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"CFD INVESTIGATION FOR HEAT TRANSFER OF HYBRID NANOFLUID WITH WIRE COIL TURBULATOR IN A DOUBLE TUBE HEAT EXCHANGER"

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ABSTRACT

After analyzing Al2O3/ water as a working fluid with tabulator in heat exchanger, hybrid nano fluid were used as a cold fluid in place of Al2O3/ water. To explore hybrid nano-fluid heat transfer effects, we have considered this work here Cu+Al2O3/water based hybrid nanofluid. Here it considered three volume fraction of nano fluid that is 0.4%, 0.8% and 1.2%. We used the hybrid nano fluid with a 0.4 percent volume concentration for the initial study of hybrid nanoparticles during heat transmission at Re = 4000. Boundary conditions were same as considered during the analysis of Al2O3/ water in heat exchanger having turbulator. Here in this section we are analyzing the influence of Cu+Al2O3/water based hybrid nanofluid in heat exchanger having turbulator, and try to find out the effect of flow of Cu+Al2O3/water based hybrid nanofluid over turbulator in respect of heat transfer enhancement.

Key Words: *Al_2O_3, hybrid nanofluid.***,** *heat transfer enhancement, fluid.*

I. INTRODUCTION

1.1. Background

Nanotechnology has interested many researchers since its inception, who have recently begun to use nano-fluids in together experimental and theoretical work. Thermo transmitting properties of nanoparticles also contributed to the usage of their respective fields of nanoparticles of industry such as solar Synthesis, gas sensing, biological sensing, nuclear reactors and the petroleum industry to enhance the heat transmission ability of conventional fluids.

Over the last decade the science of nanofluid has grown quite constantly. Although the results were contradictory and the method of heat transfer of nanofluids could not be comprehensible, it emerged as a capable thermal transfer fluid. In the continuity of nanofluid science researchers have also recently attempted to use hybrid nanoparticles, which are built to suspend various nanoparticles in combination or a composite form. The aim of the use of hybrid nanofluids is to improve thermal transmission properties further by improving the pressure drop compensation ratios, enhancing the thermal network and the synergistic impact of nanomaterials on individual suspension benefits and disadvantages.

1.2. Heat Exchanger

The heat exchange system is a heat exchanger that heats up to two or more processing fluids. Heat exchangers have a range of domestic and commercial applications. Many heat exchangers were designed for use in steam plants, manufacturing plants, heat and air conditioning facilities, transportation and cooling systems.

1.2.1 Heat Exchanger Types

Many heat exchangers may be categorized as one of a range of unique types. The four most common groups, depending on the configuration of the flow direction, are as follows:

i. In **concurrent or parallel flow**, the two fluid streams join together at one end, travel in the same direction,

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and exit together at the other end;

ii. In **countercurrent or counterflow**, the two currents pass in opposite directions;

iii. One fluid moves through the heat transfer matrix at right angles to the flow path of another fluid in **single-pass cross flow units**.

iv. For **multipass cross flow systems**, one flow stream shuttles back and forth across the flow direction of the other flow stream, typically providing a crossflow approximation to the counterflow.

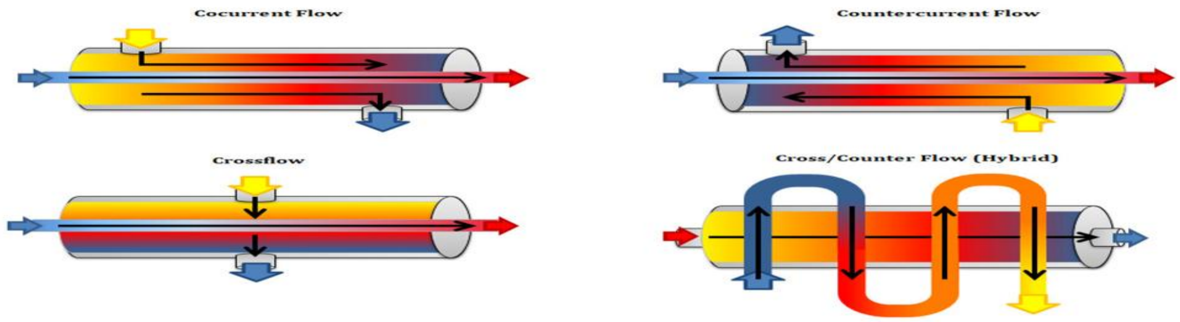

Figure 1.1 Categorization on the basis of flow direction.

