunlight through the glass cover tothe absorber which transforms solar into heat and transfers heat to the heat transfer fluid, which finish the process of solar-thermal conversion. At the same time, during the process of heat transfer, the collector will lose part of heat because of conduction, convection and radiation. The present study on the flat-plate solar collector is mainly focus on its thermal performances.

C. Solar Installations Worldwide

Some solar ponds from different parts of the world with different environmental and climatic conditions are covered briefly to show the diversity of how the concept manifests itself in various environments. Solar pond constructed in Jordan’s arid climate is a perfect fit for its location where studies show the mathematical modeling behind the plant and the efficiencies of energy storage in the different layers of the pond namely the NCZ and the LCZ. The temperatures reach high values with the ambient temperature in the surroundings reaching a peak of 40°C near the UCZ. The main purpose of the pond is desalination which is like the one at Pyramid Hill. None of the research points to the method of monitoring of the pond or the accuracy of the measurements. The area around the Dead Sea is known for having excessive levels of salinity and solar ponds being a viable and economically feasible option for the area[5]. The pond at El Paso in Texas is probably the most famous of the solar pond installations in the world and serves as a benchmark for technology associated with Salinity Gradient Solar Pond (SGSP). The DAQ system measures properties related to the pond as temperature, turbidity, density and pH by means of a scanner which has measuring points along the depth of the pond. The data obtained is logged using a computer from a location nearby. A sixteen year study with its focus mainly on this pond shows how temperature measurements were taken twice a day with other data logged at different frequencies to monitor the pond and ensure its smooth operation. The other pond, in Tibet, is unique with respect to its location because it works in such low temperature that the maximum temperature is well under 50 °C but in regions where the minimum ambient temperature is negative during winter, the positive temperature difference of 29 °C shows prospective for development and desalination. A distinctive feature of this pond is that it uses a variety of salts to create the salinity gradient mainly by magnesium salts. A shortcoming of the study conducted tells us that, the duration of the study does not give conclusive results as it ran only for a period of 105 days and not through the whole year. The system at El Paso is diverse because of the magnitude of the project; the sensors work much faster and can make recordings of the physical quantities in a shorter time span as compared to other systems. The level of automation in this plant is also higher, allowing for readings to be taken and analyzed more quickly. The data obtained at this plant however is stored only locally and analyzed at the Texas A&M University. This is good from a data security point of view but limits future research into the plant as the real time data cannot be passed onto researchers at other places who could potentially improve the results of the plant . Researchers in Algeria have built experimental solar ponds within the University of Annaba to study the effects of the use of different salts in the ponds as the brine solution. The heat transfer between the pond and the surroundings has been analyzed using the law of conservation of energy. The theoretical results have then been compared with the experimental results which have almost negligible level of errors. The temperature monitoring was done with the help of a thermocouple at a frequency of three hours. One of the major contributions of this study was the identification of the thermal conductivity of salts such as Sodium Carbonate and use of Calcium Chloride as a brine solution for newer sites because of its high conductivity. Solar ponds have been constructed in Turkey with surface areas and almost uniform depth for two separate cases to study the effect of the amount of sunny area in a zone of a solar pond mainly the LCZ. It is expressed as a ratio of total area with solar radiation incident on the area. This study allows for modeling of solar ponds prior to construction with better accuracy as we the researchers go beyond numerical modeling of the pond and it is a very important aspect to any environment. By knowing the temperature variance in an area coupled with the cloud cover for different times in the year, the study could determine a novel approach to thermal efficiencies obtained from ponds in different parts of Turkey. Researchers in Cyprus have constructed a pond and used Computational Fluid dynamics to study the pond using Ansys as a software. The purpose of this study was to compare the results obtained from the pond with other forms of Solar harvesting namely flat plate collectors and panels. The study also revolved around the comparison of salt concentrations at different depths of the pond as time passed and the weather conditions in the area changed. This model has an interesting take on solar ponds as this model has not been presented in the past and hence no basis of comparison unless carried out under different circumstances. One of the best examples of a solar pond is the one in Catalonia. There is a circular 50 m2 pond. The depth of the pond is 3m and the salt used is NaCl. The density profile of the pond along the depth is varied between 1.12g/cm3 to just over 1.2g/cm3. The salt concentration was roughly 25% by weight while filling the pond up which was done with a help of a diffuser. It is one of the more effective ways of creating salinity gradient associated with solar ponds. One important feature presented in this article was the use of the Froude number to determine inlet flow velocity which is useful to take into consideration when designing solar ponds at any site around the world. Froude number is defined as the ratio of the flow inertia to the external environment field. The pond recorded a peak temperature difference of about 16°C based on monthly averages. The entire list of sensors used to measure other parameters is summarized in the article. The study mentions the equipment used but does not mention how the data was analyzed and where it was transmitted to. The other major takeback from the study was the identification of the variability associated with the conditions prevalent to the UCZ. Solar pond systems can be compared to other renewable energy collection systems which may or may not involve solar energy. Each system usually has its own unique characteristics but may require the measurement of similar physical quantities which might need to be transmitted and analyzed away from the source. One such system which uses data transmission, and analysis has been studied, uses the server client mechanism over a TCP/IP protocol. This study is a generic investigation for renewable energy sources, used for energy generation, and is commendable as the results from the sensors for the renewable energy can be shown on the client computer in a user-friendly format using a Java applet. The software for the system which maintains the readings is also written in Java. This paper however does not get into the specifics of how accurate the readings are or the plethora of applications it can be applied but merely mentions it.

