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# ANALYSIS OF SHELL & COIL HEAT EXCHANGER BY USING CUPROUS OXIDE AND SILICA NANOFLUID AT DIFFERENT MASS FLOW RATE

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**ABSTRACT**
Shell and Helical coils are eminent coiled tubes which have been used in diversity of solicitations e.g. heat recovery, air-conditioning and preservation schemes, chemical reactors and dairy practices. Shell and Helical coil heat exchanger is the recent improvement of heat exchangers, to accomplish the industrial demand. A shell and helical coil are necessary for various heat exchangers, nuclear reactors and in chemical engineering, for of large quantity of heat is conveying in a slight space with high heat transmission rates and slight habitation time distributions even it suffers through a disadvantage of larger pressure drop. The unbiased of this work is to cheered the pressure drop inside a shell and helical coil heat exchanger, heat transfer progression can be improved by increasing secondary flow inside the coil and this can be allow by appropriate blending of the fluid inside the helical coil. For this, my planned work on CFD to scrutinize the helical coil by using ANSYS 18.2. A 3D design of CAD model of helical coil of tube outer diameter (do) 16 mm, inner diameter of helical coil (di) 12 mm, pitch of 26.3mm, pitch coil dia. 86 mm, tube length of 235 mm, shell diameter is 110 mm and shell length is 215 mm, is generated by using ANSYS fluent 18.2.

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

## 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.

Shell and Helical coils are distinguished shell and coiled tubes which have been used in multiplicity of solicitations e.g. heat recovery, air-conditioning and refrigeration schemes, chemical reactors and dairy practices. Shell and Helical coil heat exchanger is the modern improvement of heat exchangers, to fulfill the industrial demand. 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.

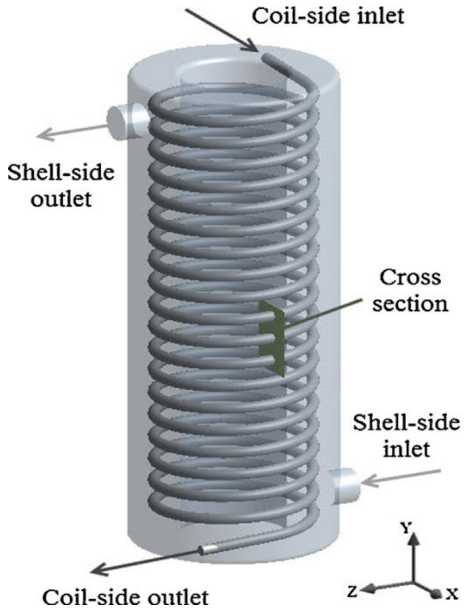


**Figure 1 : Shell and Helical Coil Heat Exchanger**

**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.

**LITERATURE REVIEW**

Shell and Helical coil is very compact in structure and it possess high heat transfer coefficient that why helical coils heat exchangers are widely used. In literature it has been informed that heat transfer rate of helical coil is larger than straight tube.

**Alok Kumar et.al. [1]** The fairness of this work is to facilitate pressure drop across the shell and spiral heat exchangers. Heat transfer performance can be improved by increasing the secondary flow in the spiral. This can be facilitated by proper mixing of fluids within the spiral coil. In addition, I plan to work on CFD to study helical coils using ANSYS. In this article, an analytical study was performed on a shell-coil heat exchanger to determine the pressure drop and temperature distribution of water as the base liquid of the shell-coil flowing under laminar flow conditions, and $Al_2O_3$ and $SiO_2$ as nanofluids. increase. Observing the CFD analysis results, the high-temperature fluid pressure drop of $Al_2O_3$ and $SiO_2$ nanofluids with water as the base fluid is larger in the shell and spiral heat exchangers.

**Pranita Bichkar et.al. [2]** has completed his research in Shell and Tube Warmness Exchangers with the effects of various baffles. This work presents numerical simulations of several baffles, including single segmental, double segmental, and helical baffles. This implies that baffles have an effect on stress decrease in shell and tube heat exchangers. Single segmental baffles exhibit the establishment of dead zones wherein the warmth switch cannot take place effectively. When compared to single segmental baffles, double segmental baffles reduce vibrational damage. The use of helical baffles results in a lower strain drop due to the elimination of unnecessary zones. The fewer dead zones result in more heat transmission. The smaller stress drop leads in lower pumping electricity, which boosts overall system performance. The comparison results demonstrate that helical baffles are more advantageous than different two baffles.

**Lei et al. [3]** finished a numerical study of various baffle inclination angles on fluid float and heat switch of non-prevent helical shell and tube warmth exchangers using a periodic model. Based on the outcomes, it was determined that the overall performance happens around 45° helix mind-set standard overall performance of heat exchanger also depends on strain drop. Leakage can reduce pressure drop, which is consistent with the compartment average heat switch coefficient.