Heat exchangers can also be categorized according to their construction physiognomies. There are, for instance, tubular, plate, plate-fin, tube-fin and regenerative exchangers.

1.3. Heat Transfer Augmentation Techniques

Essentially to increase the efficiency of the heat exchange network by incorporating additional activities that operate at comparable temperatures. This can be achieved without adjusting the surface area. This constraint explicitly implies an increase in the average surface area, task and Q and the driving force of the heat transfer coefficient (T). This is the fundamental equation used in almost every setup of the heat exchanger.

$$Q = U\,A\,\Delta T$$

Heat transfer increase system is typically classified in three broad categories:

(a) Active approach: From the point of view of use and design, these approaches are more complex since the solution requires a certain external power input to change the optimum flow and maximise the rate of heat transfer. Implementation in diverse practical applications is limited due to the need for electrical power.

(b) Passive technique: Usually, such approaches require additions or extra equipment using the surface or geometrical adjustments in the flow direction. These promote higher heat transfer coefficients, which can contribute to an increase in the pressure drop, by disturbing or changing existing flow patterns. These strategies do not need direct input from external control, but instead use the external power input from the device itself, which contributes to a decrease in fluid pressure.

(c) Compound approach: The method of compound increase is the one used to boost the thermo-hydraulic performance of the heat exchanger by more than one of the techniques referred to above. When two or more of these techniques are used together to increase the heat transfer, which is greater than that produced by each technique when used separately, they are referred to as compound.

II. METHODOLOGY

Steps taken during the analysis

- Firstly we design the turbulator double pipe heat exchanger on Workbench of ANSYS 16.0 Software.
- After designing the model it is transferred to ANSYS for CFD analysis.
- Meshing of model is done on CFD pre-processor.
- The boundary conditions are applied on the model and numerical solutions are calculated by using solver.
- In solving the problem, the finite volume approach is used.
- Solution is calculated by giving iterations to the mathematical and energy equations applied on model.
- The results can be visualized in the form contours and graphs by CFD post processor.

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- Applying formulas for calculating heat transfer coefficient, Nusselt Number, LMTD and effectiveness of double pipe heat exchanger.
- Result analysis.
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This section is planned to measure the heat exchanger's thermal efficiency. In order to investigate the efficiency of the heat exchanger with the flow-dependent turbulator, variations of the overall coefficient of the heat transfer and the sum of Nusselt are measured at different number Reynold.

III. RESULT

3.1. Validation of numerical computations

In order to authenticate the precision of established numerical method, an assessment was made with the work stated in Akyürek et al. (2018) [18]. The turbulator geometry double pipe heat exchanger used for the validation of numerical measurements was found to be the same as the geometry shown in Fig. 3.1. Here we consider aluminium oxide (Al_2O_3) to be a nanoparticle; it is mixed with 0.4% fraction volume water and is used in a heat exchanger as a nano-fluid. The temperature contours of the aluminium nanofluid on 4000 Re-numbers are seen in the following section:

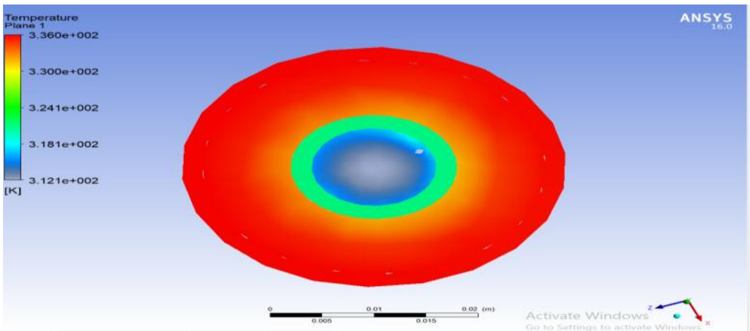

Fig 3.1. Cold fluid inlet temperature contour for Re = 4000 at 0.4 percent volume fraction for Al_2O_3.

