

Optimizing Design and Analysis on the Helically Coiled Tube Heat Exchanger Carrying Nanofluids by Providing Fins

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Abstract-Heat exchangers are an essential part in an assortment of mechanical settings, for example, cooling frameworks, force plants, refineries, and in this way ceaseless endeavor are made to expand their heat transfer efficiencies. Optimize design of helical coil heat exchanger by using fins and the Compare pressure & temperature by conventional design. The final outcome of the study increase the total heat transfer rate inside the domain. And increase the pressure drop inside the domain. The water outlet temperature decrease up to 315k and cold outlet temperature increase up to 320 k. and total pressure drop increase with the temperature increases. Finally the CFD data were compared with previous data the total pressure drop increase up to 0.65 bar for case-2.the overall efficiency of the system incites up to 5% to 6%.

Keyword: heat exchanger, helically coil, CFD, ANSYS.

I. INTRODUCTION

Heat exchangers are an essential part in an assortment of mechanical settings, for example, cooling frameworks, force plants, refineries, and in this way ceaseless endeavor are made to expand their heat transfer efficiencies. The design of heat exchangers is quite complicated, as it needs exact analysis of heat transfer rate and pressure drop estimations apart from issues such as long-term performance and the economic aspect of the equipment. The major challenge in designing a heat exchanger is to make the equipment compact and achieve a high heat transfer rate using minimum pumping power.[5-7]

Techniques for heat transfer augmentation are relevant to several engineering applications. In recent years, the high cost of energy and material has resulted in an increased effort aimed at producing more efficient heat exchange equipment. Furthermore, sometimes there is a need for miniaturization of a heat exchanger in specific applications, such as space application, through an augmentation of heat transfer. Heat transfer enhancement is one of the most promising methods to optimize heat transfer equipment and to increase heat recovery in industrial processes. Heat transfer enhancement techniques have been extensively developed to improve the thermal performance of heat exchanger systems with a view to reducing the size and cost of the systems. Swirl flow is the one of the enhancement techniques widely applied to heating or cooling systems in many engineering applications. Heat transfer enhancement techniques are classified as the - Passive Methods, Active Methods, and Compound Methods.[8-10] These methods are commonly used in areas such as process industries, heating and cooling in evaporators, air-conditioning equipment, refrigerators, radiators for space vehicles, automobiles, etc. The rate of heat transfer can be increased passively by increasing the surface area, roughness, and by changing the boundary conditions.

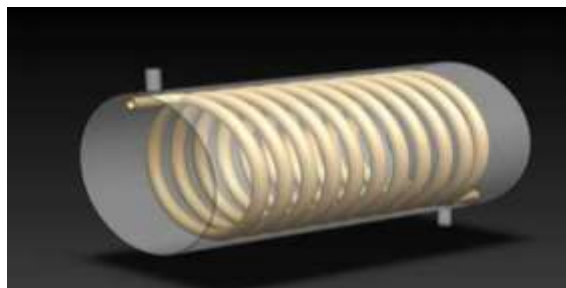


Figure 1 Helically coiled-tube heat exchanger

II. LITERATURE REVIEW

HamidKiani Salmi et al. [1] In this study, thermal and hydraulic attributes of an ecofriendly graphene nanofluid flowing within a countercurrent spiral heat exchanger are evaluated. The cold water flows in one side while the hot nanofluid or hot base fluid moves in the other side of heat exchanger. The heat transfer rate and overall heat transfer coefficient enhance with increasing either Reynolds number or concentration. The results show that the value of effectiveness is much great (higher than 0.85) in all cases under investigation. Moreover, the effectiveness and number of transfer units decrease by increasing the Reynolds number. The pressure drop intensifies with the Reynolds number increment, and the nanofluid demonstrates a greater pressure drop than the base fluid especially at higher Reynolds numbers.

Mehdi Bahiraei et al. [2] Heat exchangers have already proven to be important devices for thermal systems in many industrial sectors. In order to improve the efficiency of heat exchangers, nanofluids have recently been used as refrigerants. As for the unique properties of nanofluids, research in this area has seen remarkable growth. This article summarizes recent research on the use of nanofluids in heat exchangers, including that conducted on plate heat exchangers, dual tube heat exchangers, shell and tube heat exchangers and exchangers.