**Vidula Vishnu Suryawanshi et.al. [4]** He completed his examination in format and assessment of heat exchanger. In this article, CFD evaluation has been performed by way of several exceptional diameter one-of-a-kind material. Future efforts wanted for better development of helical warmth exchanger are: CFD evaluation and optimization of the curvature ratio. The usage of the Dean range and the

Colburn component for boundary circumstances with constant wall temperature and constant wall warm temperature flux for both laminar and turbulent flow. To investigate the results and adjust the heat transfer charge by varying the pitch of the helical coil.

**Vishal Momale et.al. [5]** Examine the usual overall performance of a conical helical tube heat exchanger with right away and conical shell using cfd. Computational fluid dynamics is used to evaluate the conical helical tube warmth exchanger. Heat transfer can progress significantly because the larger shell fluid comes into contact with the tube fluid even when we employ a conical shell rather than a helical shell. With a conical shell configuration, the stress drop will increase. However, if we utilise baffles, we will increase the warmth switch.

**The Mohamed Ali et.al. [6]** The experimental study of natural convection was carried out to investigate, regular type natural convection was received from turbulence herbal convection to water. The experiment was carried out with a four coil diameter to tube diameter ratio for five and ten coil tubes, as well as a five pitch outer diameter ratio. He linked Rayleigh range for two exceptional coil units, and the heat transfer coefficient falls with coil period for tube diameter do =.012m but increases with coil period for do=.008m. Important D/d0 is obtained for a maximum warmness transfer coefficient for a tube diameter of 0.012 m with either five or ten coil turns.

**R. Patil et.al. [7]** recommended design approach for helical coil heat exchanger. The internal coil diameter hi is used to determine the heat transfer coefficient, which is based entirely on one of the Sieder-Tate equations or a plot of the Colburn aspect, JH versus Re. The outer heat transfer coefficient is derived using correlation for a wide range of Reynolds numbers. Helical coil heat exchangers are preferred when space is limited and low flow charges or laminar flow conditions exist.

## COMPUTATIONAL FLUID DYNAMICS

Computational fluid dynamics, as the name implies it is a subject that deals with computational approach to fluid dynamics with numerical solution of the equations which bring about the flow of the fluid and although it is also called computational fluid dynamics; it does not just deal with the equations of the fluid flow, it is also generic enough to be able to solve simultaneously together the equations that direct the energy transfer and as well the equations that determine the chemical reaction rates and how the chemical reaction proceeds and mass transfer takes place; all these things can be tackled together in an identical format. So, this outline enables us to deal with a very complex flow circumstances in reasonably fast time, such that for a particular set of conditions, an engineer will be capable to simulate and see how the flow is taking place and what kind of temperature distribution there is and what kind of products are made and where they are formed, so that we can make changes to the parameters that are under his control to modify the way that these things are happening. So, in that case CFD becomes a great tool of design for an engineer. It is also a great tool for an analysis for an examination of a reactor or equipment which is not functioning well because in typical industrial applications.

## 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 ANSYS fluent 15.

| S.No. | Dimensional Parameters | Dimensions |
|---|---|---|
| 1 | Pitch Coil Diameter | 86 mm |
| 2 | Helical Coil Outer Diameter | 16 mm |
| 3 | Helical Coil Inner Diameter | 12 mm |
| 4 | Pitch | 26.3 mm |
| 5 | Tube Length | 235 mm |
| 6 | Shell Diameter | 110 mm |
| 7 | Shell Length | 215 mm |

