# Thermal Analysis of Tube with Helical Coil Inserts Using CFD

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**Abstract -***Helical coil heat exchangers are a common piece of equipment in many industrial applications. Because of their higher heat and mass transfer coefficients, narrow residence time distributions, and compact structure, helical coils are widely used as heat exchangers and reactors. The current work employs CFD analysis of heat transfer in a tube-in-tube helical coil heat exchanger to investigate the effect of outer and inner tube flow rates on heat transfer coefficients. The fluid used in the CFD simulation is Al2O3/water (1 percent volume fraction). The analysis is carried out for various fluid inlet velocities, namely 0.01m/s, 0.02m/s, 0.03m/s, 0.04m/s, and 0.05m/s. Comparison of parameters such as temperature plot, pressure drop and heat transfer coefficient, Nusselt number*

***Key Words***: *Heat Transfer, Pressure Drop, Reynolds Number, Nusselt number, CFD Model*

## 1. INTRODUCTION

Heat exchanger thermal efficiency is adequate for the commercial operation of industrial machinery. Several active or passive strategies, such as changing the fluid passage, adding spin creators, and mixing Nano fluids, are used to improve the thermal efficiency of heat exchanger pipe sideways convection heat transmission. These methods reduce plant irreversibility; improve heat transfer efficiency, volume, and fluid flow characteristics. Researchers from all over the world have been studying the thermal efficiency generation of convective heat transmission in tubes using various types of addition as a liquid way transformer. The majority of the addition geometry, normal velocity gradients, and works as a mixing inducer, disorder swirl generator, and abode time accompaniment.

### 1.2 NANOFLUIDS APPLICATION IN HEAT EXCHANGER

The scale of heat exchangers cannot become compact if the fluids complex has low thermal conduction and efficiency is too low due to low thermal conduction of fluids. Heat transmission improvement in the heat exchanger is possible with the development of the fluid's heat assets. It is a straightforward method of increasing heat potential by suspending small, fine particles in fluids. For example, different types of powders, metal, non-metal, and polymeric particles, can be used to frame slurries in liquids. Heat capacity is greater in complete suspended fluids than in simple fluids.

### 1.3 NANOFLUIDS PREPARATION

The main enterprise in the application of Nano phase elements to adjust the thermal exchange execution of normal solutions is Nano fluid readiness. The term "Nano fluid" refers to more than just a solid mixture of fluids. Some unusual prerequisites are required, such as an interruption, constant interruption, strong interruption, small particle collection, and no liquid concoction shift. In general, the following are effective suspension planning techniques:

1. Changing the estimated pH of the suspension; 2. Using both activators and dispersants for surfaces; and 3. Allowing the use of accelerated vibration.

## 2. CAD Model Import

The CAD model of helix geometry is built in Creo modelling software using dimensions from the literature [50]. 'The cylindrical part of the insert has a diameter of 19 mm, and the helical insert swept around it has a height of 4 mm and a width of 1 mm. The insert is approximately 350 mm long and has a rotation ratio of 1.92. It has a 25 mm inlet downwash and ends 50 mm before the outlet'[50]. The CAD model is encased in a cylindrical enclosure that conforms to the dimensions specified in the literature [50].

### 2.1 Identification of the issue

A heat exchanger's performance will be improved by the introduction of nanofluids since they offer a faster rate of heat transfer than base fluids.

In order to improve the heat transmission capabilities of helical insert tubing, the impact of nanofluids must be studied.

## 3. RESEARCH GAP

Previous studies focused on improving heat transmission using twisted tapes by employing nanofluids and tabulators. To improve heat transfer enhancement, some studies have used parametric optimization of twisted tapes. In order to improve heat transmission and decrease friction coefficient, this study investigated the usage of Al2O3/water and CuO/water nanofluids.