Nima Mazaheri et al. [3] In the present work, attempts are made to numerically study the hydrothermal properties and energy efficiency of a hybrid nanofluid with graphene-nanoplate-platinum composite powder in a three-tube heat exchanger with fins inserted. The nanofluid flows from the side of the inner ring, while cold water and normal water flow respectively from the side of the tube and from the side of the outer ring. The fins are fixed to the outer surface of the inner tube. The overall heat transfer coefficient, efficiency and heat transfer rate

of the heat exchanger are improved by increasing the concentration of nanoparticles and the height of the fins and decreasing the spacing of the fins.

Reza Rahmani et al. [4] This article summarizes recent research on the use of nanofluids in heat exchangers, including that conducted on plate heat exchangers, dual tube heat exchangers, shell and tube heat exchangers and exchangers. In the meantime, some fascinating aspects of the combination of nanofluids with heat exchangers are presented. In addition, challenges and opportunities for future research are presented and discussed.

III. OBJECTIVE

There are following objective of the present work.

- Optimize design of helical coil heat exchanger by using fins
- Compare pressure & temperature by conventional design
- Optimize rate of heat exchanger by best proposed design

IV. METHODOLOGY

1) STEPS OF WORKING

Step 1: Collecting information and data related to helically coiled tube heat exchanger.

Step 2: A fully parametric model of the helically coiled tube heat exchanger

Step 3: Model obtained in Step 2 is analyzed using ANSYS 18.2.

Step 4: Finally, we compare the results obtained from ANSYS.

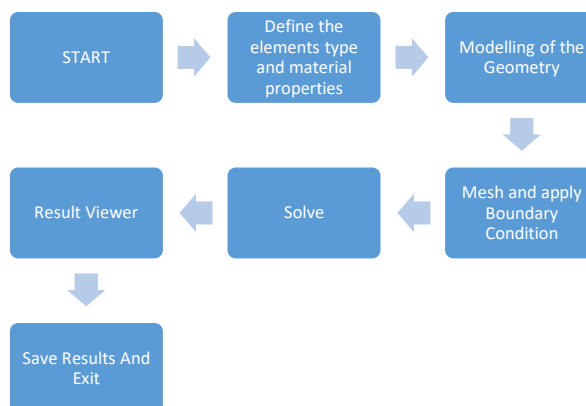


Figure 2: Setup of working

2) Finite elements analysis

Finite elements analysis is a branch of fluid mechanics that uses numerical analysis and data structures to solve and analyze problems that involve solid structure. For the present work ANSYS 18.2 software used.

ANSYS Capabilities:

In finite element analysis ANSYS software is used that helps engineers for performing the following tasks:

- To build computer prototype, components, transfer CAD models of structures in a system products.
- Enhances the profile of structural member with shape optimization.
- Physical responses, such as stress levels, temperature distributions, or electromagnetic field scan be studied.
- To reduce production costs optimization of design is done early in the development process.
- Testing of prototypes is done in environments where it otherwise would be undesirable or impossible (for example, biomedical applications).

Graphical user interface (GUI) in ANSYS gives users an easy, interactive approach to documentation, program functions, commands, and reference material. To navigate through the ANSYS program an intuitive menu system is used by users. Input data can be given using a mouse, a keyboard, or a combination of both.

3) STEPS OF ANSYS ANALYSIS

The different analysis steps involved in ANSYS are mentioned below.

1. PREPROCESSOR

The model setup is basically done in preprocessor. The different steps in pre-processing are

- Build the model
- Define materials
- Generation of element mesh

2. BUILDING THE MODEL

Table 1 Dimensional parameters of Double helically coiled tube.

Inner diameter of inner coil (dii)	5.85mm
Outer diameter of inner coil (dio)	6.35mm
Internal diameter of outer coil (doi)	12mm
External diameter of outer coil (doo)	12.7mm
Coil pitch(P)	20mm
No.of Coils turns(n)	15
Mean Coil inner diameter (Di)	100mm
Mean Coil outer diameter (Do)	125.35mm
Thermal conductivity of copper K	401W/m K
Thermal conductivity of copper K	8960 kg/m3