**Table 1 : Parameters of Geometry of Shell and Helical Coil**

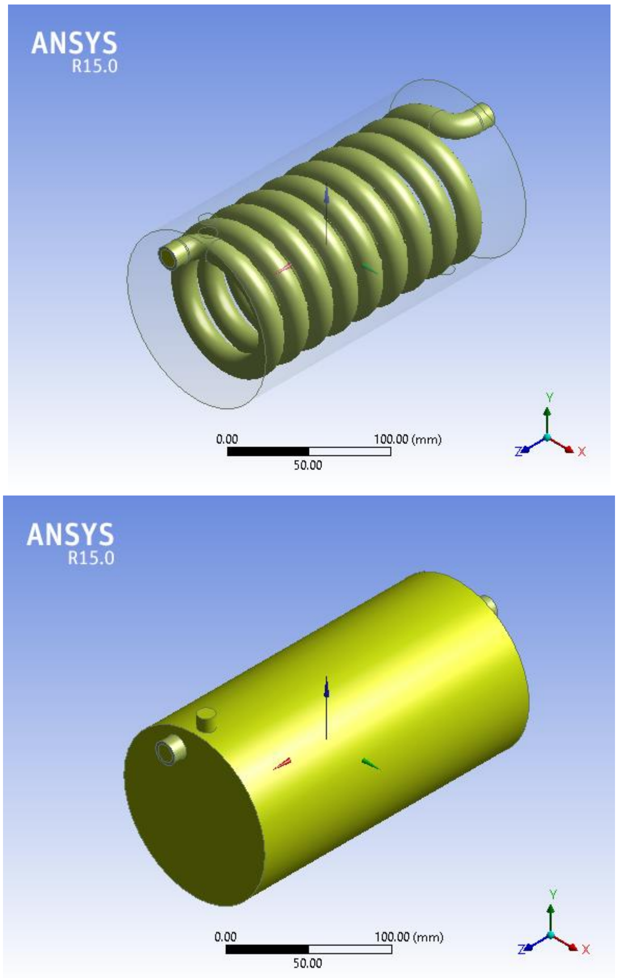


**Figure 2: 3D model of shell & helical coil heat exchanger.**

**STEP 2**

Mesh - Create a mesh version within ANSYS.

Create a meshed version of a shell-and-coil heat exchanger with one pitch diameter and one tube diameter. Meshing is an important process in CFD. CAD geometry is discretized into a large number of nodes and factors during the meshing process. A mesh is the correct arrangement of nodes and components within a region. The accuracy and length of time of assessment are affected by the length and location of the procedure. As the mesh length (number of elements) increases, the CFD evaluation decreases, but accuracy increases.

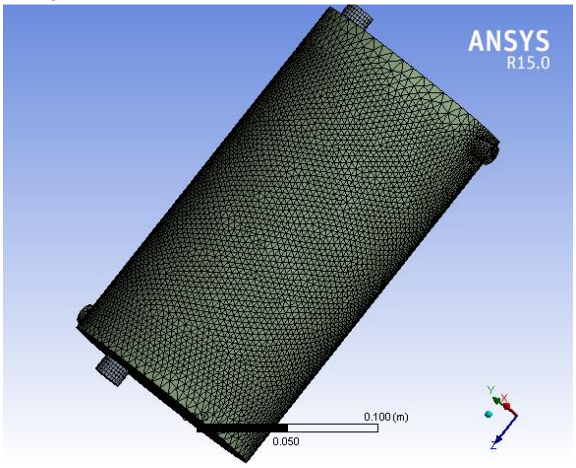


**Figure 4.2: Meshed model with of shell & helical heat exchanger.**

| Mesh type | Fine grid mesh |
|---|---|
| No. of nodes | 166306 |
| No. of elements | 287633 |

**Table 2: Meshing Stats**

**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-ε two equation turbulence model
- Mixture- mixture

**STEP 4**

Fluid Property

| | |
|---|---|
| Density (ρ) | 6320 kg/m$^3$ |
| Viscosity (µ) | 0.0001548 kg/m-s |
| Specific heat ($C_p$) | 0.531 KJ/Kg-K |
| Thermal conductivity (W/mk) | 32.9 Watt/mK |

**Table 3: Properties of Cuprous oxide Nanofluid**

| | |
|---|---|
| Density (ρ) | 2220 kg/m$^3$ |
| Viscosity (μ) | 0.0001308 kg/m-s |
| Specific heat ($C_p$) | 0.745 KJ/Kg-K |
| Thermal conductivity (W/m k) | 1.4 Watt/mK |

**Table 4: Properties of Silica Nanofluid**

| | |
|---|---|
| Density (ρ) | 998.2 kg/m$^3$ |
| Viscosity (μ) | 0.0010003 kg/m-s |
| Specific heat ($C_p$) | 4.182 KJ/Kg-K |
| Thermal conductivity ( k) | 0.6 Watt/K |

**Table No.5 Property of water**

**STEP 5**

Boundary Conditions

| | |
|---|---|
| Hot Inlet temperature ($T_h$) | 345 K |
| Cold Inlet Temperature (Ti) | 283 K |
| Mass Flow Inlet | 0.05 & 0.06 kg/s |
| Outlet ($P_{out.}$) | Pressure outlet |
| Operating condition pressure ($P_{opr.}$) | 101325 Pa |

**Table No. 6 Boundary Conditions**

**SOLUTION**

Solution Method

Pressure - Velocity - Coupling – Scheme - Simple

- Pressure – standard pressure
- Momentum- 2$^{nd}$ order
- Turbulence –kinetic energy 2$^{nd}$ order
- Turbulence dissipation rate 2$^{nd}$ order

**SOLUTION INITIALISATION**

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

**Run Solution**

Run the solution by giving 300 number of iteration 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.