II. LITERATURE

Technical Institute / Hawija, Northern Technical University, Iraq- An empirical and theoretical investigation was achieved on a cylindrical storage collector. It was suggested in this work for a cylinder to be cut at an inclined cutting plane. The tests were achieved for both summer and winter climate conditions with and without hot water removal. The hourly system performance parameters were investigated systematically for different experiments. These included the average storage temperature, velocity distribution, and temperature distribution. In the cylindrical collector, the ultimate magnitude of the average storage temperature was 25 °C, while the maximum temperature at the tip of the cylindrical collector was 58 °C for a typical spring day. Meanwhile, the rectangular collector can warm up the stored water to a temperature of 23 °C, when the inlet water temperature was 12 °C. The performance of the new solar collector was, in general, similar to the performance of the conventional thermosyphon flat plate solar water heaters. The Fluent program was used to confirm the experimental results. The free convection in the cylindrical collector was investigated based on the method of control volume. From the Fluent data and analysis of the collector, the temperature and velocity distributions throughout the day were obtained. The Fluent program data was well compatible with the experimental results. 2. Ranjith P. V.a,*, Aftab A. Karimb -Solar liquid collectors are potential candidates for enhanced heat transfer. The enhancement techniques can be applied to thermal solar collectors to produce more compact and efficient energy collection/storage mechanism. Those collectors can be induced for simplest and most direct applications of energy conversion of solar radiation into heat. This work presents a comparative representation of computational simulation and experimental for the processes occurring in liquid flat-plate solar collectors. The working fluid used is propylene glycol and the concentration of propylene glycol (PG) is varied for various mass flow rates. The effect of this variation, on the efficiency of a flat plate solar collector was investigated computationally and experimentally. The experiments were carried out using 4 different mixture concentrations. The designed model is simulated under various flow conditions by varying the mass flow rate and varying the working fluid concentration. In order to verify the designed model and results, an experiment was designed and conducted for several days with variable ambient conditions, flow rates and concentrations. The comparison between the computed and measured results of the fluid temperature at the collector outlet showed a satisfactory convergence. The model is appropriate for the verification of overall efficiency of the system and can be used for any number of working fluids in order to find the outlet temperature. 3. Lippinpaulya*, L Rekhab, Christy V Vazhappillya, Melvinraj C Ra -Solar energy is one of the renewable energy sources which have potential for future energy applications. The current well-liked technology converts solar energy into electricity and heat individually. In this paper, an effort is made to simulate and evaluate the overall performance of a hybrid photovoltaic thermal (PV/T) air collector using computational fluid dynamics (CFD) software. The numerical analysis of the flow and heat transfer in hybrid PV/T systems is computationally quite complicated and the number of research works on this topic is quite low. Based on numerical analysis, the performance of a solar hybrid PV/T air collector has been studied. The numerical simulation was done in commercial software ANSYS FLUENT 14.5.0. The electrical energy conversion in solar cell was calculated with user defined function. The numerical results are validated with experimental results from literature. The results show a good agreement between experimental and simulated result for outlet air temperature and PV cell temperature. Using validated model, effect of mass flow rate and duct depth on the performance of solar hybrid PV/T collector has been studied and optimum values are identified. In order to increase the overall performance of a solar hybrid PV/T air collector, a novel design is proposed here. The result shows in the proposed design gives 20% enhancement in overall performance compared to conventional solar hybrid PV/T air collector. 4. Adrian Ciocăneaa*, Dorin Laurențiu Burețea -The effect of vibrations over a flow tube from a solar water heating collector was studied in order to enhance the heat exchange. First, a hydrodynamic model for the internal flow of the tube was proposed, in order to obtain the pattern for the relative motion of the liquid. The results highlighted a strong exchange of liquid volumes between the upper and the lower part of the pipe over the transversal section of the tube for a vertical displacement of the flow. In order to validate the positive effect of the internal motion over the heat transfer between the pipe and the water flow, an experiment was accomplished. The flow tube filled with liquid was introduced in a water recipient and vibrated at several frequencies. The water temperatures inside and outside the tube were recorded. The values for water temperatures measured during the warming and cooling intervals confirm that by vibration, the time for heat exchange is decreasing if the vibrating frequencies near the resonance frequency are considered.