- Creating a solid model within CATIA

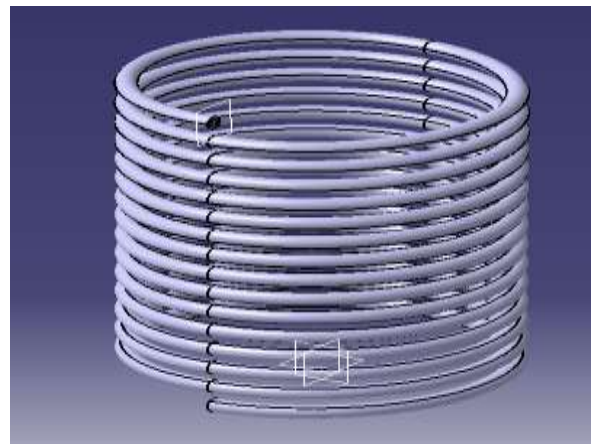


Figure 3: overall Creating a solid model within CATIA

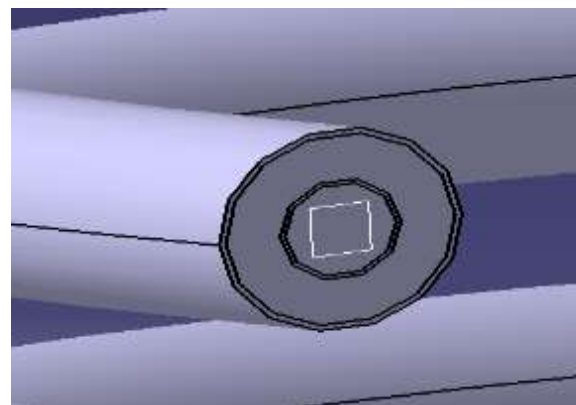


Figure 4: section creating a solid model within CATIA

Helically coiled tube	Copper
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single phase fluid. The effect of radiation and net convection are neglected. The thermo physical properties are not temperature dependent. Uniform dispersion nanoparticles. The flow is hydro dynamic. And constant heat flux condition is used. Fig shows the boundary conditions of the test section.

Table 4 Details of meshing.

Domain	Nodes	Elements
All body parts	642975	1616796

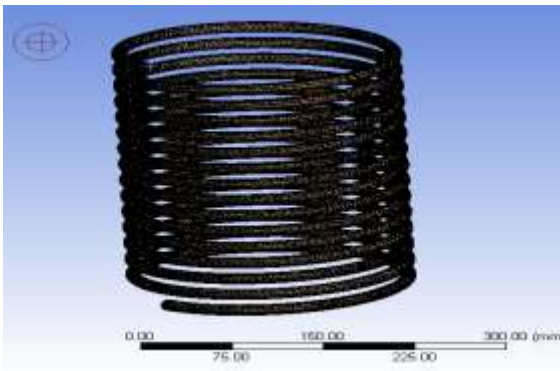


Figure 7: Over all Meshing

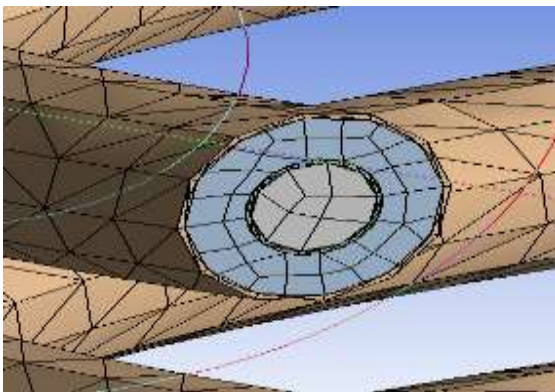


Figure 8: Section view of Meshing

Case-2

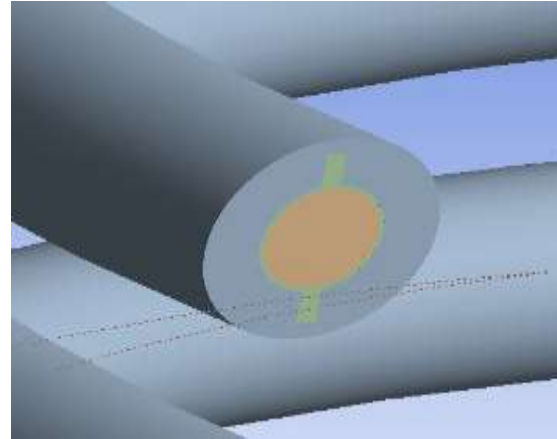


Figure 9: Case-2 Design

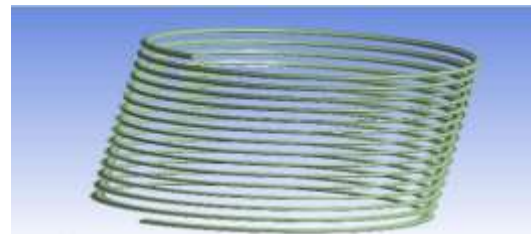


Figure 10: Case-2 overall Design

Table 4.5 Details of meshing.

