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Observation on CFD Analysis of ZnO and TiO_2 Nanofluid with Oil and Ethylene Glycol in Square and Helical Coil Heat Exchanger

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ABSTRACT

The study of this investigation is the comparison CFD Analysis of ZnO & TiO_2 Nano-Fluid with Oil and Ethylene Glycol as a base fluid in Tapered Helical Coil Heat Exchanger with the help of CFD on copper tube. The Zinc Oxide (ZnO) & Titanium Oxide (TiO_2), are used as Nano fluid and water and ethylene glycol is a base fluid. Tapered Helical coil was fabricated by bending 500 mm length of copper tube having 10mm tube diameter, 50mm pitch coil diameter, 20mm pitch and Square shaped coil was fabricated by bending 500 mm length of copper tube having 10mm square side, 50mm pitch coil dia, 20 mm pitch. The comparison of pressure drop and temperature variation between ZnO & TiO_2 nano fluid with oil as its base and ZnO & TiO_2 nanofluid with ethylene glycol as its base is found in this analysis. The result indicates that the ZnO nanofluid with oil as a base fluid have maximum pressure drop and also have maximum temperature variation compare with other nano fluid and base fluid as a base fluid. A computational fluid dynamics (CFD) methodology using ANSYS FLUENT 15 is used here to investigate pressure drop of Zinc Oxide (ZnO) & Titanium Oxide (TiO_2) nanofluid with ethylene glycol and water as its base fluid on the heat transfer characteristics in a tapered helically coil-tube.

Keywords: *Helical Coil, Square Shaped Helical coil, Nano-fluid, Heat Exchanger, CFD, Pressure Drop, Temperature Distribution.*

1. INTRODUCTION

In the era of growing population of world, per capita income along with demand for fresh and processed food and drinks is increasing enormously resulting in critical need in effective process technologies to produce them. Right nowadays, half of the world's inhabitant's lives in a town or city and this can be expected to be 9 billion people on the planet by 2050. Processed nutrients and liquid refreshment from name-brand manufacturers, packed to suit the needs of customers, are in just as high request as fresh products – particularly among urban buyers. Heat exchange is a key element that points on these products 'journey to the person who lastly consumes. Cooling is vital but not sufficient alone; in addition, loss of liquid and vitamins must be efficiently prevented. Heat exchangers form us set criteria with awe to energy efficiency, mid-air throw and effectiveness. These are crucial features for accessibilities, food distribution centres, storerooms, invention halls and hypermarkets require tremendous cooling duty.

The heat exchangers can be upgraded to execute heat-transfer duty by transferring of heat and upsurge techniques as active and passive techniques. The active technique involves exterior forces, e.g., electric field and surface vibrations etc. The passive technique requires fluid flow behaviour and distinct apparent geometries. Curved tubes are used for transferring of heat improvement procedures, relatively a lot of heat transfer applications.

Helical coils are distinguished coiled tubes which have been used in multiplicity of solicitations e.g. heat recovery, air-conditioning and refrigeration schemes, chemical reactors and dairy practices. Helical coil heat exchanger is the modern improvement of heat exchangers, to fulfill the industrial demand. A helical coil are necessary for various heat exchangers, nuclear reactors and in chemical engineering, because of large quantity of heat is transferring in a small space with high heat transmission rates and slight residence time dispersals even it suffers through a disadvantage of larger pressure drop. Pressure drop features are essential for calculating fluid effect to overwhelmed pressure drops and for arrangement of necessary mass flow rates. The pressure drops are also a function of the pipe curvature. The curvature creates secondary flow arrangement which is perpendicular to main axial stream path. This secondary flow has insignificant capability to increase heat transfer allocated to mixing of the fluid. The strength of secondary flow established in the tube. It is the value of tube diameter and coil diameter. The force which arises due to curvature of the tube and results in secondary flow advancement with increased rate of heat transfer is centrifugal force.

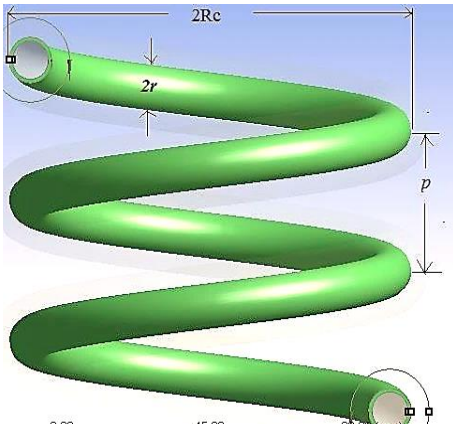

Figure 1: Helical Coil Heat Exchanger

2. APPLICATIONS OF HELICAL COIL

Applications of helical coil heat exchangers in various heat transfer applications are:

1) Helical coils are used for transmitting heat in chemical industries because of high heat transfer coefficient as compared to other configurations.
2) Due to compact shape they can be recycled in heat transfer applications with space limitations, for e.g. marine cooling systems, cooling of lubricating oil, steam generation in marine system and industrial applications.
3) Helically coiled tubes are broadly used in cryogenic industry for the liquefaction of gases.
4) The helical coil heat exchangers are used in food beverage industries like in food treating and pre-heating, for storing them at desired temperatures and pasteurization of liquid food objects.
5) Helical coil heat exchangers are also used as condensers in HVACs.
6) Helical coils are used in hydrocarbon processing industries for recovery of CO2 & for cooling of liquid hydrocarbons.
7) Also employed in polymer industries for cooling purposes.

3. NANO FLUID

Now a day, it is seen that the liquid coolants which are used today, they have very poor thermal conductivity (with the omission of liquid metal, which cannot be used at most of the relevant useful temperature ranges). For example, water is evenly poor in heat conduction than copper, in the case with engine coolants, the oils, and organic coolants. The liquid having thermal conductivity and it will be limited by the natural restriction on creating turbulence or increasing area. To overcome this problem the suspension of solid in cooling liquid is a better option and a new fluid will be made which is used to increase the thermal conduction behaviour of cooling fluids.