III. OBJECTIVE OF THE STUDY

This investigation will presents a summary about Nano fluid with solar collector applications, an existing emerging class of heat transfer fluid, in terms of barriers, future research and environmental contests. Nano fluids are used to enhance the performance of many thermal engineering systems.

The main objective is to prepare a CFD model and using Nano fluid as flowing fluid, which examine the efficiency of square flat plate solar collector and enhancement in heat transfer with the use of different Nano fluid as compare to water . Therefore we are agreeing the simulation method to resolve the problem of Use of Nano fluid in the flat plate collector and to come to be the improved results by using computational fluid analysis in ANSYS 14.5 by FLUID FLOW (FLUENT) solver.

IV. METHODOLOGY

A. Pre Processing

1) *CAD Modelling:* Creation of CAD Model by using CAD modelling tools for creating the geometry of the part/assembly of which we want to perform FEA. CAD model may be 2D or 3D.
2) *Type of Solver:* Choose the solver for the problem from Pressure Based and density based solver.
3) *Physical model:* Choose the required physical model for the problem i.e. laminar, turbulent, energy, multiphase, etc.
4) *Material Property:* Choose the Material property of flowing fluid
5) *Boundary Condition:* Define the desired boundary condition for the problem i.e. velocity, mass flow rate, temperature, heat flux etc.

B. Solution

1) *Solution Method:* Choose the Solution method to solve the problem i.e. First order, second order.
2) *Solution Initialization:* Initialized the solution to get the initial solution for the problem.
3) *Run Solution:* Run the solution by giving no of iteration for solution to converge**.**

C. Post Processing

For viewing and interpretation of result, this can be viewed in various formats like graph, value, animation etc.

D. CFD Simulation Method

The ANSYS 14.5 finite element program was used for analyzing Pipe flow. The equation of motion of Pipe is solved using FEA tool (ANSYS 14.5 – Fluid flow Fluent) as the equation of motion for a Pipe is difficult to visualize therefore some FEA tool is the only solution method for analyzing hydrodynamic characteristics. To find out the Reynolds number for different Nano fluid we are adopting Reynolds stress model for CFD simulation.

E. Step1 -Geometry Generation

The geometry and mesh was created by using ANSYS FLUENT 14.5 .The FLUENT is an integrated postprocessor for CFD analysis. The sequences of fluent steps are shown in Figure 4.1.