**GEOMETRY AND PARAMETERS FOR HELICAL COIL**

The most geometric dimensional parameters include the diameter of the tube(d), curvature diameter or pitch circle diameter of the coil (D) and coil pitch (increase of height per rotation, p). Table 7 show dimensional and operating parameters used in the present study.

| S.No. | Dimensional Parameters | Dimensions |
|---|---|---|
| 1 | Pitch Coil Diameter | 86 mm |
| 2 | Helical Coil Outer Diameter | 16 mm |
| 3 | Helical Coil Inner Diameter | 12 mm |
| 4 | Pitch | 26.3 mm |
| 5 | Tube Length | 235 mm |
| 6 | Shell Diameter | 110 mm |
| 7 | Shell Length | 215 mm |
| 8 | Working fluid | $SiO_2$ & CuO nanofluid as water as its base |

**Table 7 Dimensional & Functional Parameters of Shell and Helical Heat Exchanger**

## RESULTS AND DISCUSSION

1) The effect of overall strain on the shell and helical coil warmth exchanger with the usage of cuprous oxide at a mass flow rate of 0.05 m/s in the helical coil.

| Case | Fluid | Pressure drop (Pa) |
|---|---|---|
| 1 | $CuO_2$ Nano fluid | 1551 |

**TABLE 8 Effect of total pressure**

2) The impact of total strain on the shell and helical coil warmness exchangers by utilising cuprous oxide at 0.05 m/s mass waft price in the shell.

| Case | Fluid | Pressure drop Pa) |
|---|---|---|
| 1 | $CuO_2$ Nano fluid | 1654 |

**TABLE 9 Effect of total pressure**

3) The effect of overall strain on the shell and helical coil heat exchangers employing cuprous oxide at 0.06 m/s mass glide charge in the helical coil.

| Case | Fluid | Pressure drop (Pa) |
|---|---|---|
| 1 | $CuO_2$ Nano fluid | 2999.4 |

**TABLE 10 Effect of Total Pressure**

4) The effect of general pressure on the shell and helical coil heat exchangers employing cuprous oxide at 0.06 m/s mass flow charge in the shell..

| Case | Fluid | Pressure drop (Pa) |
|---|---|---|
| 1 | $CuO_2$ Nano fluid | 1708 |

**TABLE 11 Effect of Total Pressure**

5) The impact of general stress on the shell and helical coil heat exchanger by employing silica at 0.05 m/s mass waft rate in the helical coil.

| Case | Fluid | Pressure drop Pa) |
|---|---|---|
| 1 | Silica Nano fluid | 632 |

**TABLE 12 Effect of total pressure**

6) The effect of general stress on the shell and helical coil warmth exchanger by utilising silica at 0.05 m/s mass float charge in the shell.

| Case | Fluid | Pressure drop (Pa) |
|---|---|---|
| 1 | Silica Nano fluid | 857 |

**TABLE 13 Effect of total pressure**

7) The effect of total stress on the shell and helical coil warmth exchangers when silica is used at 0.06 m/s mass float rate in the helical coil.

| Case | Fluid | Pressure drop (Pa) |
|---|---|---|
| 1 | Silica Nano fluid | 2548 |

**TABLE 14 Effect of total pressure**

8) The impact of total stress on the shell and helical coil heat exchanger using silica at 0.06 m/s mass drift price in shell.

| Case | Fluid | Pressure drop (Pa) |
|---|---|---|
| 1 | Silica Nano fluid | 1038 |

**TABLE 15 Effect of total pressure**

9) The effect of general temperature on the shell and helical coil warmth exchangers using cuprous oxide at 0.05 m/s mass flow charge in the helical coil.

| Case | Fluid | Temperature (K) |
|---|---|---|
| 1 | $CuO_2$ Nano fluid | 343.7 |

**TABLE 16 Effect of total temperature**

10) The impact of overall temperature at the shell and helical coil heat exchangers using cuprous oxide at zero.05 m/s mass waft charge in the shell.

| Case | Fluid | Temperature (K) |
|---|---|---|
| 1 | $CuO_2$ Nano fluid | 322.9 |

**TABLE 17 Effect of total temperature**

11) The effect of total temperature on the shell and helical coil warmth exchangers when cuprous oxide is used at a mass flow rate of 0.06 m/s in the helical coil.

| Case | Fluid | Temperature (K) |
|---|---|---|
| 1 | $CuO_2$ Nano fluid | 344.1 |

**TABLE 18 Effect of total temperature**

12) The effect of overall temperature on the shell and helical coil heat exchangers using cuprous oxide at 0.06 m/s mass flow rate in the shell.

| Case | Fluid | Temperature (K) |
|---|---|---|
| 1 | $CuO_2$ Nano fluid | 345 |

**TABLE 19 Effect of total temperature**

13) The effect of ambient temperature on the shell and helical coil warmth exchangers by the use of silica at 0.05 m/s mass drift fee in the helical coil.

| Case | Fluid | Temperature (K) |
|---|---|---|
| 1 | $SiO_2$ Nano fluid | 337.4 |

**TABLE 20 Effect of total temperature**

14) Effect of total temperature at the shell and helical coil warmth exchanger with silica at zero.05 m/s mass flow charge in shell.

| Case | Fluid | Temperature (K) |
|---|---|---|
| 1 | $SiO_2$ Nano fluid | 331.1 |

**TABLE 21 Effect of total temperature**

15) The influence of silica at 0.06 m/s mass drift charge in the helical coil on total temperature at the shell and helical coil warmth exchanger.

| Case | Fluid | Temperature (K) |
|---|---|---|
| 1 | $SiO_2$ Nano fluid | 342 |

**TABLE 22 Effect of total temperature**

16) The influence of ambient temperature on the shell and helical coil warmth exchangers employing silica at a mass flow rate of 0.06 m/s in the shell.

| Case | Fluid | Temperature (K) |
|---|---|---|
| 1 | $SiO_2$ Nano fluid | 329 |

**TABLE 23 Effect of total temperature**

**Case-1** The effect of overall strain on the shell and helical coil warmth exchanger with the usage of cuprous oxide at a mass flow rate of 0.05 m/s in the helical coil.