Nanofluid are fluid particles which are a lesser amount even a µ (nearly 10-9 times smaller) in diameter and very reactive and effective material which can be used to rise factor like rate of reaction, thermal conductivity of some metal or material are that much reactive and offered four possible methods in nano fluids which may contribute to thermal conduction.

a) Brownian motion of nano particles.
b) Liquid layering at the liquid/particle edge.
c) Ballistic nature of heat transport in nano particles.
d) Nano particle clustering in nano fluids.

The Brownian motion of nano particles is too slow to transfer heat over a nano fluid. This mechanism works well only when the particle collecting has both the positive and negative effects of thermal conductivity which is gained indirectly through convection.

4. LITERATURE REVIEW

V Murali Krishna et. al. [1] has done his analysis on Heat Transfer Enhancement by using ZnO Water Nanofluid in a Concentric Tube Heat Exchanger under Forced Convection Conditions. The nanofluids are prepared at different volumetric concentration (0.1 to 0.5%). For the stability of nanoparticles 10% of surfactant is added to the nano-fluids. The experiment is conducted in a double pipe heat exchanger. Before conducting the experiment the heat exchanger is calibrated and then ZnO-water nanofluid is sent through annulus and readings are noted down. The nanofluid readings are compared with base fluid readings (water). The overall heat transfer coefficient for ZnO water nanofluid is increased by 11% with volume fraction 0.5% compared with water. The increase in heat transfer coefficient is due to increase in thermal conductivity of water with the addition of nanoparticles, and also due to increase in heat transfer to the cold fluid due to random motion of nanoparticles suspended in water and availability of larger surface area with nano sized particles. **Karishma Jawalkar et. al [2]** has done her study on the comparison on CFD Analysis of Zinc oxide, Silicon dioxide and manganese oxide nano fluid using oil and water as a base fluid in a Helical Coil Heat Exchanger. A computational Fluid dynamics (CFD) ANSYS FLUENT 15 is used here to investigate pressure drop of different nano-fluids (Zinc Oxide, Magnesium Oxide & Silicon Dioxide) on the heat transfer characteristics in a helically coil-tube. Analysis has been done for different nano-fluids using oil as its base of a helical coil tube by some boundary conditions. Based on the CFD results, the oil give higher pressure drop as compared to water when using a nano-fluid in a helical coil heat exchanger using oil as its base.

Hemasunder Banka et. al. [3] has done an methodical investigation on the shell and tube heat exchanger by forced convective heat transfer to determine flow physical appearance of nano fluids by fluctuating volume fractions and mixed with water, the nano fluids are titanium carbide (TiC), titanium nitride (TiN) and ZnO nanofluid and dissimilar volume concentrations (0.02, 0.04, 0.07 & 0.15%) flowing under turbulent flow conditions. CFD analysis is done on heat exchanger by relating the properties of nano fluid with different volume fractions to obtain temperature distribution, heat transfer coefficient and heat transfer rate. He found that heat transfer coefficient and heat transfer rates are growing by cumulative the volume fractions.

Arvind Kumar Pathak et. al. [4] has done his study on the comparison of CFD analysis of Natural Fluid and Nano fluid in a helical coil heat exchanger. He has used water as a natural fluid and Titanium Oxide (TiO2) and Zinc Oxide (ZnO) is used as a Nano fluid with base as water. He has fabricated a helical coil of aluminium and copper by bending 1000 mm of tube with 8 mm tube diameter, pitch of 15 mm and coil diameter is 35 mm. He has done his work on 0.05 kg/s mass flow rate. He found that aluminium coil give more pressure drop on Zinc oxide Nano fluid as compared to other tubes of aluminium and copper and also water, titanium oxide nano fluids.

K. Abdul Hamid et. al. [5] has done work on pressure drop for Ethylene Glycol (EG) based nanofluid. The nanofluid is prepared by dilution technique of TiO2 in based fluid of mixture water and EG in volume ratio of 60:40, at three volume concentrations of 0.5 %, 1.0 % and 1.5 %. The experiment was conducted under a flow loop with a horizontal tube test section at various values of flow rate for the range of Reynolds number less than 30,000. The experimental result of TiO2 nanofluid pressure drop is compared with the Blasius equation for based fluid. It was observed that pressure drop increase with increasing of nanofluid volume concentration and decrease with increasing of nanofluid temperature insignificantly. He found that TiO2 is not significantly increased compare to EG fluid. The working temperature of nanofluid will reduce the pressure drop due to the decreasing in nanofluid viscosity.

Palanisamy et. al [6] observes the heat transfer and the pressure drop of cone helically coiled tube heat exchanger by (Multi wall carbon nano tube) MWCNT/water nanofluids. The MWCNT/water nanofluids at 0.1%, 0.3%, and 0.5% atom volume absorptions were equipped with the calculation of surfactant by using the two-step method. The investigations were showed under the turbulent flow in the Dean number range of 2200 <De <4200. The tests were attended with tentative Nusselt number is 28%, 52% and 68% higher than water for the nanofluids volume concentration of 0.1%, 0.3% and 0.5% respectively. It is originate that the pressure drop of 0.1%, 0.3% and 0.5% nanofluids are found to be 16%, 30% and 42% respectively more than water.

Shiva Kumar et. al [7] have controlled on both straight tube and helical tube heat exchanger. He has compared CFD results with the results found by the replication of straight tubular heat exchanger of the same length under identical operating conditions. Results specified that helical heat exchangers showed 11% increase in the heat transfer rate over the straight tube. Simulation results also presented 10% increase in nusselt number for the helical coils whereas pressure drop in circumstance of helical coils is higher when compared to the straight tube.