F. Pre-processing

Therefore the geometry will be taken for the simulation for different Nano fluid like SiO2 + Water as Case 1, AL2O3 + Water as Case 2, Ti2O + Water as Case 3&CuO + water as Case 4 was shown below in figure 4.1

Table 1 Parameters of geometry

S. No	Dimensional Parameters	Dimensions
1	Tube outer Diameter& thickness	7.6 mm & 1.0
2	Tube internal diameter	6.5 mm
3	Dimension of Frame (aluminum)	1070 mm x 1070 mm (diagonal) for all pipe diameter

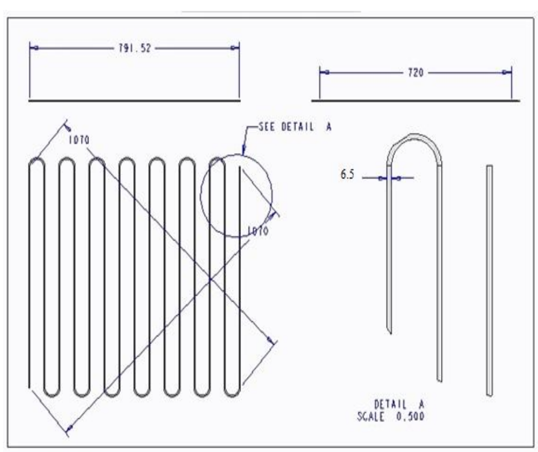

Figure 4.1: 2D diagram for 6.5 mm pipe diameter &for different Nano fluid

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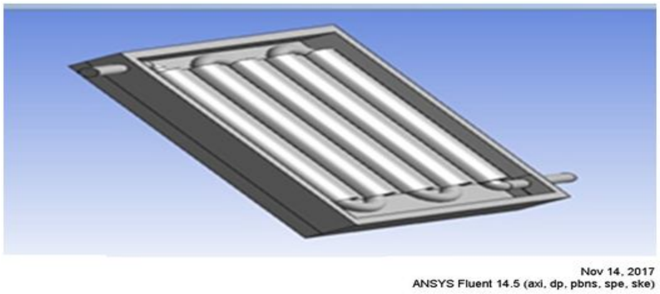

Figure 4.2: CAD model of flat plate solar collector

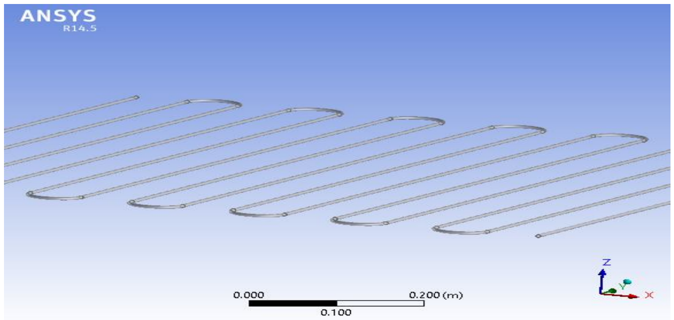

Figure 4.3: CAD model for 6.5 mm pipe diameter &for different Nano fluid

1) *Step 2 –Meshing:* Mesh – Generate mesh model in the ANSYS Making meshed model of flat plate collector pipe. Meshing is a critical operation in CFD. In this operation, the CAD geometry is discretized into large numbers of small elements and nodes. The arrangement of nodes and elements in space in a proper manner is called mesh. The analysis accuracy and duration depends on the mesh size and orientations. With increase in mesh size (increasing number of element), the CFD analysis speed decreases but the accuracy increases.