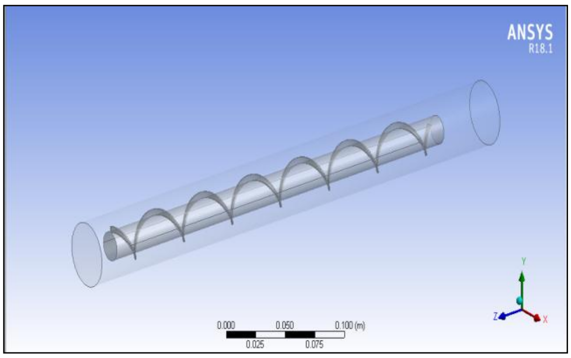


Figure 4.1: Introduced CAD model of the helix in ANSYS design modeler

### 4.2.1 Meshing CAD model

Using tetrahedral elements, the CAD model meshes. The size of significance is set at fine and inflation is set at neutral.

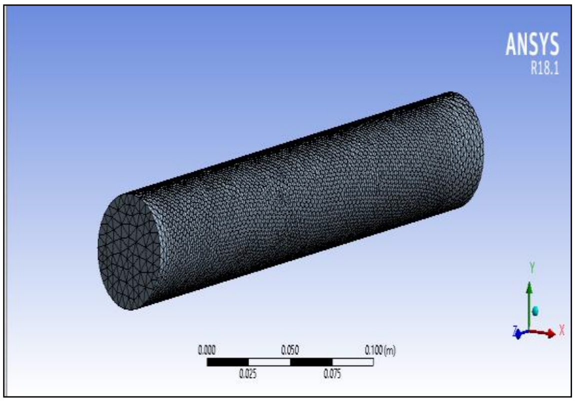


Figure 4.2: Imported CAD model of a helix in ANSYS design modeler

The number of generated nodes is 66669 and 334874 is the number of generated elements. The transition ratio is set to 0.77 and the growth rate is set to 1.2.

### 4.2.2 Loads and Boundary Condition

The loads and boundary condition involves domain definition, turbulence definition, and material definition. Fluid form and reference pressure set to 1atm are the specified domain. RNG k-epsilon was the turbulence model and thermal energy was the energy model.

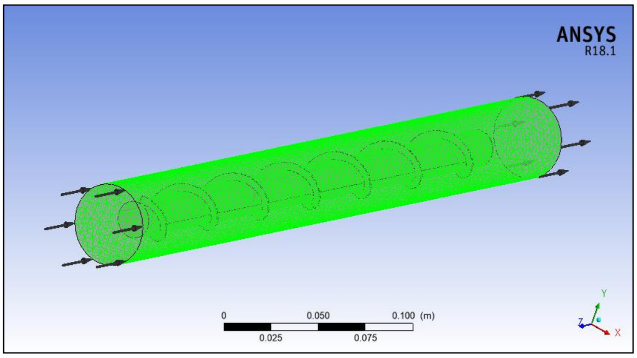


Figure 4.3: Fluid domain

WATER AS FLUID CUO (2 % VOLUME FRACTION)

CuO/water (2 percent volume fraction) is used as the fluid in the third CFD simulation. Different fluid inlet velocities, including 0.01 m/s, 0.02 m/s, 0.03 m/s, 0.04 m/s, and 0.05 m/s, are used in the analysis.

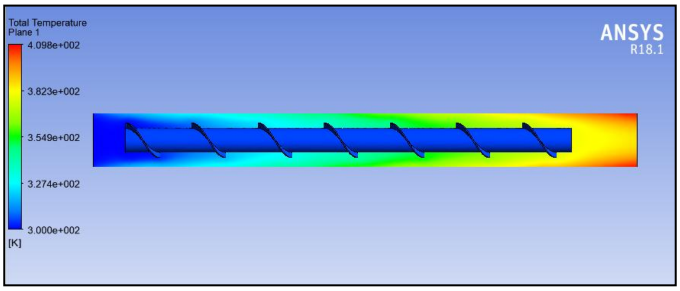


Figure 5.7: temperature plot of CuO/water as fluid (u=.01)

CuO/water (2 percent volume fraction) is used as the fluid, and the temperature map is obtained for helical screw tape insert in a pipe. The contour map shows how the temperature rises as one moves from the fluid inlet to the fluid output wall. The heavy blue tint, which gets lighter as you get closer to the exit, indicates a temperature of 300K at the fluid input. The contour plot displays the temperature shift from 300K to 354K in the middle region, which is indicated by green, and 409K towards the exit, which is indicated by red on the edge and yellow in the centre.