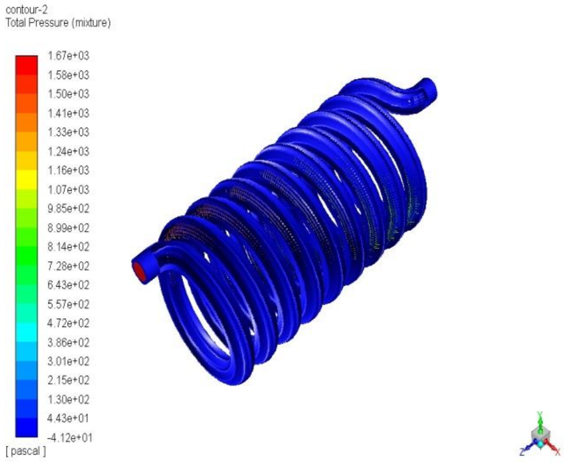


**Figure-3 Total pressure in shell and helical coil for hot fluid**

**Case-2** The impact of total strain on the shell and helical coil warmness exchangers by utilising cuprous oxide at 0.05 m/s mass waft price in the shell.

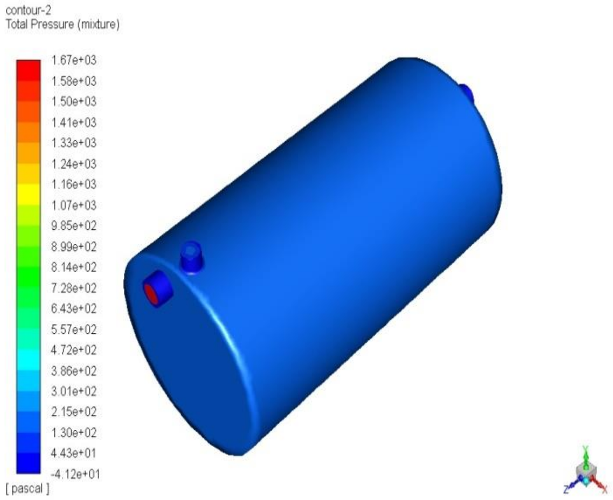


**Figure-4 Total pressure in shell and helical coil for cold fluid**

**Case-3** The effect of overall strain on the shell and helical coil heat exchangers employing cuprous oxide at 0.06 m/s mass glide charge in the helical coil.

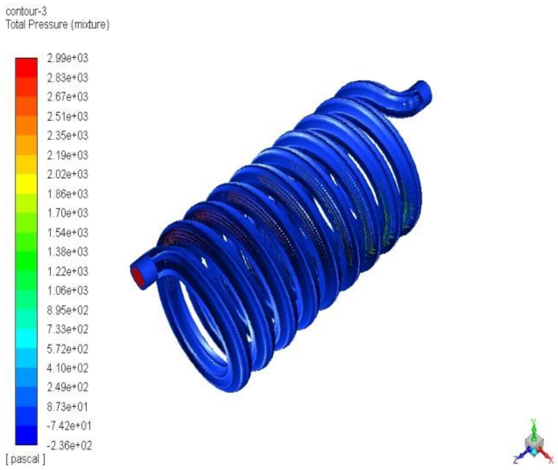


**Figure-5 Total pressure in shell and helical coil for hot fluid**

**Case-4** The effect of general pressure on the shell and helical coil heat exchangers employing cuprous oxide at 0.06 m/s mass flow charge in the shell

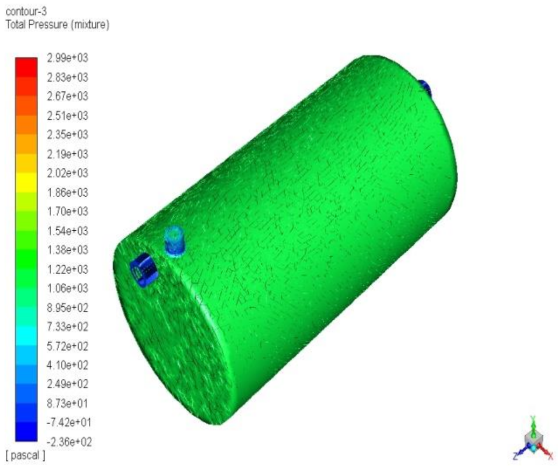


**Figure-6 Total pressure in shell and helical coil for cold fluid**

**Case-5** The impact of general stress on the shell and helical coil heat exchanger by employing silica at 0.05 m/s mass waft rate in the helical coil.