Table 4.2: Meshed geometry of tube diameter 5.1 mm pipe diameter

Mesh type	Fine grid mesh
No. of nodes	1026512
No. of elements	631536

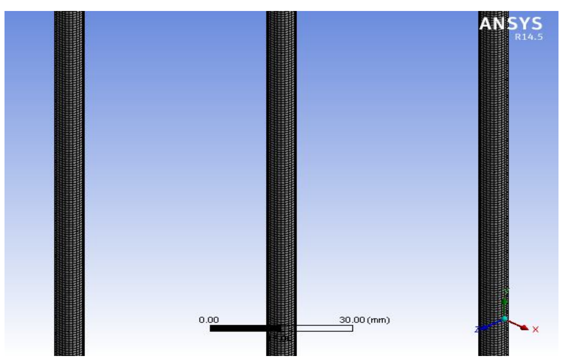

Figure 4.5: MESH MODEL

2) Step 3-Setupfor SimulationFluent Setup: After mesh setup generation define the following steps in the ANSYS fluent 14.5

a) Problem Type -3D solid

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b) Type of Solver – pressure
c) Physical Model – Turbulence model

3) Step 4 -Boundary conditions
Boundary Conditions

Table 4.3:Boundary Conditions

Constant wall temperature (Ti)	273 K
Constant heat flux	1.8 W/m-k
Outlet ($P_{out.}$)	Pressure outlet
Solver type	Pressure based
Velocity formulation	Absolute
Time	Steady
Energy & viscous	On & laminar
Volume concentration	2%
Mass flow rate	5 kg/s
Operating condition pressure	1 bar
Working fluid	SiO2 + Water, AL2O3+ Water, Ti2O+ Water, and CuO+ water

Fluid Property

Table No.4.4: Fluid Property

Type of fluid	SiO2 + Water	AL2O3+Water	Ti2O+Water	CuO+ water
Density (ρ) kg/m^3	2650	1037.4	1034.9	1136.7
Viscosity (μ x 10^4) (kg/m-s)	4.271	4.271	4.271	4.271
Specific heat (C_p)J/Kg-K	680	4119	4117	4111
Thermal conductivity (k)W/m-K	1.3	0.744	0.730	0.749

4) Step 5– Solution: Solution Method Pressure - Velocity - Coupling – Scheme - Simple

a) Pressure – standard pressure
b) Momentum- 2nd order
c) Turbulence –kinetic energy 2nd order
d) Turbulence dissipation rate 2nd order

V. RESULTS & DISCUSSION

Validation and comparison between Water, Water+ Nano-fluid Al_2O_3(Experimental) and Water+ Nano-fluid Al_2O_3 (CFD Simulation)

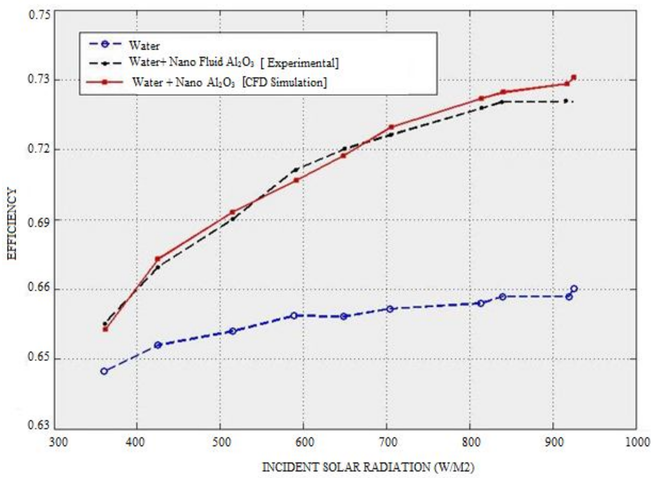
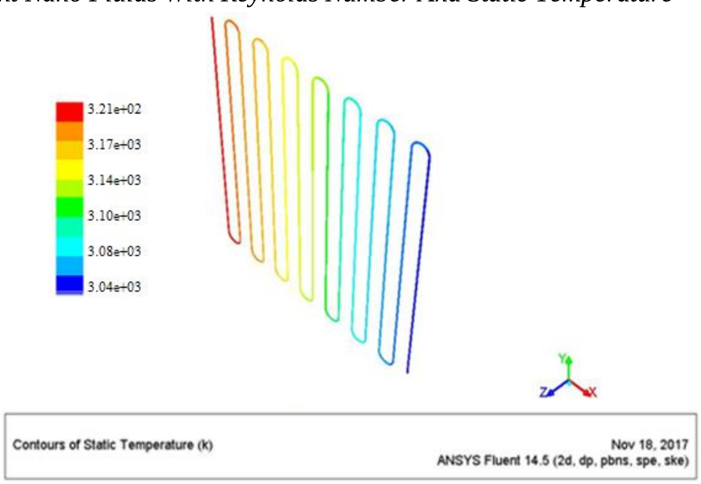