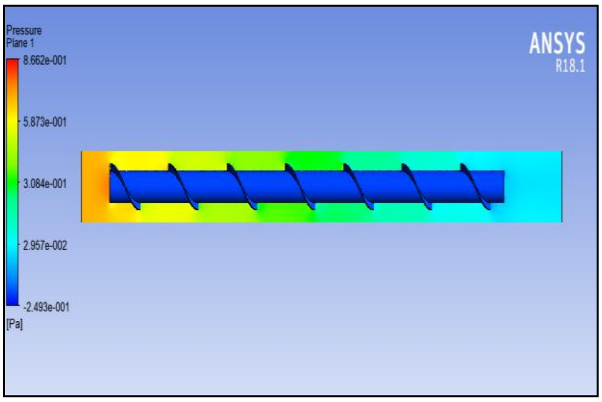


Figure 5.8: Pressure plot of CuO/water as fluid (u=.01)

In figure 5.8 above, the pressure plot obtained for CuO/water (2 percent volume fraction) as fluid is Illustrated. As Illustrated by the orange and dark red colors, the plot indicates higher inlet pressure. The pressure near the helical screw tape is high in the magnitude of .86Pa which reduces as the fluid passes through the coil and move towards the exit. The pressure at exit is .24Pa (negative) as shown by the dark blue color region.

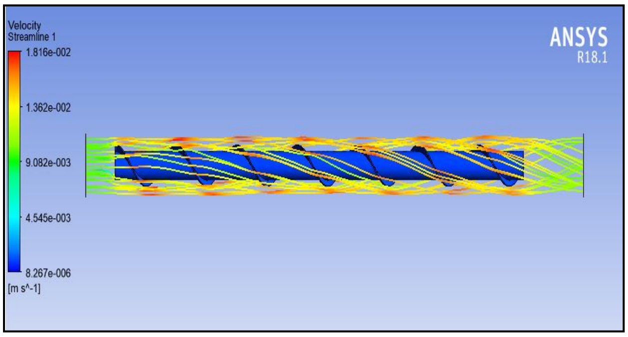


Figure 5.9: Streamline plot of CuO/water as fluid (u=.01)

In figure 5.9 upper, the velocity streamline obtained for CuO/water as fluid is Illustrated. The plot indicates a .009m/s fluid inlet velocity at the domain inlet that changes as the fluid passes through the helix region. The streamlined flow of fluid changes to turbulent flow and remains turbulent till the fluid reaches the exit of the domain. The fluid velocity at the helix zone is .018m/s asillustratedin red-colored lines while fluid velocity at the outlet is the same as that of the inlet.

CuO/water (2 percent volume fraction) is used as the fluid, and the temperature map is obtained for helical screw tape insert in a pipe. The contour map shows how the temperature rises as one moves from the fluid inlet to the fluid output wall. The heavy blue tint, which gets lighter as you get closer to the exit, indicates a temperature of 300K at the fluid input. The contour plot displays the temperature shift from 300K to 354K in the middle region, which is indicated by green, and 409K towards the exit, which is indicated by red on the edge and yellow in the centre.

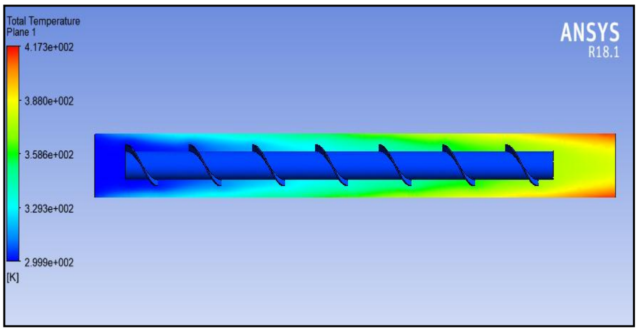


Figure 5.10: Temperature plot of $Al_2O_3$/water as fluid (u=.01)

Al2O3/water (1 percent volume fraction) is used as the fluid, and the temperature map is obtained for the helical screw tape insert in the pipe. The contour plot shows how the temperature rises as you move from the fluid inlet to the fluid outlet wall. The heavy blue tint, which gets lighter as you get closer to the exit, indicates a temperature of 300K at the fluid input. The contour plot shows a temperature difference from 300 K to 358 K in the middle, which is shown by the colour green, to 417 K towards the exit, which is shown by the colour red on the edge and the colour yellow in the middle.