5. COMPUTATIONAL FLUID DYNAMICS

Computational simulation is technique for examining fluid flow, heat transfer and related phenomena such as chemical réactions. This project uses CFD for analysis of flow and heat transfer. CFD analysis accepted out in the numerous industries is used in R&D and manufacturing of aircraft, internal combustion engines and in power plant combustion as well as in many industrial applications. The advancement in the high speed computers and the computational fluid dynamics (CFD) has a great impression on the engineering strategy and survey of the heat exchangers. In the previous decades, explain compound geometry and complex drift problem to increasing capability of design and examination and for decreasing the cost and time. The CFD methodology has appear to become an effective approach for collecting information to improve engineering design and investigation of heat exchangers.

6. METHODOLOGY

Pre Processing

CAD Modeling: Creation of CAD Model by by means of CAD modeling tools for making the geometry of the part/assembly of which we want to accomplish FEA. CAD model may be 2D or 3D.

1. **Type of Solver:** Pick the solver for the problem from Pressure Based and density based solver.
2. **Physical model:** Choose the required physical model for the problem i.e. laminar, turbulent, energy, multiphase, etc.
3. **Material Property:** Choose the Material property of flowing fluid.
4. **Boundary Condition:** Define the desired boundary condition for the problem i.e. velocity, mass flow rate, temperature, heat flux etc.

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.

Post Processing:

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

STEP 1

CFD analysis of helical coil heat exchanger by using ANSYS 15

Pre-processing:

CAD Model: Generation of 3D model by using SOLIDWORKS and exporting to the IGES format and then import in ANSYS fluent 15.

CAD modelling / meshing has been done by following steps

1) Open Solid works then select part for modelling.
2) In part modelling select circle of 50 mm diameter.
3) After that select helix geometry of pitch 20 mm, tapered angle 20 and length 500 mm.
4) Now again come to circle command and at the end of helix pierce it.
5) Then select sweep command and in sweep command selecting tube then click to curve and geometry came.

Table 1: Parameters of Geometry of Helical Coil

S.No.	Dimensional Parameters	Dimensions
1	Pitch Coil Diameter	50 mm
2	Side of square	10 mm
3	Pitch	20 mm
4	Tube Length	500 mm

Table 2: Parameters of Geometry of Square Coil

S.No.	Dimensional Parameters	Dimensions
1	Pitch Coil Diameter	50 mm
2	Tube Diameter	10 mm
3	Pitch	20 mm
4	Tube Length	500 mm

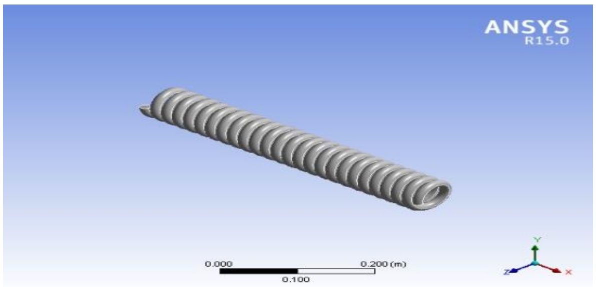

Figure 2: 3D model of helical coil heat exchanger with PCD 50 mm and tube diameter 10 mm.

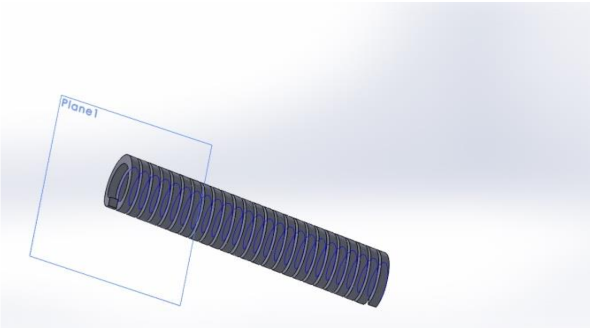

Figure 3 : 3D model of square coil heat exchanger with PCD 50 mm and tube diameter 10 mm

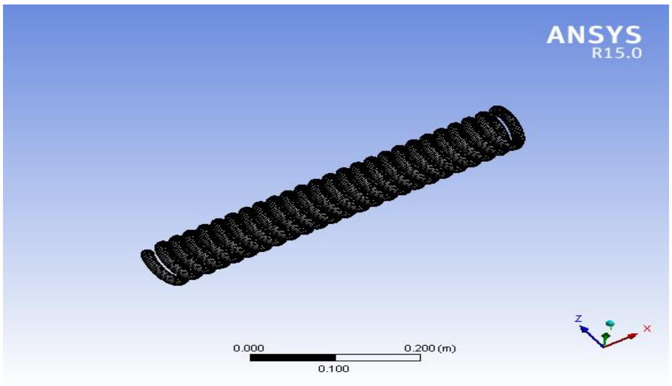

Figure 4: Meshing of Helical Coil Heat Exchanger

Table 3 : Helical Coil Meshing Statistics

Mesh type	Fine grid mesh
No. of nodes	150487
No. of elements	110458

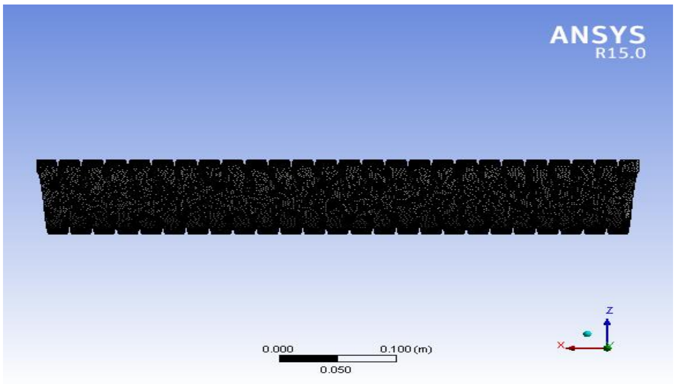

Figure 5 : Meshing of Square Coil Heat Exchanger

Table 4 : Square Coil Meshing Statistics

Mesh type	Fine grid mesh
No. of nodes	190482
No. of elements	157633

STEP 3

Fluent Setup:

After mesh setup generation define the following steps in the **ANSYS** fluent 15.