Figure 5.1: Validation with experimental data and CFD simulation

The efficiency is compared with reference paper results for 6.5 mm pipe diameter for Al_2O_3+ water Nano fluid. For the water and Al_2O_3/Water Nano fluid the data were in used from the experimental results. Comparison between Experimental and CFD simulation is performed with the help of ANSYS (Fluent 14.5), which shows in graph. First we compare the efficiency between Fluid and water + Al_2O_3 as experimental results given, as we see in graph the efficiency of water is 0.66 and for Nano fluid its value is 0.725. CFD Simulation shows that when we taken Nano fluid Al2o3 with water its efficiency is near about 7.32. Now we can say clearly that the result obtained from CFD simulation for 6.5 mm diameter for (Al_2O_3 + water) Nano fluid is in good agreement with experimental results and we gained the increase value of efficiency, which is directly proportionate to heat transfer.

A. Comparison Between Different Nano Fluids With Reynolds Number And Static Temperature



(a)

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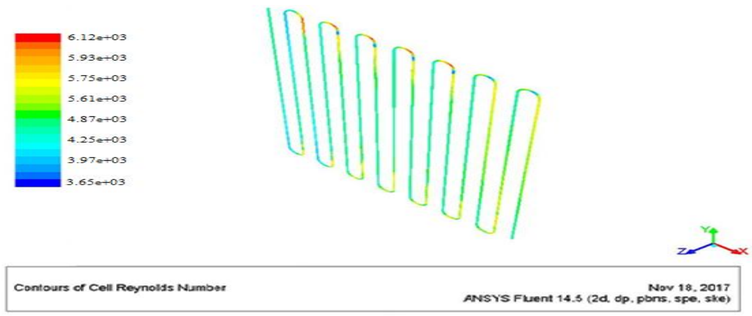

(b)

Figure 5.2: (a) & (b) Represents Contour of total temperature &Reynolds number for SiO2 + water Nano fluid respectively . As of figure 5.2 (a), the value of Reynolds number is 6120 for 6.5 mm pipe diameter and for SiO2 + Water Nano fluid (i.e. Case 1).From figure 5.2 (b), the maximum outlet value of total temperature for SiO2 + water Nano fluid is 321 k for 6.5 mm pipe diameter and for SiO2 + Water Nano . This is maximum value as compared to experimental SiO2 + Water Nano fluid for pipe flow.

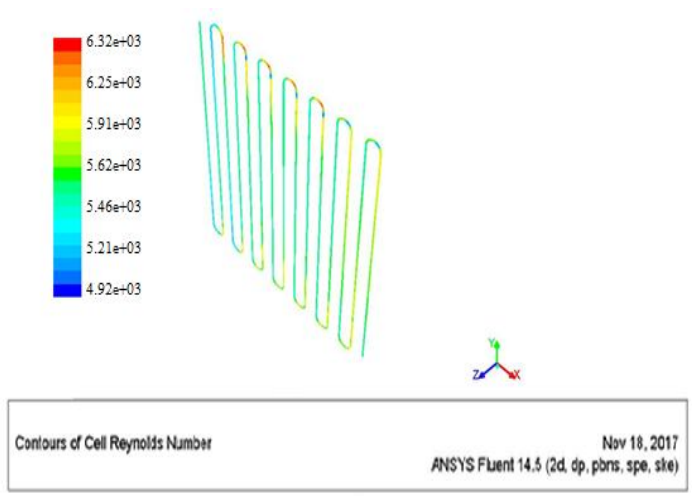

Figure 5.3: Contour of Reynolds number for (AL2O3+ water) Nano fluid.