Domain	Nodes	Elements
All body parts	825149	2712220

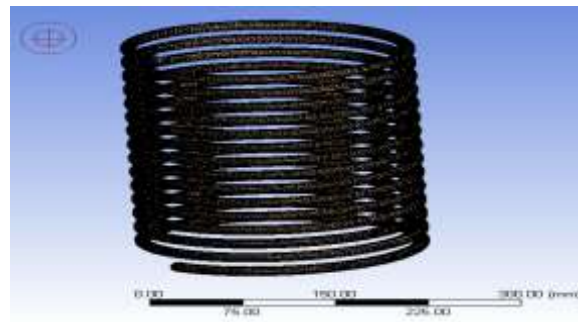


Figure 11: Case-2 mashing Design

3. Result:-

In this study calculated the total pressure drop at differnet volume concentrations with the Dean number range of 1300–2000.

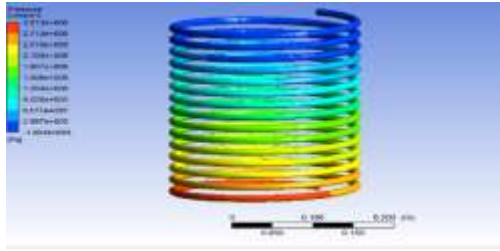


Figure 12: Pressure contours for case-1

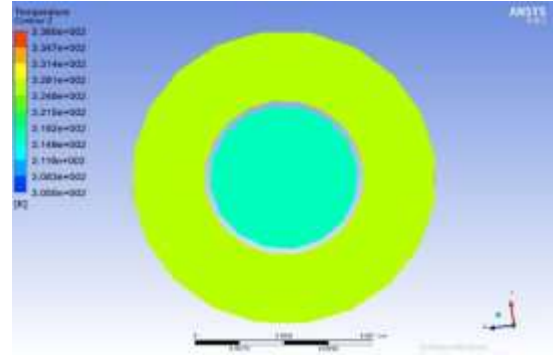


Figure 16: Temperature contours for case-1(0.4 concentration) (cold inlet and hot outlet)

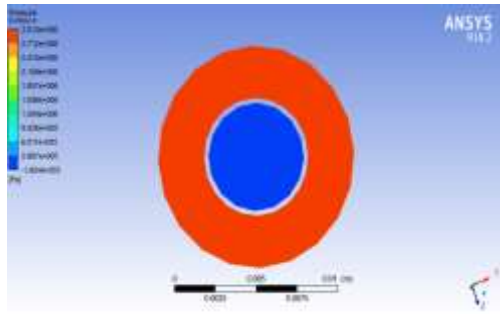


Figure 13: Pressure contours for case-1(cold outlet and hot inlet)

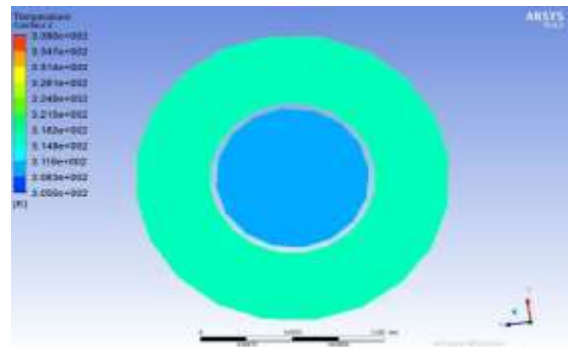


Figure 17: Temperature contours for case-1(0.6 concentration) (cold inlet and hot outlet)

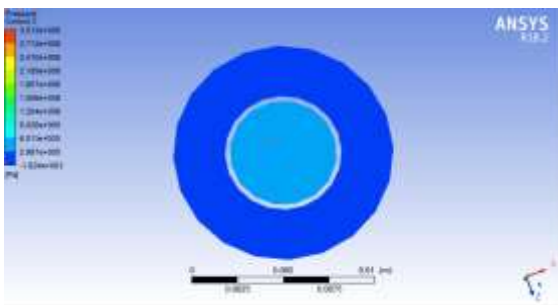


Figure 14: Pressure contours for case-1 (cold inlet and hot outlet)