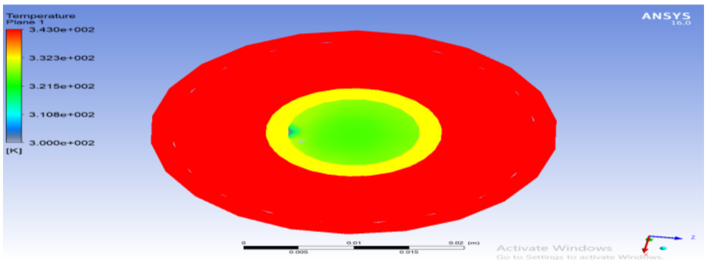

Fig 3.2. Cold fluid outlet temperature contour for Re = 4000 at 0.4 percent volume fraction for Al_2O_3.

Likewise, aluminium oxide (Al_2O_3) can be a nanoparticle, being used as a nanofluid in heat transfer combined with water on vol. fraction of 0.8 percent. Aluminium nano-fluid thermal contours at Re=4000 are seen in the following section:

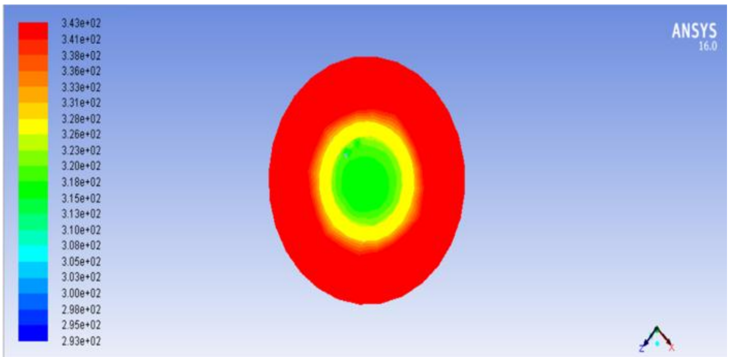

Fig 3.3. Cold fluid inlet temperature contour for Re = 4000 at 0.8 percent volume fraction for Al_2O_3.

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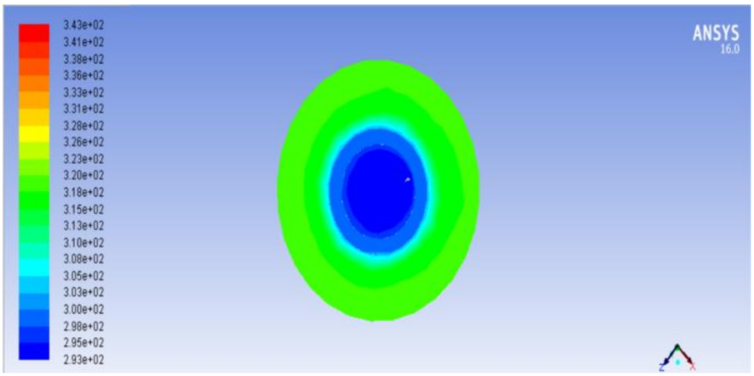

Fig 3.4. Cold fluid outlet temperature contour for Re = 4000 at 0.8 percent volume fraction for Al_2O_3.

