Employing Al2O3 And MWCNT Water Nanofluids To Improve The Thermal Performance Of Varied Flow Configuration Heat Sinks For Electronic Cooling: An Experimental Evaluation

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Abstract

This research investigates the uses of nano fluids with an emphasis on its distinctive thermal characteristics & its potential to increase systems' heat transfer effectiveness. One important factor which affects a fluid's capacity to transport heat is its thermal conductivity. Moreover, the size, shape, & concentration of nanoparticles are among the elements that this research looks at in order to determine how well nanofluids transport heat. This study looks at the possibility of employing nano fluids to improve heat transfer during the cooling of electronic equipment. The research's results indicate that MWCNT/water nanofluids has a substantially higher thermal conductivity than Al2O3/water Nanofluid, and this leads to the conclusion that MWCNT/water Nanofluid has a higher heat transfer coefficient than Al2O3/water nanofluids. Al2O3/water Nanofluid& MWCNT/water nanofluids at volumes concentrations of 0.1% & 0.7%, respectively, had similar coefficients of heat transfer. The coefficient of heat transmission while using MWCNT/water Nanofluids is much greater than when using Al2O3/water Nanofluids. Due to the increased thermal conductance of MWCNT nanoparticles comparing to Al2O3 nanoparticles, heat transfer coefficients was found to be greater in MWCNT/water Nano fluids at 0.1%, 0.3%, 0.5%, & 0.7% vol. concentrations for all 3 tests sections. Moreover, the heat transfer coefficients rise as the test section's diameter decreases.

Key words: Nanofluids, Nanoparticles, heat transfer enhancement, applications of nanofluids, Heat Transfer Efficiency

1. Introduction

Particles of metals or metal oxide that are 100 nm in size or little were dispersed in a base liquid, like water, to create a nanofluids. By utilising nanofluids, it is possible to attain heat transfer coefficients values which were greater than those of the basic liquids. The dispersal of solid nanoparticles, that have a greater heat conductance than the underlying liquids, is what makes this possible. Nanofluids could be used in a wide range of engineering applications, including absorption refrigeration's, micro electromagnetic systems, lubrication of equipment, the production of innovative miniaturized camera lenses, coolant in machine tools, radiator cooling for automobiles, personal desktops, solar water heating, heat condensers, a few medical technologies, nuclear reactors, & numerous aerospace technologies. By suspending nanometer-sized nanoparticles in working fluids, recent developments in materials technologies have made it feasible to create novel heat transfer fluids that might alter the liquids' thermals & transporting characteristics. Nanofluids are solid-liquid composites made of liquid suspending solids nanoparticles no bigger than 100 nm in size (Hussein et al., 2013)

By evenly dispersing & stabilizing the suspensions of nanomaterials in host fluids, nanofluids aim to obtain the best thermal characteristics at the lowest concentrations. A colloidal solvent with scattered nanometer-sized particles (between 1 and 100 nm) is referred to as a nanofluids. One of the biggest technological problems that high-tech sectors like microelectronics, transportations, manufacturing, & metallurgy face is cooling. When utilised as coolants, nanofluids may significantly enhance the thermal characteristics of host fluids (Asst & St, n.d.).

Applications of nanofluids

A type of fluid known as a Nanofluid is one in which a base fluid contains nanoparticles with sizes less than 100 nm. They have shown promise as a new class of materials with unique rheological & thermal properties. Due to its exceptional thermal properties, nanofluids offer a broad variety of potential applications. In electronics cooling applications, nanofluids have the possibility of enhancing heat transfer &, as a result, the efficiency of electronic cooling systems. The enhanced cooling capacity could help keep electronic elements from overheating & increase their reliability. Heat exchangers using nanofluids might be more effective overall & at transferring heat, which makes them a good fit for use in air conditioning equipment, power plants, & industrial operations.