Case-2 result

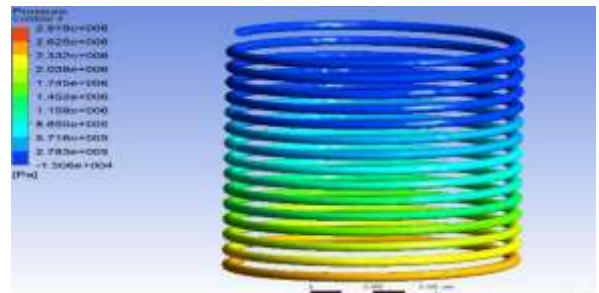


Figure 18: Temperature contours for case-2 (0.2 concentration) (cold outlet and hot inlet)

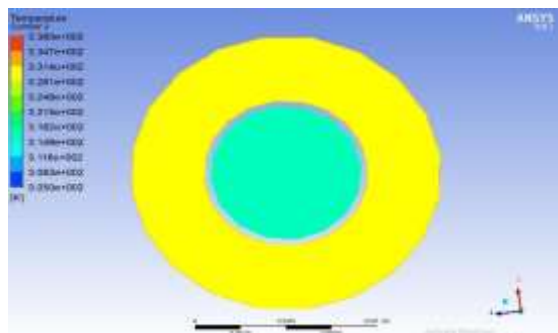


Figure 15: Temperature contours for case-1 (0.2 concentration) (cold inlet and hot outlet)

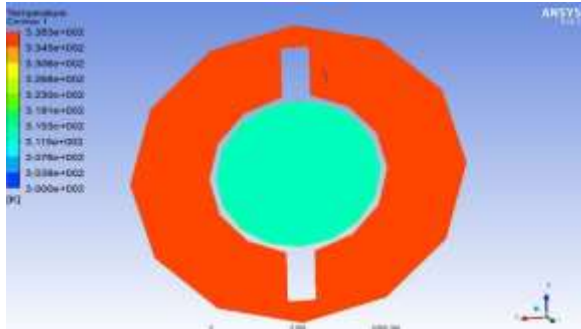


Figure 19: Temperature contours for case-2 (0.2 concentration) (cold outlet and hot inlet)

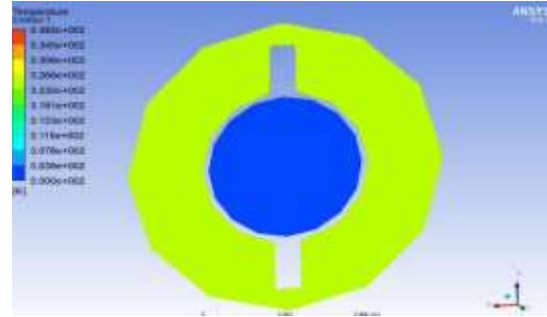


Figure 23: Temperature contours for case-2 (0.4 concentration) (cold inlet and hot outlet)

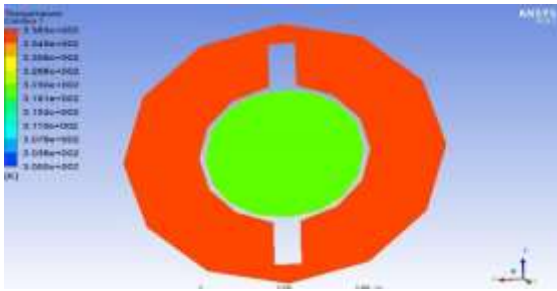


Figure 20: Temperature contours for case-2 (0.4 concentration) (cold outlet and hot inlet)

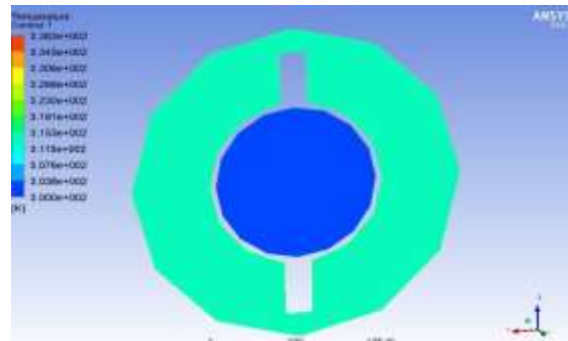


Figure 24: Temperature contours for case-2 (0.6 concentration) (cold inlet and hot outlet)