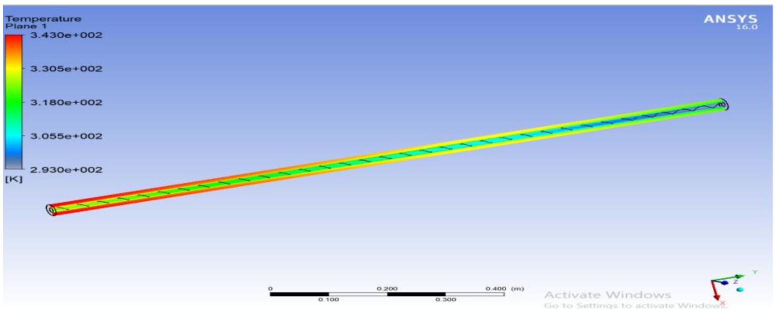

Figure 3.5 Center plane Temperature contour of heat exchanger at 0.8% volume fraction for Al_2O_3.

Aluminum oxide (Al_2O_3) also acts as a nanoparticle; it is used as a nanofluid in the heat exchanger, mixed with water at a volume of 1.2 %. The aluminium nano-fluid temperature contours at Re=4000 are seen in the following section:

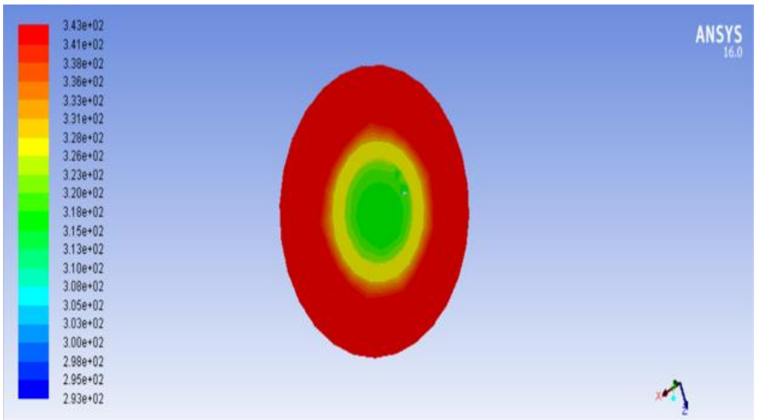

Fig3.6. Cold fluid inlet temperature contour for Re = 4000 at 1.2 percent volume fraction for Al_2O_3.

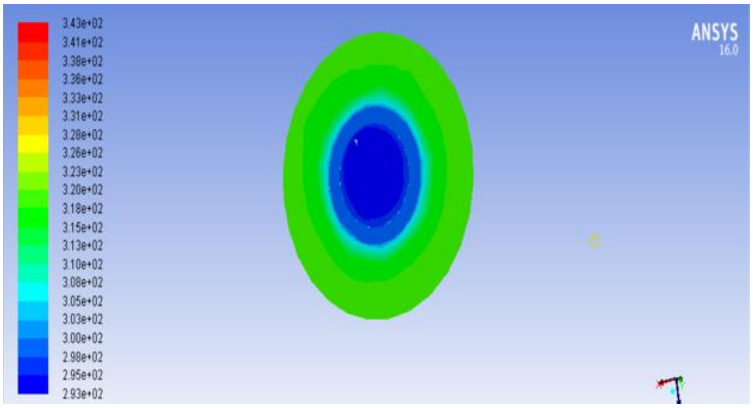

Fig 3.7. Cold fluid outlet temperature contour for Re = 4000 at 1.2 percent volume fraction for Al_2O_3.