From figure 5.3 the value of Reynolds number is 6320 for 6.5 mm pipe diameter and forAL2O3 + Water Nano fluid (i.e. Case 2). This is maximum among all other Nano fluid.

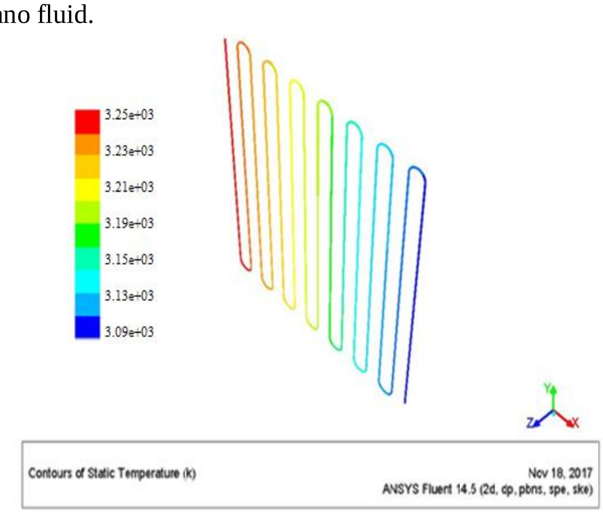

Figure 5.4: Contour of Static Temperature for (AL2O3+ water) Nano fluid.

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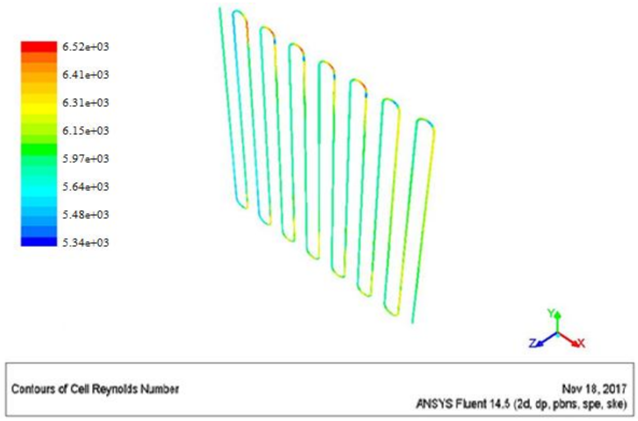

Figure 5.5: Contour of Reynolds number for (Ti2O + water) Nano fluid

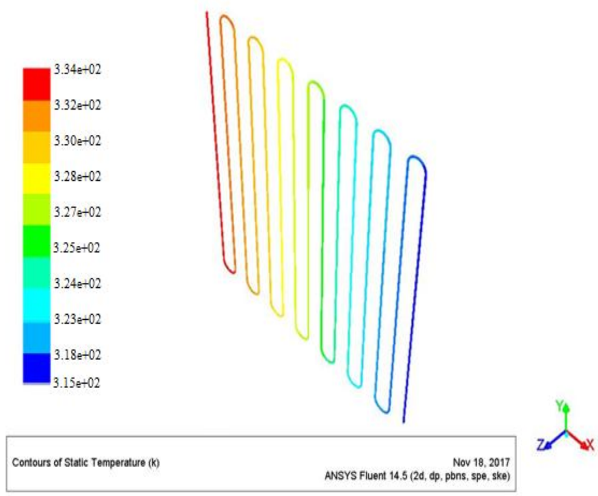

Figure 5.6: Contour of Static Temperature for (Ti2O + water) Nano fluid.

From figure 5.4 the value of Reynolds number is 6520 for 6.5 mm pipe diameter and forTi2O + Water Nano fluid (i.e. Case 3). This is highest among all other Nano fluid.