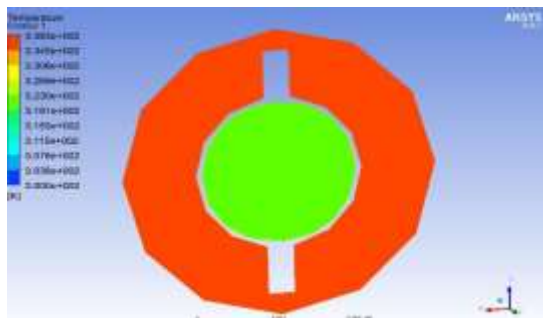


Figure 21: Temperature contours for case-2 (0.6 concentration) (cold outlet and hot inlet)

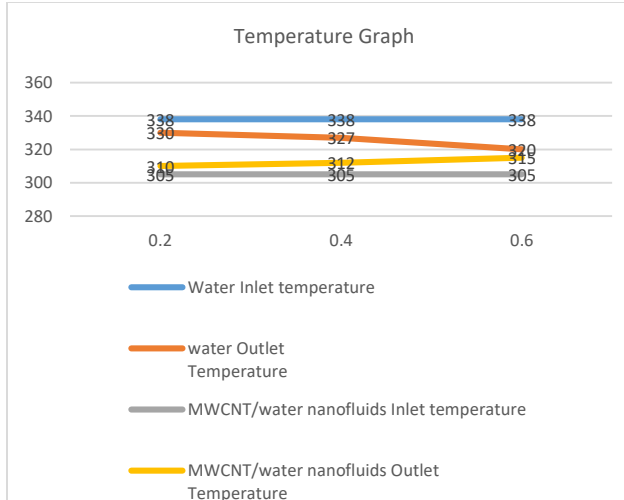


Figure 22: Temperature contours for case-2 (0.2 concentration) (cold inlet and hot outlet)

V. RESULTS

Case-1 Results

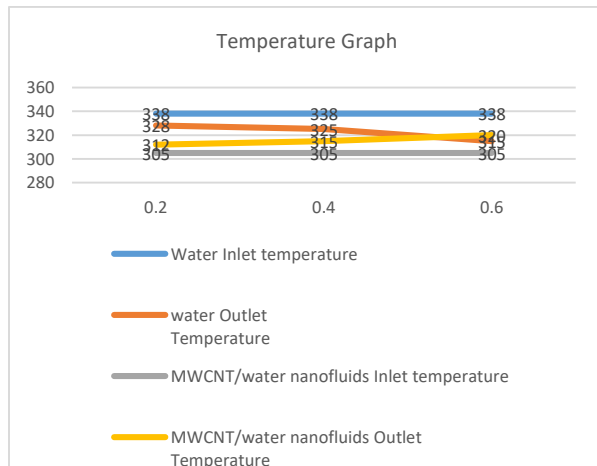
Volume concentration of nano fluid	Water		MWCNT/water nanofluids	
	Inlet temperature	Outlet Temperature	Inlet temperature	Outlet Temperature
0.2	338	330	305	310
0.4	338	327	305	312
0.6	338	320	305	315