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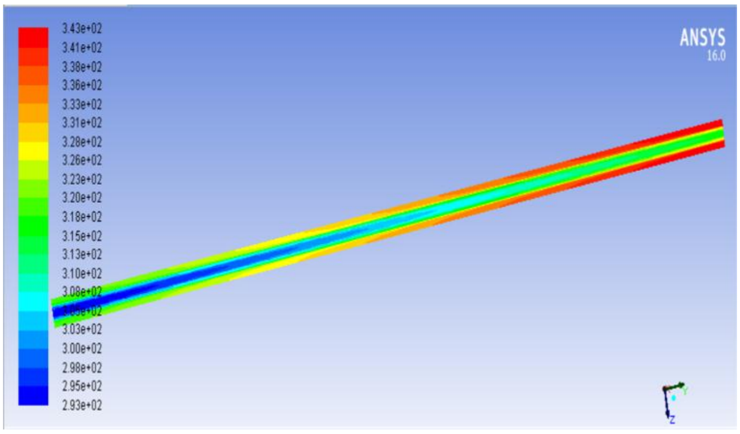

Figure 3.8 Center plane Temperature contour of heat exchanger at 1.2 % volume fraction for Al_2O_3.

By CFD analysis, the value of the hot and cold fluid in the Re = 4000 inlet / outlet was determined in a number of volume fractions depending on which the value of the Nusselt volume and the overall heat transfer coefficient is estimated.

The values of Nusselt number and total heat transfer coefficients calculated for CFD modelling were contrasted with values obtained from the analyses by Akyürek et al. (2018) [18].
Table 1 indicates the Overall heat transfer coefficient values at 0.4 percent volume fraction for Al_2O_3 determined from CFD models opposed to the values derived from **Akyürek et al. (2018)** [18] study for double pipe heat exchanger with turbulator.

Table.1 Indicates the Overall heat transfer coefficient values

S.No.	**Reynold's number**	**Overall heat transfer coefficient (W/m^2-K) (Base Paper)**	**Overall heat transfer coefficient (W/m^2-K) (Present Study)**
1.	4000	1250	1253.45
2.	8000	1310	1315.83
3.	12000	1380	1384.95
4.	16000	1435	1440.71
5.	20000	1480	1487.98

Table 2 indicates the Nusselt number values at 0.4 percent volume fraction for Al_2O_3 determined from CFD models opposed to the values derived from **Akyürek et al. (2018)** [18] study for double pipe heat exchanger with turbulator.
Table 2 Indicates the Nusselt number values

S.No.	**Reynold's number**	**Nusselt number (Base Paper)**	**Nusselt number (Present Study)**
1.	4000	85	88.43
2.	8000	120	125.61
3.	12000	155	158.74
4.	16000	190	193.49
5.	20000	225	228.63

The above verified study indicates that the Nusselt values and the measured total CFD heat transfer are similar to the Nusselt value and the estimated heat transfer from the base journal. Here, the CFD heat exchanger turbulator model is right.

3.2 Hybrid Nano-fluid as a working fluid

After analyzing Al_2O_3/ water as a working fluid with turbulator in heat exchanger, hybrid nano fluid were used as a cold fluid in place of Al_2O_3/ water. To explore hybrid nano-fluid heat transfer effects, we have considered this work

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here Cu+Al_2O_3/water based hybrid nanofluid. Here it considered three volume fraction of nano fluid that is 0.4%, 0.8% and 1.2%.

We used the hybrid nano fluid with a 0.4 percent volume concentration for the initial study of hybrid nanoparticles during heat transmission at Re = 4000.

Boundary conditions were same as considered during the analysis of Al_2O_3/ water in heat exchanger having turbulator. Here in this section we are analyzing the influence of Cu+Al_2O_3/water based hybrid nanofluid in heat exchanger having turbulator, and try to find out the effect of flow of Cu+Al_2O_3/water based hybrid nanofluid over turbulator in respect of heat transfer enhancement.

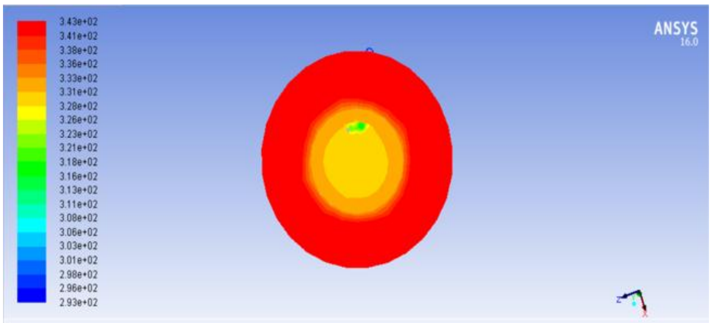

Figure 3.9 Temperature contour at the exit of cold fluid i.e. Cu+Al_2O_3/water based hybrid nanofluid at Re = 4000 at 0.4% volume fraction.