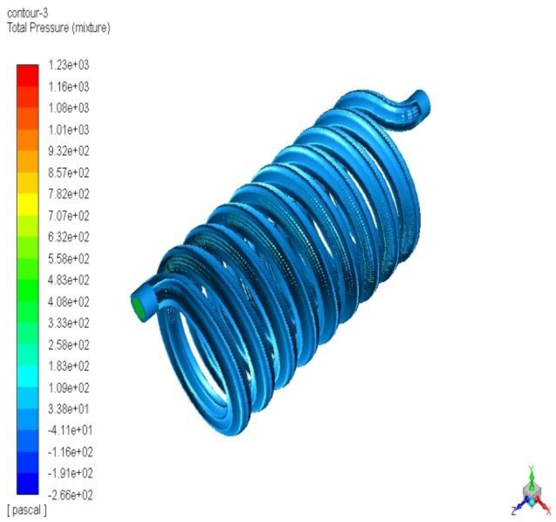


**Figure-7 Total Pressure in shell and helical coil for hot fluid**

**Case-6** The effect of general stress on the shell and helical coil warmth exchanger by utilising silica at 0.05 m/s mass float charge in the shell.

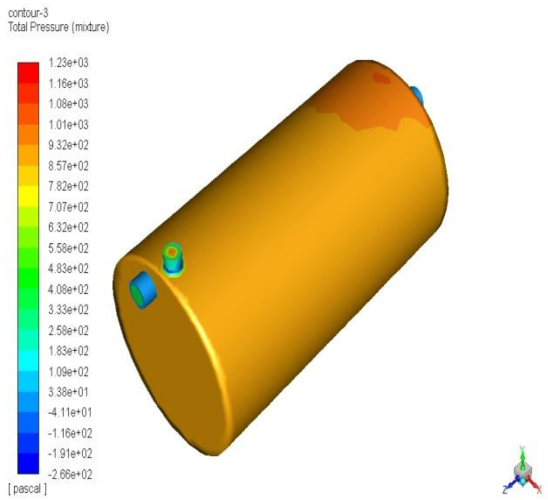


**Figure-8 Total Pressure in shell and helical coil for cold fluid**

**Case-7** The effect of total stress on the shell and helical coil warmth exchangers when silica is used at 0.06 m/s mass float rate in the helical coil.

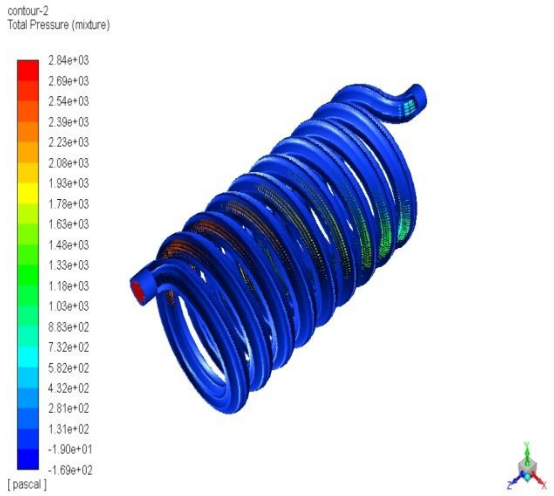


**Figure-9 Total Pressure in shell and helical coil for hot fluid**

**Case-8** The impact of total stress on the shell and helical coil heat exchanger using silica at 0.06 m/s mass drift price in shell.

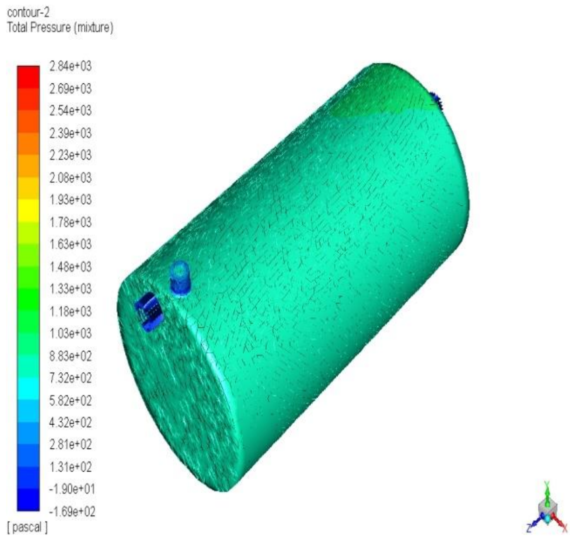


**Figure-10 Total Pressure in shell and helical coil for cold fluid**

**Case-9** The effect of general temperature on the shell and helical coil warmth exchangers using cuprous oxide at 0.05 m/s mass flow charge in the helical coil.