- Problem Type -3D solid
- Type of Solver – pressure
- Physical Model – viscous k- two equation turbulence model
- Mixture- Volume of fraction

STEP 4

Fluid Property

Table 5: Properties of Oil

Type of fluid	Oil
Density (ρ)	800 kg/m^3
Viscosity (μ)	0.2 kg/m-s
Specific heat (Cp)	1.67 KJ/Kg-K
Thermal conductivity (k)	0.162 Watt/mK

Table 6: Properties of Zinc Oxide

Type of fluid	Zinc Oxide
Density (ρ)	1091.7 kg/m^3
Viscosity (μ)	0.0010531 kg/m-s
Specific heat (Cp)	3.7982 KJ/Kg-K
Thermal conductivity (k)	25.32 Watt/mK

Table 7: Properties of Titanium Oxide

Type of fluid	Titanium Oxide Nanofluid
Density (ρ)	1109.12 kg/m3
Viscosity (μ)	0.00189 kg/m-s
Specific heat (Cp)	3.350 KJ/Kg-K
Thermal conductivity (k)	0.538 Watt/mK

Table 8: Properties of Ethylene Glycol

Type of fluid	Ethylene Glycol
Density (ρ)	1111.4 kg/m3
Viscosity (μ)	0.0157 kg/m-s
Specific heat (Cp)	2.415 KJ/Kg-K
Thermal conductivity (k)	0.252 Watt/mK

Solution

Solution Method

Pressure - Velocity - Coupling – Scheme - Simple

- Pressure – standard pressure
- Momentum- 2nd order
- Turbulence –kinetic energy 2nd order
- Turbulence dissipation rate 2nd order

Solution Initialisation

Initiate the solution to get the initial solution for the problem.

Run Solution

Run the solution by giving 500 number of iterations for solving the convers.

Post Processing

For viewing and interpret of result, the result can be viewed in various formats like graph, value, animations etc.

7. RESULTS AND DISCUSSION

1. The pressure drop data were collected for the configuration of helical and square coil for the TiO_2 and ZnO nanofluid as oil its base and TiO_2 and ZnO nanofluid as ethylene glycol as its base fluid. The various effects of mass flow rate and the tube diameter were observed.
2. CFD computations were done for copper helical coiled tube.
3. Performance parameters adopted for comparison of pressure drop and temperature distribution in all the cases.
4. Effect of pressure drop on the helical coil by using TiO_2 nanofluid as oil as its base fluid.

Table 9: Effect of pressure drop on the helical coil by using TiO_2 nanofluid as oil as its base fluid.

Case	Tube diameter	Fluid	Pressure drop (Pa)
1	10 mm	TiO_2 Nano fluid	364000

5. Effect of Temperature on the helical coil by using TiO_2 nanofluid with oil as its base fluid on high pressure.

Table 10: Effect of Temperature on the helical coil by using TiO_2 nanofluid with oil as its base fluid on high pressure

Case	Tube diameter	Fluid	Temperature (K)
1	10 mm	TiO2 Nano fluid	307

6. Effect of pressure drop on the helical coil by using ZnO nanofluid as oil as its base fluid.

Table 11 : . Effect of pressure drop on the helical coil by using ZnO nanofluid as oil as its base fluid.

Case	Tube diameter	Fluid	Pressure drop (Pa)
1	10 mm	ZnO Nano fluid	366875

7. Effect of Temperature on the helical coil by using ZnO nanofluid as oil as its base fluid on high pressure

Table 12: Effect of Temperature on the helical coil by using ZnO nanofluid as oil as its base fluid on high pressure

Case	Tube diameter	Fluid	Temperature (K)
1	10 mm	ZnO Nano fluid	324.5

8. Effect of pressure drop on the helical coil by using TiO_2 nanofluid as ethylene glycol as its base fluid.

Table 13: Effect of pressure drop on the helical coil by using TiO_2 nanofluid as ethylene glycol as its base fluid.

Case	Tube diameter	Fluid	Pressure drop (Pa)
1	10 mm	TiO_2 Nano fluid	8238

9. Effect of temperature on the helical coil by using TiO_2 nanofluid as ethylene glycol as its base fluid on high pressure.

Table 14: Effect of temperature on the helical coil by using TiO_2 nanofluid as ethylene glycol as its base fluid on high pressure.

Case	Tube diameter	Fluid	Temperature (K)
1	10 mm	TiO_2 Nano fluid	308.5

10. Effect of pressure drop on the helical coil by using ZnO nanofluid as ethylene glycol as its base fluid.

Table 15: Effect of pressure drop on the helical coil by using ZnO nanofluid as ethylene glycol as its base fluid.

Case	Tube diameter	Fluid	Pressure drop (Pa)
1	10 mm	ZnO Nano fluid	8259

11. Effect of temperature on the helical coil by using ZnO nanofluid as ethylene glycol as its base fluid on high pressure.

Table 16: Effect of temperature on the helical coil by using ZnO nanofluid as ethylene glycol as its base fluid on high pressure.

Case	Tube diameter	Fluid	Temperature (K)
1	10 mm	ZnO Nano fluid	326

12. Effect of pressure drop on the square coil by using TiO_2 nanofluid as oil as its base fluid.

Table 17: Effect of pressure drop on the square coil by using TiO_2 nanofluid as oil as its base fluid.