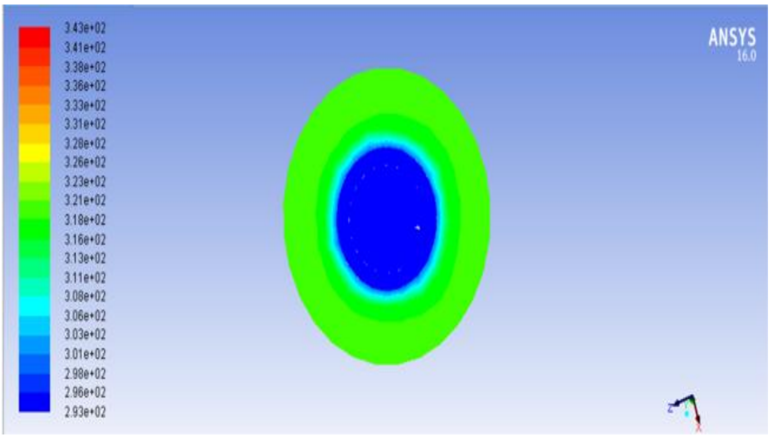

Figure 3.10 Temperature contour at the inlet of cold fluid i.e. Cu+Al_2O_3/water based hybrid nanofluid at Re = 4000 at 0.4% volume fraction.

Now at 0.8% volume concentration of nano particles hybrid nano fluid having at Re =4000.

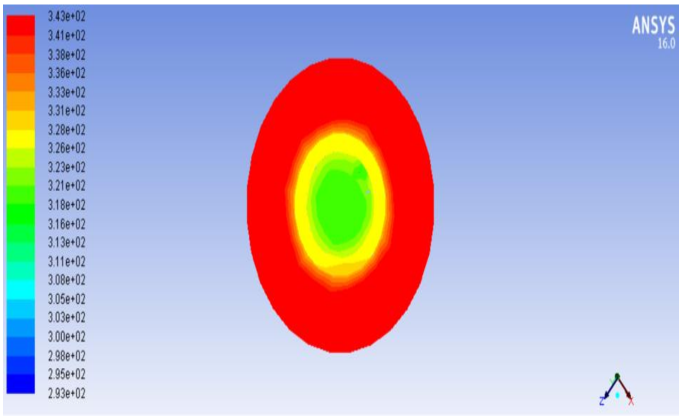

Figure 3.11 Temperature contour at the exit of cold fluid i.e. Cu+Al_2O_3/water based hybrid nanofluid at Re = 4000 at 0.8% volume fraction.

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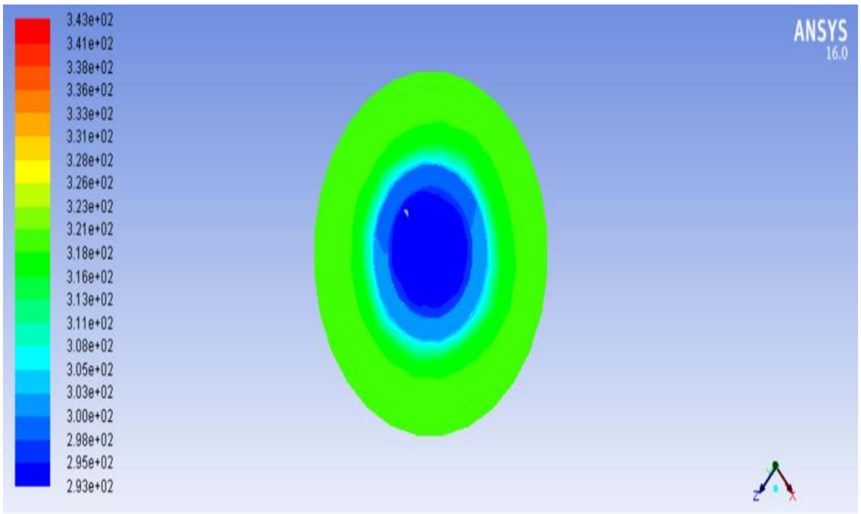