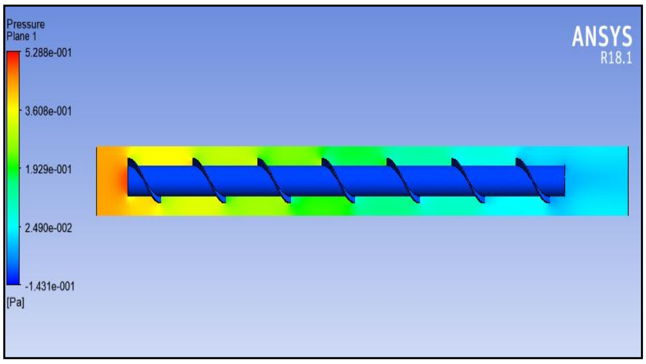


Figure 5.11: Pressure plot of $Al_2O_3$/water as fluid (u=.01)

The pressure plot for the fluid Al2O3/water (1% volume fraction) is shown in Figure 5.11 top. Orange and dark red colors used in the plot demonstrate higher inlet pressure. As the fluid moves through the coil and toward the outlet, the pressure at the helical screw tape, which is high by the order of.52Pa, decreases? The dark blue hue zone on the graph indicates that the pressure at exit is.24Pa (negative).

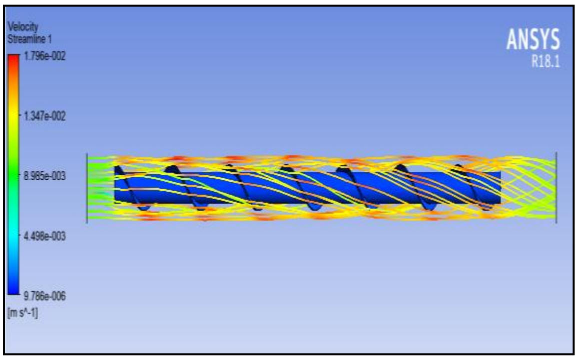


Figure 5.12: Streamline plot of $Al_2O_3$/water as fluid (u=.01)

The upper figure 5.12 shows the velocity streamlines obtained for the fluid Al2O3/water. The graph shows how the fluid's initial inlet velocity, which is 0.89 m/s at the domain inlet, changes as it passes through a helix's zone. The fluid's streamlined flow transforms into turbulent flow and stays turbulent all the way to the domain's exit. As shown by the red lines, the fluid velocity at the helix zone is.017 m/s, while the fluid velocity at the outlet is equal to that at the intake.

## 5. CONCLUSION

To investigate how nanofluids affect the spiral screw tape addition tube's heat transmission properties, a numerical simulation is run. The CFD study showed how well it worked at analysing the properties of heat transmission and fluid flow via pipes. When compared to experimental testing methods, using computer simulation software is more affordable and quicker.

1. The NN rose with an increase in RN for all fluids that can be linked to an increase in heat transfer at higher fluid velocities. The fluid flow becomes turbulent with an advanced heat transfer frequency at higher fluid velocities.

2. The use of Al2O3/water nanofluids has significantly enhanced the characteristics of water's heat transmission.

3. Using CuO/water nanofluids has resulted in decreased heat transfer features compared to water, which has a high friction factor.

4. Compared to water with a lower fluid velocity of.01 m/s, the use of Al2O3/water nanofluids has improved heat transmission by 43.7%.

5. The use of Al2O3/water nanofluids led to a 41.5 percent increase in heat when compared to water with a fluid velocity of.03 m/s.

6. A 34.04 percent heat transmission related to water was observed when Al2O3/water nanofluids were used at a fluid velocity of.05 m/s.

7. The FF dropped as the RN increased for all fluids, including water, Al2O3/water, and CuO/water.

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