Case	Tube diameter	Fluid	Pressure drop (Pa)
1	10 mm	TiO_2 Nano fluid	209875

13. Effect of temperature on the square coil by using TiO_2 nanofluid as oil as its base fluid.

Table 18: Effect of temperature on the square coil by using TiO_2 nanofluid as oil as its base fluid.

Case	Tube diameter	Fluid	Temperature (K)
1	10 mm	TiO_2 Nano fluid	304

14. Effect of pressure drop on the square coil by using ZnO nanofluid as oil as its base fluid.

Table 19: Effect of pressure drop on the square coil by using ZnO nanofluid as oil as its base fluid.

Case	Tube diameter	Fluid	Pressure drop (Pa)
1	10 mm	ZnO Nano fluid	508568

15. Effect of temperature on the square coil by using ZnO nanofluid as oil as its base fluid on high pressure.

Table 20: Effect of temperature on the square coil by using ZnO nanofluid as oil as its base fluid on high pressure.

Case	Tube diameter	Fluid	Temperature (K)
1	10 mm	ZnO Nano fluid	327.5

16. Effect of pressure drop on the square coil by using TiO_2 nanofluid as ethylene glycol as its base fluid.

Table 21: Effect of pressure drop on the square coil by using TiO_2 nanofluid as ethylene glycol as its base fluid.

Case	Tube diameter	Fluid	Pressure drop (Pa)
1	10 mm	TiO_2 Nano fluid	3803

17. Effect of temperature on the square coil by using TiO_2 nanofluid as ethylene glycol as its base fluid on high pressure.

Table 22: Effect of temperature on the square coil by using TiO_2 nanofluid as ethylene glycol as its base fluid on high pressure.

Case	Tube diameter	Fluid	Temperature (K)
1	10 mm	TiO_2 Nano fluid	306

18. Effect of pressure drop on the square coil by using ZnO nanofluid as ethylene glycol as its base fluid.

Table 23: Effect of pressure drop on the square coil by using ZnO nanofluid as ethylene glycol as its base fluid.

Case	Tube diameter	Fluid	Pressure drop (Pa)
1	10 mm	ZnO Nano fluid	3945

19. Effect of pressure drop on the helical coil by using ZnO nanofluid as ethylene glycol as its base fluid.

Table 24: Effect of pressure drop on the helical coil by using ZnO nanofluid as ethylene glycol as its base fluid.

Case	Tube diameter	Fluid	Temperature (K)
1	10 mm	ZnO Nano fluid	339.4

Case-1 Tube Diameter is 10 mm, TiO_2 nanofluid is used as oil as its base fluid in copper helical coil, Pressure drop is 364000 Pa

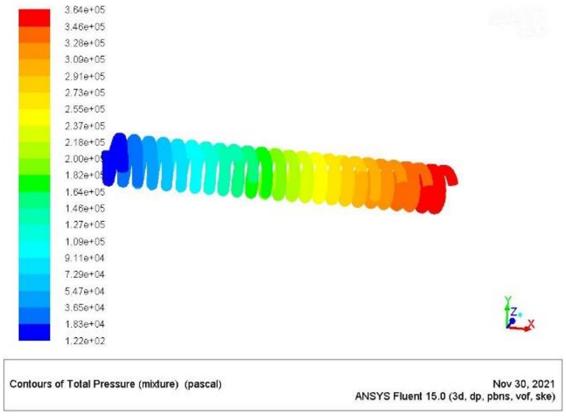

Figure 6 : Total Pressure in copper helical coil using TiO_2 nanofluid as oil as a base fluid

Case-2 Tube Diameter is 10 mm, ZnO nanofluid is used as oil as its base fluid in copper helical coil, pressure drop is 366875 Pa.

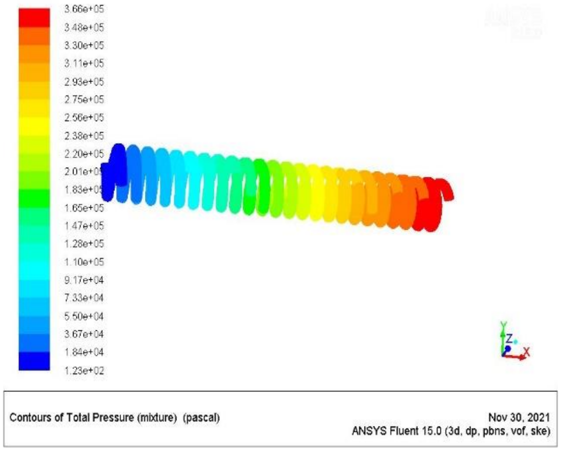

Figure 7 :Total Pressure in copper helical coil using ZnO as a nano fluid and oil as a base fluid

Case-3 Tube Diameter is 10 mm, TiO_2 nanofluid is used as ethylene glycol as its base fluid in copper helical coil, pressure drop is 8238 Pa.

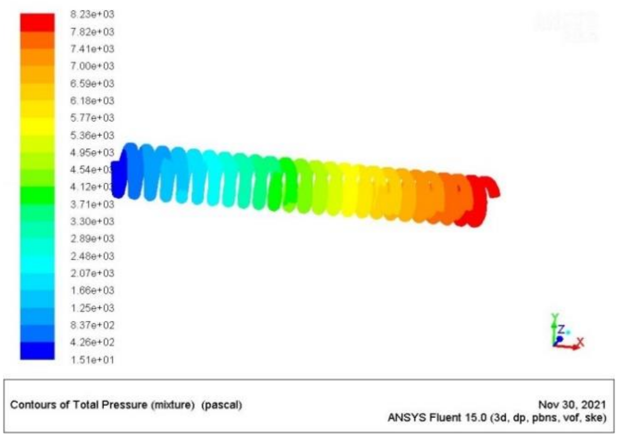

Figure 8 :Total Pressure in copper helical coil using TiO_2 as a nano fluid and ethylene glycol as a base fluid.