Figurer 3.12. Temperature contour at the inlet of cold fluid i.e. Cu+Al_2O_3/water based hybrid nanofluid at Re = 4000 at 0.8% volume fraction.

Similarly at 1.2 % volume concentration of nano particles hybrid nano fluid having at Re =4000.

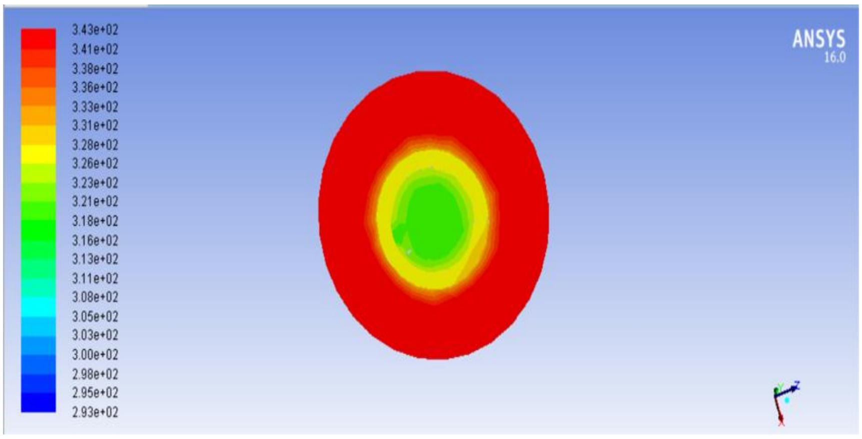

Figure 3.13 Temperature contour at the exit of cold fluid i.e. Cu+Al_2O_3/water based hybrid nanofluid at Re = 4000 at 1.2% volume fraction.

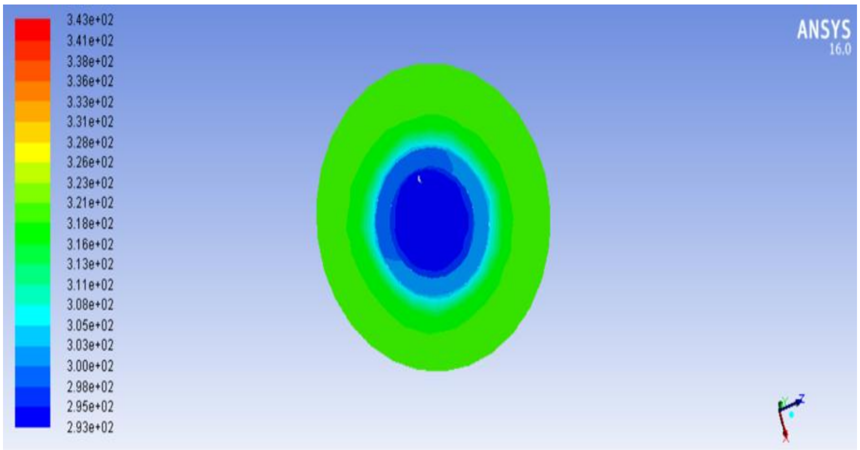

Figure 3.14 Temperature contour at the inlet of cold fluid i.e. Cu+Al_2O_3/water based hybrid nanofluid at Re = 4000 at 1.2% volume fraction.