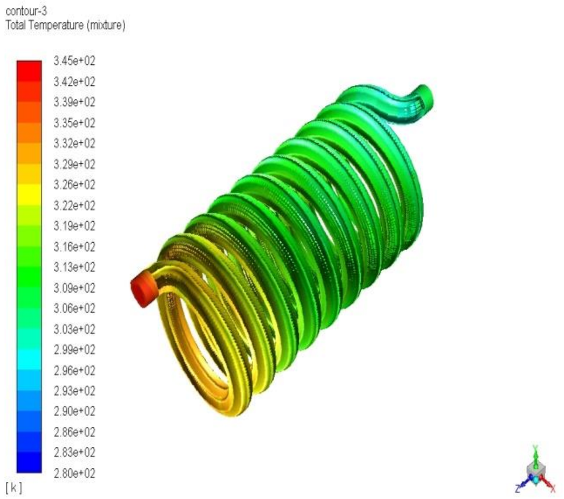


**Figure-11 Total Temperature in shell and helical coil for hot fluid**

**Case-10** The impact of overall temperature at the shell and helical coil heat exchangers using cuprous oxide at zero.05 m/s mass waft charge in the shell.

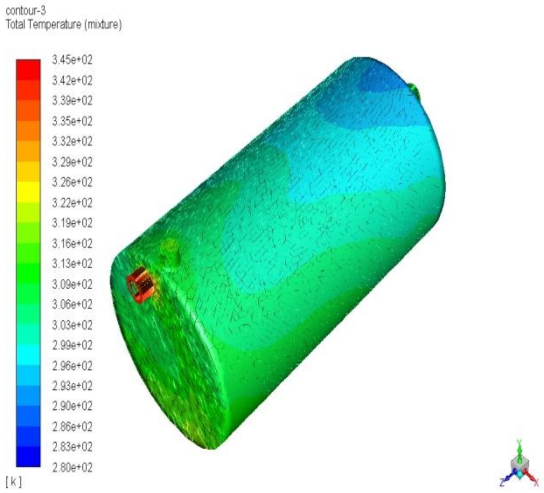


**Figure-12 Total temperature in shell and helical coil for cold fluid**

11) The effect of total temperature on the shell and helical coil warmth exchangers when cuprous oxide is used at a mass flow rate of 0.06 m/s in the helical coil.

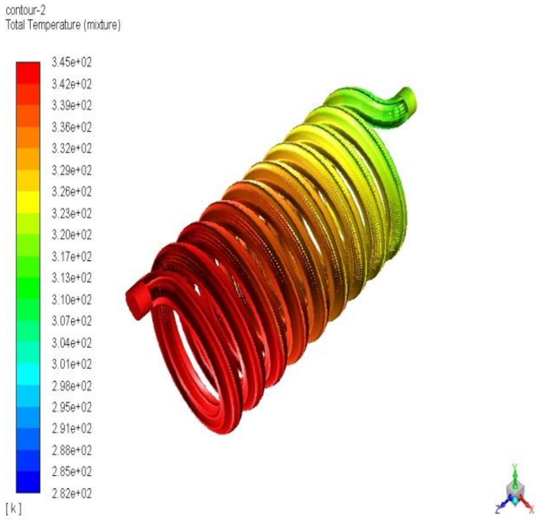


**Figure- 13 Total temperature in shell and helical coil for hot fluid**

12) The effect of overall temperature on the shell and helical coil heat exchangers using cuprous oxide at 0.06 m/s mass flow rate in the shell.

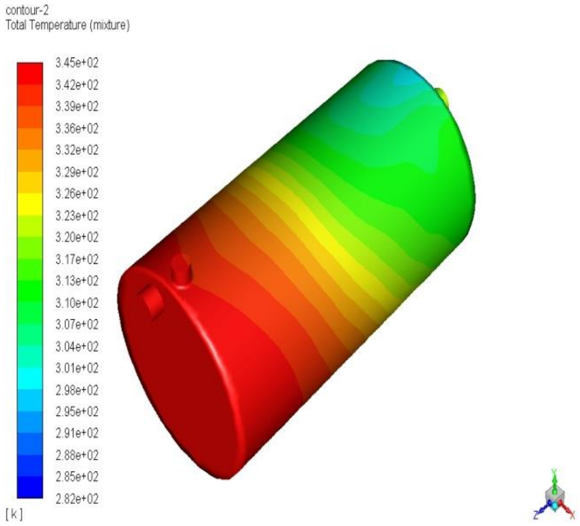


**Figure- 14 Total temperature in shell and helical coil for cold fluid**

13) The effect of ambient temperature on the shell and helical coil warmth exchangers by the use of silica at 0.05 m/s mass drift fee in the helical coil.