Case-4 Tube Diameter is 10 mm, ZnO nanofluid is used as ethylene glycol as its base fluid in copper helical coil, pressure drop is 8259 Pa.

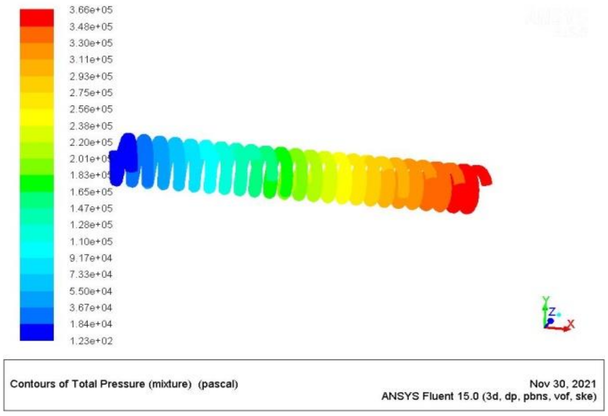

Figure 9 :Total Pressure in copper helical coil using ZnO as a nano fluid and ethylene glycol as a base fluid

Case-5 Tube Diameter is 10 mm, TiO_2 nanofluid is used as oil as its base fluid in copper square coil, pressure drop is 209875 Pa.

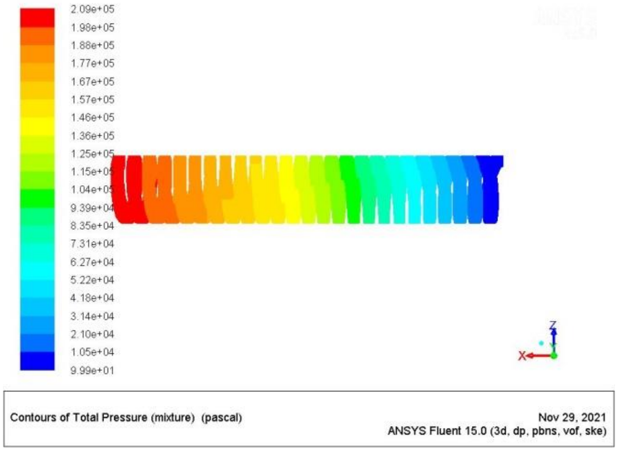

Figure 10 : Total Pressure in copper square coil using TiO_2 as a nano fluid and oil as a base fluid

Case-6 Tube Diameter is 10 mm, ZnO nanofluid is used as oil as its base fluid in copper square coil, pressure drop is 508568 Pa.

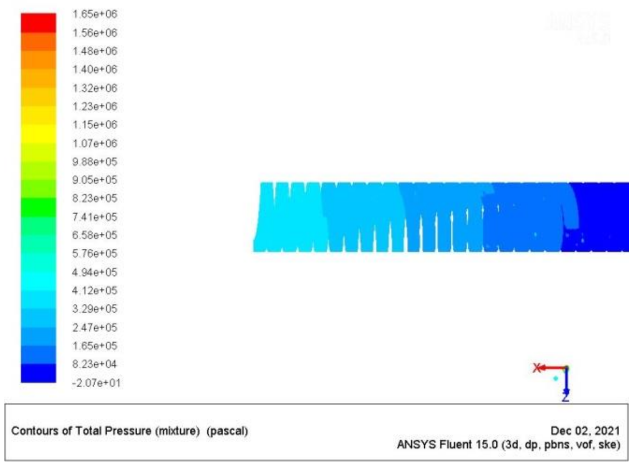

Figure 11 : Total Pressure in copper square coil using ZnO as a nano fluid and oil as a base fluid

Case-7 Tube Diameter is 10 mm, TiO_2 nanofluid is used as ethylene glycol as its base fluid in copper square coil, pressure drop is 3803 Pa

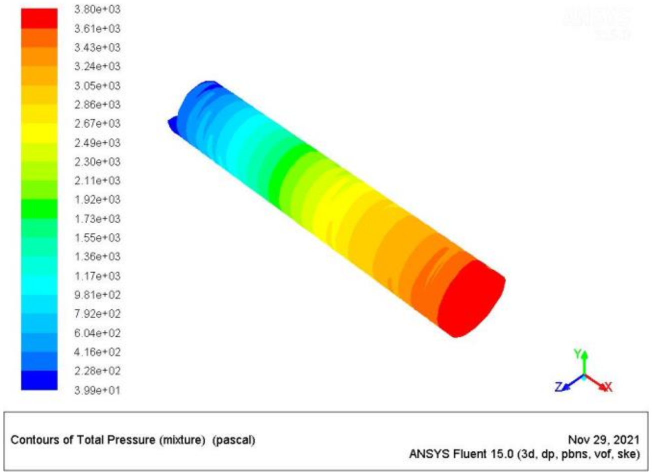

Figure 12 : Total Pressure in copper square coil using TiO_2 as a nano fluid and ethylene glycol as a base fluid

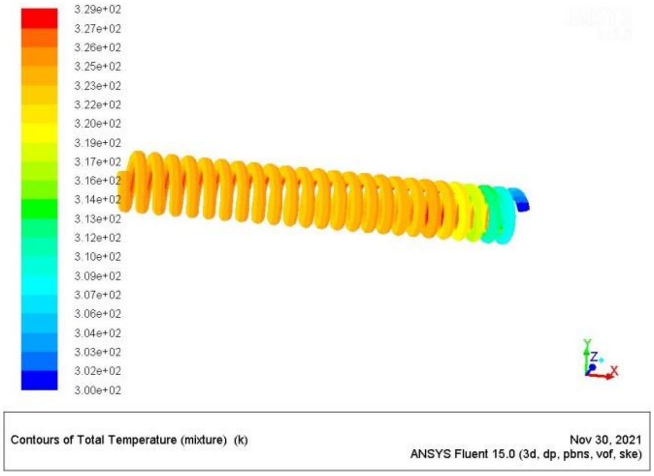

Figure 15: Distribution of temperature in Copper helical coil using ZnO nanofluid using oil as its base.