3.2 Comparison between Mono nanofluid and Hybrid nanofluid at different Reynolds number at different concentration

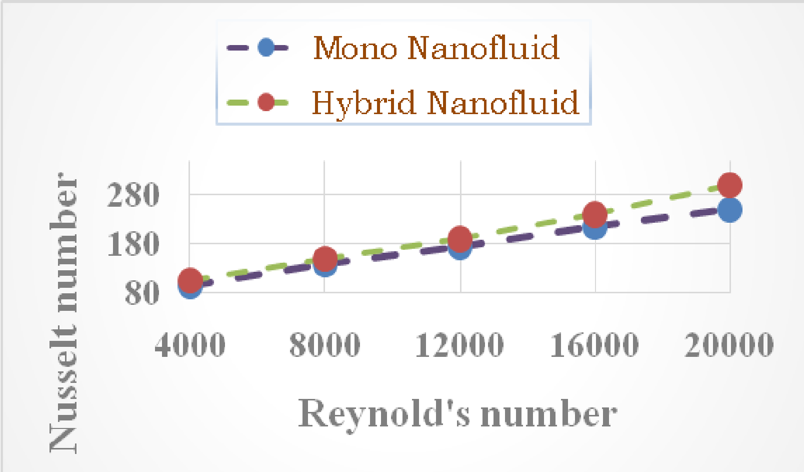

Figure 3.15 Comparison of Nusselt number between mono and hybrid nanofluid at different Reynolds number for 0.8 % volume concentration.

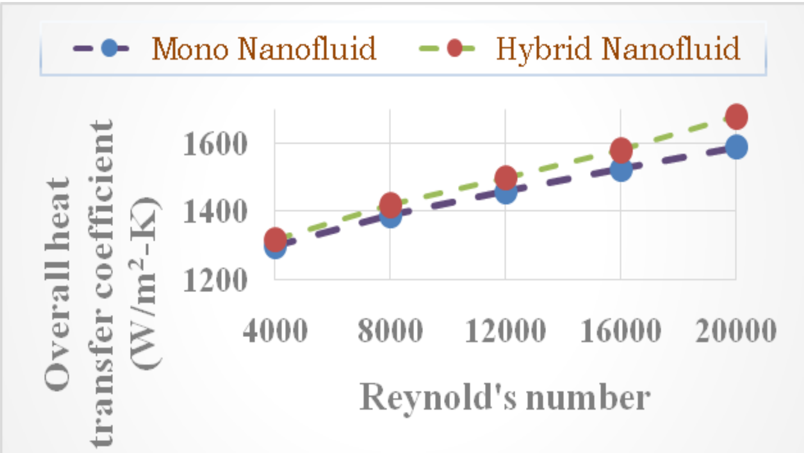

Figure 3.16 Comparison of overall heat transfer coefficient between mono and hybrid nanofluid at different Reynold's number for 1.2 % volume concentration.

VI. CONCLUSIONS

CFD turbulent heat flow simulations in a dual pipe heat interchangeable with a turbulator using the nanofluid hybrid, i.e. Cu+Al_2O_3 / water was carried out at varying volume concentrations at different numbers of Reynolds. The calculations were performed for variable Reynolds numbers ($4000 \leq Re \leq 20000$), volume fractions (0.4-1.2 percent). Based on the effects of the CFD measurements, it is observed that:

- Ordinarily, the presence of Cu+Al_2O_3 nanoparticles in the base fluid increases the properties of convective heat transfer and is thus more efficient than Al_2O_3 nanoparticles (at a steady concentration of volume).
- The findings revealed that the average heat transfer coefficient increases in line with the Reynolds number.
- Analysis has shown that the average thermal transfer coefficient value for hybrid nanofluid is 12 percent greater than the average for a single nanofluid.
- In the case of hybrid nanofluid compared to Mono nanofluid, the value of Nusselt is 18 per cent higher.
- Investigations revealed the superior thermal efficiency of the hybrid nanofluid in a flow-suitable two-pipe heat interchangeable turbulator.

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