Graph:-1 Temperature Graph for case-1

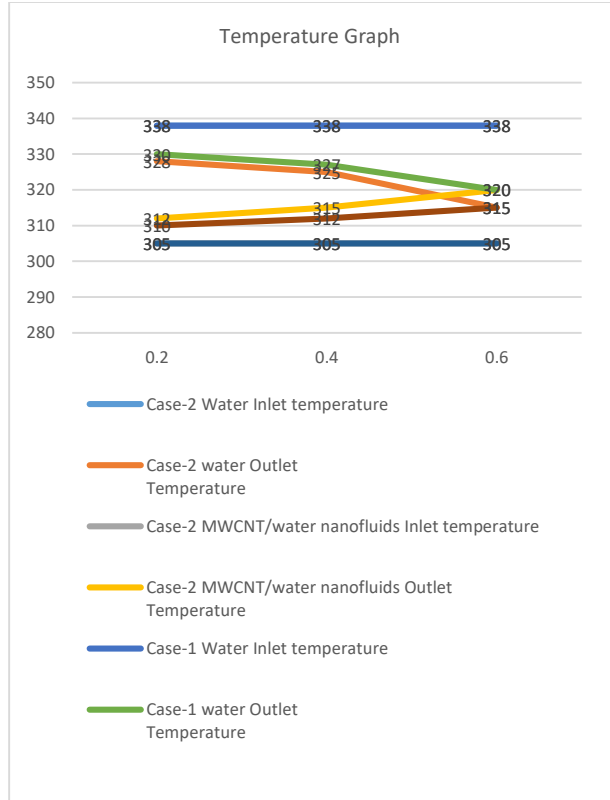
Case-2 Results

Volume concentration of nano fluid	Water		MWCNT/water nanofluids	
	Inlet temperature	Outlet Temperature	Inlet temperature	Outlet Temperature
0.2	338	328	305	312
0.4	338	325	305	315
0.6	338	315	305	320



Graph:-2 Temperature Graph for case-2

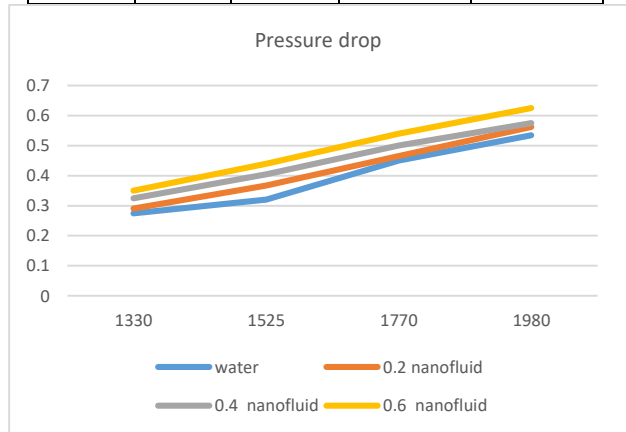
1) Comparison graph case-1 and case-2



Graph:-3 Comparison graph case-1 and case-2

2) Case-1 Pressure drop (Bar)

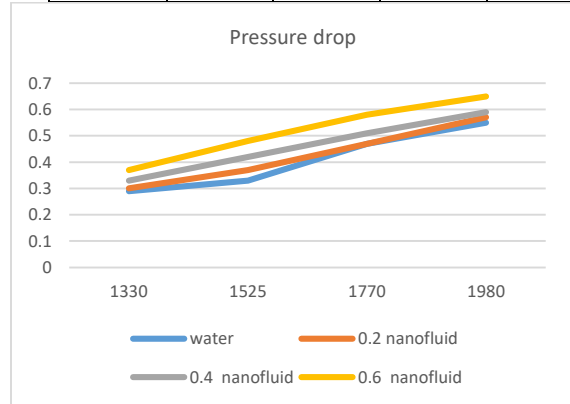
Dean number	water	0.2 nanofluid	0.4 nanofluid	0.6 nanofluid
1330	0.275	0.29	0.325	0.35
1525	0.32	0.367	0.405	0.44
1770	0.45	0.465	0.5	0.54
1980	0.534	0.562	0.575	0.625



Graph:-4 pressure drop graph

3) Case-2 Pressure drop (Bar)

Dean number	water	0.2 nanofluid	0.4 nanofluid	0.6 nanofluid
1330	0.29	0.3	0.33	0.37
1525	0.33	0.37	0.42	0.48
1770	0.47	0.47	0.51	0.58
1980	0.55	0.57	0.59	0.65



Graph:-5 pressure drop graph

VI. CONCLUSION

In this analysis, the heat transfer and pressure drop of a double helically coiled tube heat exchanger handling MWCNT/water nanofluids have been studied with CFD software package. Initially, hot and cold water are used to check the simulation and recorded the pressure and temperature of MWCNT/water of nanofluids at 0.2%, 0.4% and 0.6% volume concentrations with the Dean number range of 1300–2000. The final outcome of the study increase the total heat transfer rate inside the domain. And increase the pressure drop inside the domain. The water outlet temperature decrease up to 315k and cold outlet temperature increase up to 320 k. and total pressure drop increase with the temperature increases. Finally the CFD data were compared with previous data the total pressure drop increase up to 0.65 bar for case-2.the overall efficiency of the system incites up to 5% to 6%.

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