Case-8 Tube Diameter is 10 mm, ZnO nanofluid is used as ethylene glycol as its base fluid in copper square coil, pressure drop is 3946 Pa

Case-11 Tube Diameter is 10 mm, TiO_2 nanofluid is used as ethylene glycol as its base fluid in copper helical coil, Max temperature is 308.5K

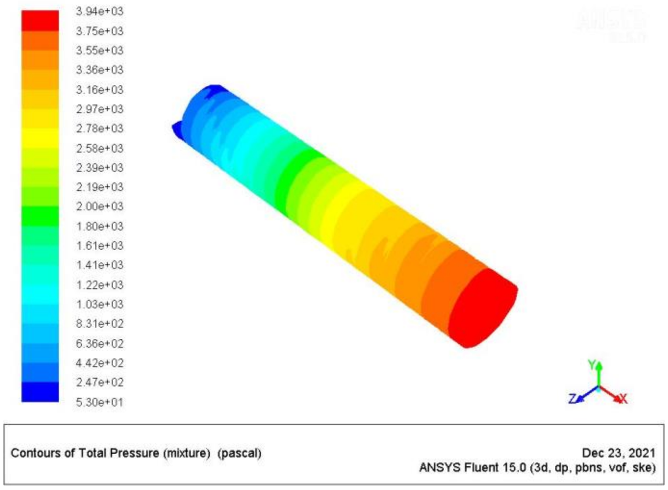

Figure 13 : Total Pressure in copper square coil using ZnO as a nano fluid and ethylene glycol as a base fluid

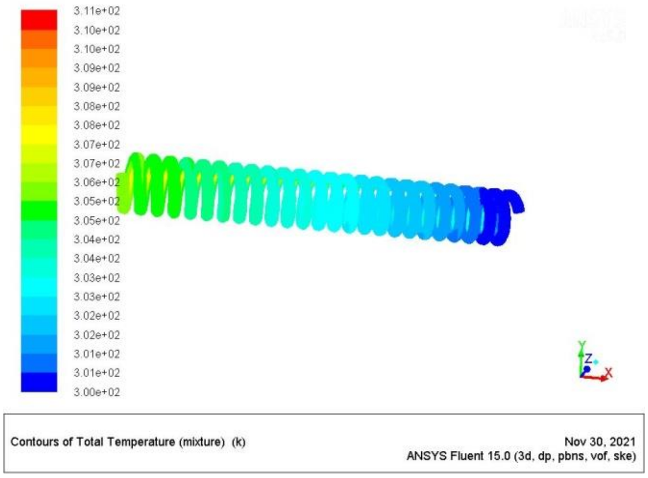

Figure 16: Distribution of temperature in Copper helical coil using TiO_2 nanofluid using ethylene glycol as its base.

Case-9 Tube Diameter is 10 mm, TiO_2 nanofluid is used as oil as its base fluid in copper helical coil, Max temperature is 307K

Case-12 Tube Diameter is 10 mm, ZnO nanofluid is used as ethylene glycol as its base fluid in copper helical coil, Max temperature is 326K

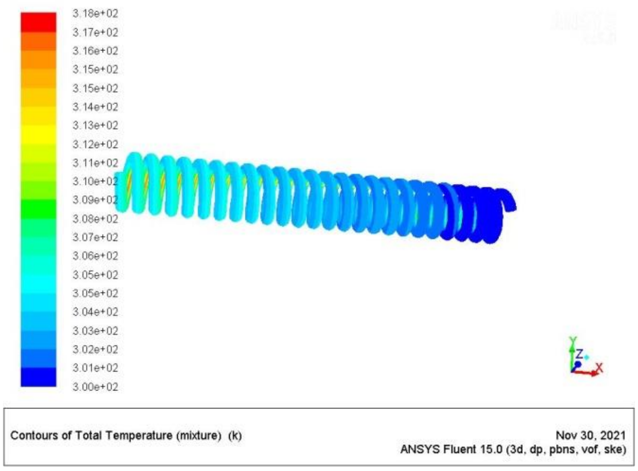

Figure 14: Distribution of temperature in Copper helical coil using TiO_2 nanofluid using oil as its base.

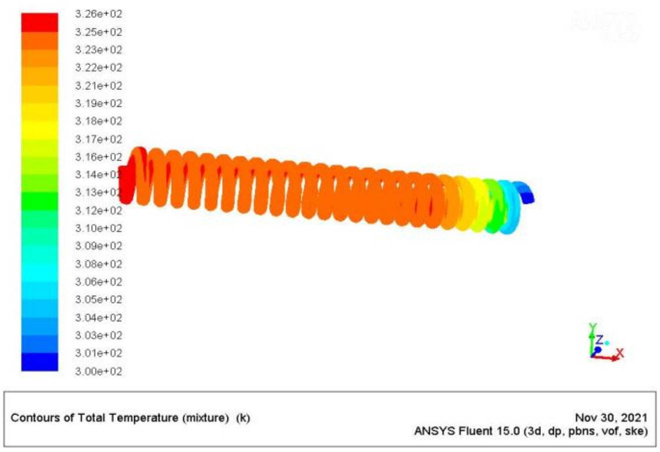

Figure 17: Distribution of temperature in Copper helical coil using ZnO nanofluid using ethylene glycol as its base.