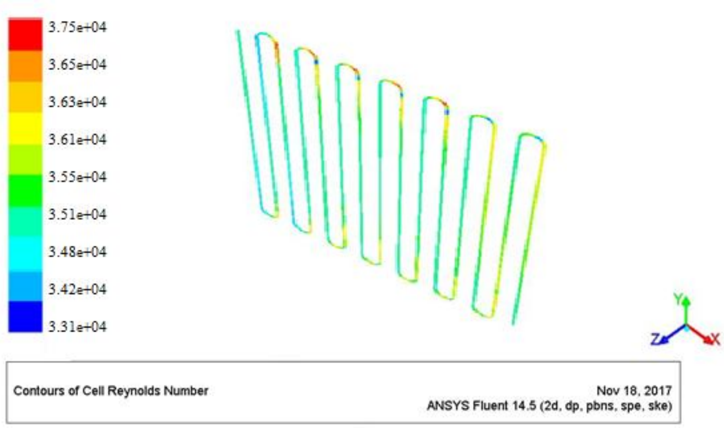

Figure 5.7: Contour of Reynolds number for (CuO + water) Nano fluid.

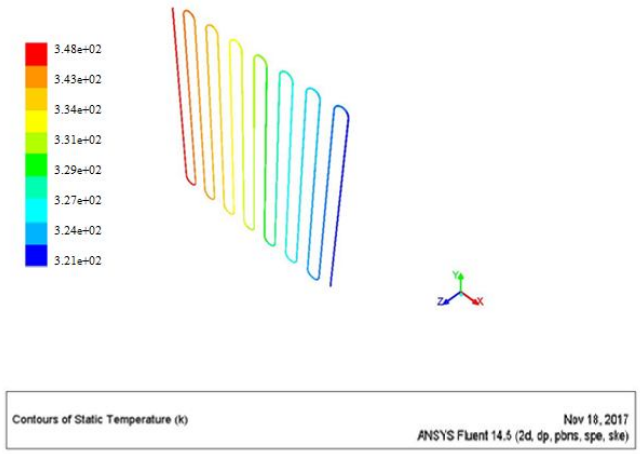

Figure 5.8: Contour of Static Temperature for (CuO + water) Nano fluid.

From figure 5.8 the value of Reynolds number is 37500 for 6.5 mm pipe diameter and for CuO + Water Nano fluid (i.e. Case 4). This is highest among all other Nano fluid.

Table 5.1: Reynolds numbers for different Nano fluid

Case	Nano fluid	Reynolds Number	Static Temperature (˚k)
Case 1	SiO2 + WATER	6120	321
Case 2	AL2O3 + WATER	6320	325
Case 3	Ti2O + WATER	6520	334
Case 4	CuO+ WATER	37500	348

VI. CONCLUSION

This investigation presents summary about Nano fluid with solar collector applications, an existing emerging class of heat transfer fluid, in terms of barriers, future research and environmental contests. Nano fluids are used to enhance the performance of many thermal engineering systems. It is originate from the researches that the heat transfer increases with increasing Reynolds number of the flow. Now, we change the Nano fluid for model, like SiO2 + Water called as Case 1, Al_2O_3+ Water called as Case 2, Ti2O+ Water called as Case 3 &CuO+ water called as Case 4 respectively by provide constant diameter of pipe 6.5 mm and Evaluation between different Nano fluid with constant velocity of 1.5 m/s. As of table 5.1 we found the result, after the contour of Reynolds number for different Nano fluid and it was observed that the maximum value for Reynolds number obtained with the CuO + Water Nano fluid i.e. Case 4 and here after we can say that the heat transfer will also increases with increasing Reynolds number of the flow. From CFD Simulation results we can conclude that among the four nano fluid which we have used in current study for increasing the heat transfer characteristics of solar collector , CuO + Water nano fluids have a great heat transfer rate as compare to others. Absorbing Temperature and Reynolds Numbers are much higher in case of CuO + Water nano fluids than the other nano fluids we used. The midpoint point was to evaluate the use of different Nano fluid in the developed region of the tube flow containing water + Nano fluid ($Al_20_3$and Ti_2O, CuO, and SiO2) on heat transfer characteristics. It was observed that all Nano fluids ($Al_20_3$and Ti_2O, CuO, and SiO2) revealed higher heat transfer characteristics than that of the base fluid (water).

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