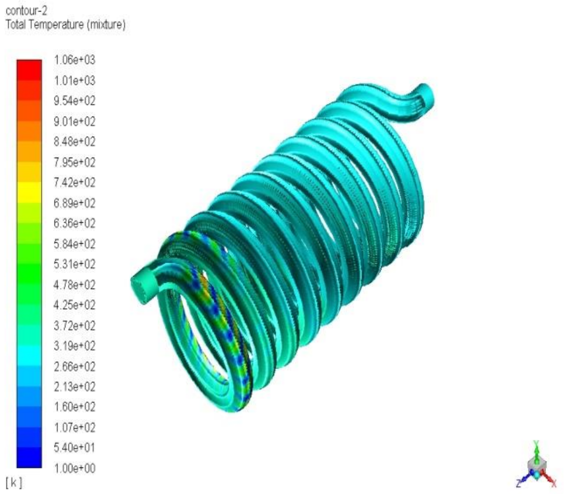


**Figure- 15 Total temperature in shell and helical coil for hot fluid**

14) Effect of total temperature at the shell and helical coil warmth exchanger with silica at 0.05 m/s mass flow charge in shell.

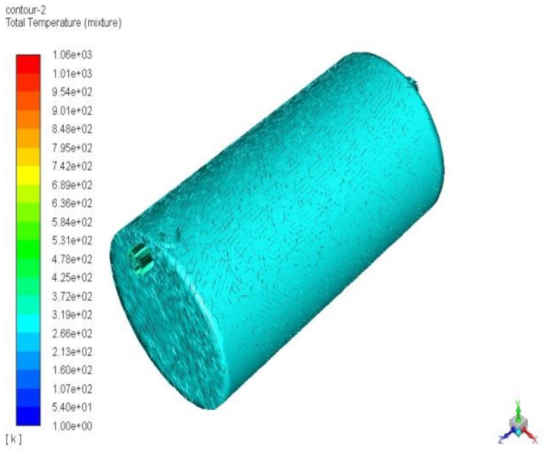


**Figure- 16 Total temperature in shell and helical coil for cold fluid**

15) The influence of silica at 0.06 m/s mass drift charge in the helical coil on total temperature at the hell and helical coil warmth exchanger.

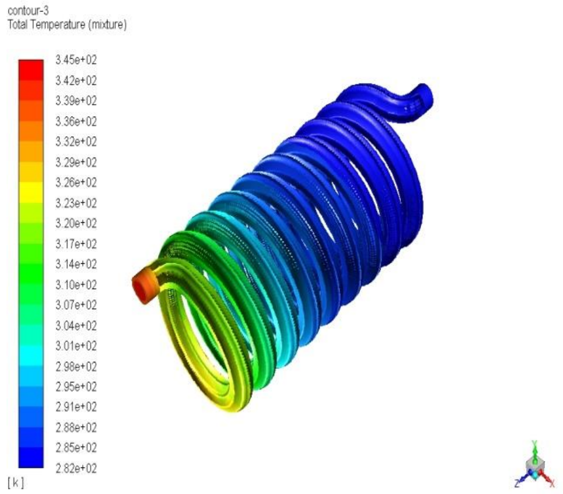


**Figure- 17 Total temperature in shell and helical coil for hot fluid**

16) The influence of ambient temperature on the shell and helical coil warmth exchangers employing silica at a mass flow rate of 0.06 m/s in the shell.

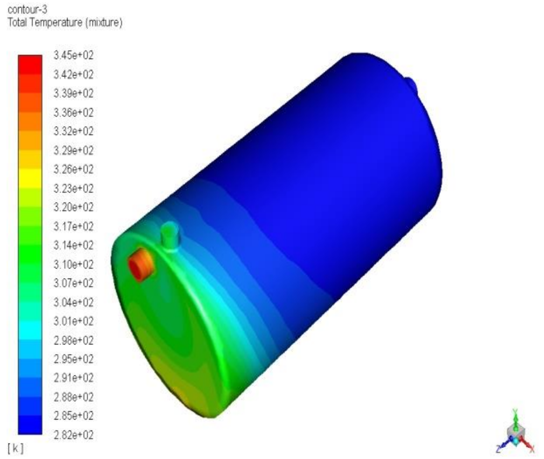


**Figure- 18 Total temperature in shell and helical coil for cold fluid**

## CONCLUSION

The quantity that varies exactly here is pressure. In these dimensions, we achieve greater stress, which is consistent with the earlier paper. Nanoparticle accumulation in base fluid enhanced stress decrease, indicating increased warmness transfer into the fluids. As a result, nano fluids will be a potential alternative for natural water in warmness exchangers when more effective heat transmission is required. The dispersion of nanoparticles in distilled water enhances the thermal conductivity and viscosity of the nanofluid; this enhancement rises with particle concentration. As the thermal conductivity of a fluid increases, the temperature rises as well. We can claim that by employing helical pipes instead of straight tubes, we may significantly increase the heat transmission price, and the usage of nano fluids contributes to this.

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