Case-10 Tube Diameter is 10 mm, ZnO nanofluid is used as oil as its base fluid in copper helical coil, Max temperature is 324.3K

Case-13 Tube Diameter is 10 mm, TiO_2 nanofluid is used as oil as its base fluid in copper square coil, Max temperature is 304K

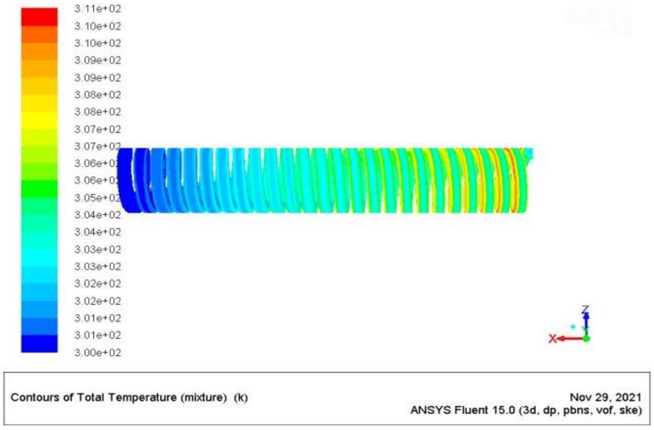

Figure 18: Distribution of temperature in Copper square coil using TiO_2 nanofluid using oil as its base.

Case-14 Tube Diameter is 10 mm, ZnO nanofluid is used as oil as its base fluid in copper square coil, Max temperature is 327.5K.

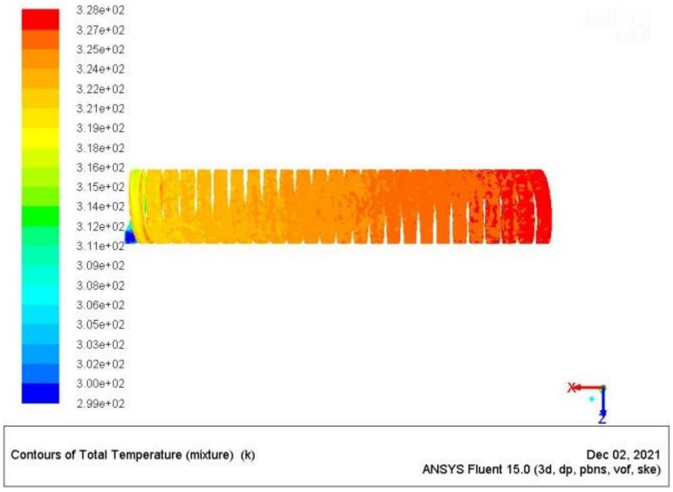

Figure 19: Distribution of temperature in Copper square coil using ZnO nanofluid using oil as its base.

Case-15 Tube Diameter is 10 mm, TiO_2 nanofluid is used as ethylene glycol as its base fluid in copper square coil, Max temperature is 306K

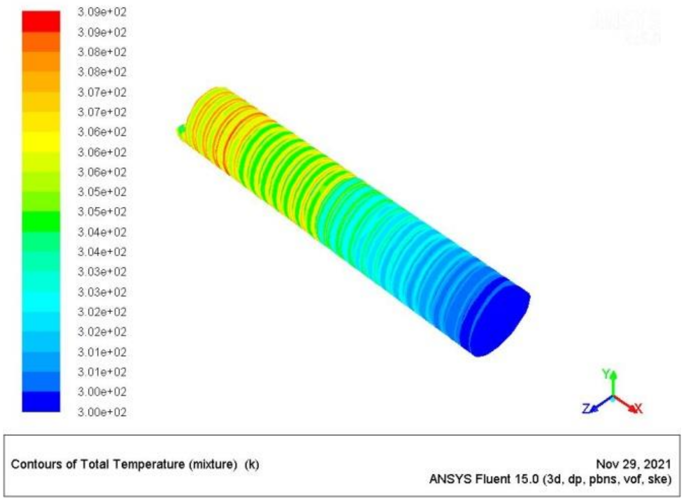

Figure 20: Distribution of temperature in Copper square coil using TiO_2 nanofluid using ethylene glycol as its base.

Case-16 Tube Diameter is 10 mm, ZnO nanofluid is used as ethylene glycol as its base fluid in copper square coil, Max temperature is 306K

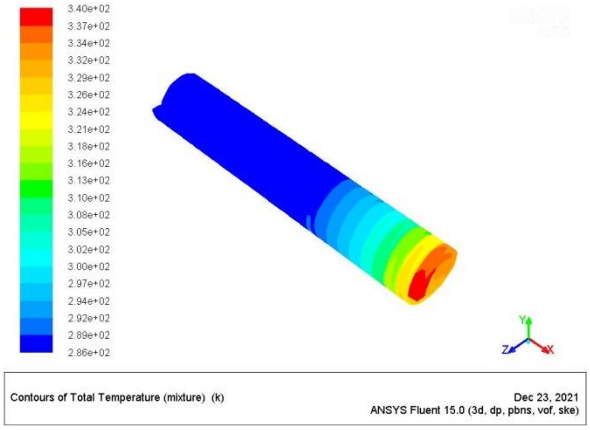

Figure 21: Distribution of temperature in Copper square coil using ZnO nanofluid using ethylene glycol as its base.

From above it is clear that when we used the ZnO nanofluid using oil as a base fluid in square coil then pressure drops increases in ZnO because of presence of metal particles and the base fluid properties. The numerical study considers the effect of ZnO nanofluid using oil and ethylene glycol as its base fluid and TiO_2 nanofluid using oil & ethylene glycol as its base fluid on the flow and heat transfer characteristics of tube.

8. CONCLUSION

In this paper, analytical investigations are done on the helical and square coil heat exchanger, to determine pressure drop and temperature distribution of oil an ethylene glycol as a base fluid and a titanium oxide and zinc oxide as a nanofluid on copper helical and copper square coil flowing under laminar flow conditions. By observing the CFD analysis results, we know that the material which has high thermal conductivity that fluid will give high pressure drop. The pressure drop is more in Zinc oxide nanofluid with oil as a base fluid in square helical coil heat exchanger.

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