Additionally, using nanofluids as imaging agents, drug delivery systems, & therapeutic hyperthermia for the treatment of cancer is being researched. Nanoparticles' small size enables targeted drug delivery to specific body regions, & they can also be used for cancer hyperthermia therapy thanks to their special thermal properties. To improve heat transfer & energy converting efficacy in solar energy platforms, nanofluids can be utilized. To improve the efficiency of energy storage & retrieval, they can also be used in thermal energy storage platforms. To combat the extreme heat conditions in space, nanofluids can be utilized in spacecraft & satellite cooling systems. Nanofluids can be utilised to lubricate mechanical platforms because they reduce wear & friction. Additionally, nanofluids can be used as catalysts in chemical changes to quicken & improve selectivity (Prasad et al., 2017)

Nanofluid Thermal Conductivity Research on the thermal conductance of nanofluids revealed that employing nanofluids may result in significant increases in thermal conductivity. With a particle volume fraction less than 5%, thermal conductivity improvements bigger than 20% are attainable. These enhanced levels go beyond what theoretical models created for suspensions having bigger particles predicted. This is seen as a sign that there are more nanofluids thermal transport enhancing techniques present.

Heat Transfer Enhancement

The increase of the thermal effectiveness of any heat transporting method, heat exchanges medium, components, devices, or equipment is referred to as heat transfer enhancement, augmenting, or intensifying. The critical heat fluxes for pool boiling heat transfers might have risen, the peak temperatures of a chip hot spot could have decreased, the thermally conductance, specific heat capacity, or latent heat of an energetic storage medium could have enhanced, etc. Enhancing heat transfer is the act of making heat exchangers more efficient. This may be accomplished by increasing a device's capacity for heat transmission or by lowering the pressure losses it produces. This effects may be achieved using a number of approaches, such as creating powerful secondary flows or boosting boundary layers turbulent(Guo, 2020).

Improving Heat Transfer Efficiency

In several applications, heat transport is crucial. For instance, for a vehicle to function properly, the heat produced by the primary mover must be evacuated. In a similar manner, electrical devices release heat and need a cooling systems. Other heat transfer techniques are also included in heating, ventilation, & air conditioning systems. The primary mechanism in thermal power plants is heat transfer. In additional to this, a lot of manufacturing processes use heat transmission in different ways, such as chilling machine tools, pasteurizing food, or adjusting temperatures to start a chemical reaction. Heat transmission is accomplished in the majority of those applications using heat transfer equipment such heat exchangers, evaporators, condensers, & heat sinks. It would be advantageous to increase the heat transfer efficiencies of those devices since doing so would reduce the area that they take up, that is critical for applications that need compactness. Also, because a pump often circulates the working fluids in heat transfer systems, efficiencies gains in this area may reduce the power requirements. The effectiveness of heat transmission may be increased in a number of ways. Using extending surfaces, vibrating the heat transferring surfaces, & using microspheres were a few techniques. The working fluid's ability to transmit heat may be enhanced by raising its thermo conductance. As comparing to the thermally conductance of solids, often utilized heat transfer fluids like water, glycols, & motor oil has comparatively lower thermal conductivities. Little solid particles may be added to a fluid with high thermal conductivity to boost the fluid's thermal conductivity. Some studies have already looked at the viability of using similar suspensions of solids particles having diameters on the order of 2 millimeters or micrometers, & major downsides are found. The practical use of suspensions of solids in base fluids as improved work fluids in heat transfers applications was prohibited by those limitations, that include particles sedimentation, channel blockage, & channel wall erosion(Kumar & Chakrabarti, 2014).

Due to the fast development of micro-electromechanical systems (MEMS) & micro total analysis systems, researchers have also paid close attention to the properties of flow & heat transfers in microchannel& micro tubes. The micro exchangers, bioengineering, the genomics projects, and medicinal engineering are all significantly impacted by those discoveries(Kumar & Chakrabarti, 2014).

ZhixiongGuo, et al.,conducted research on the thermal characteristics of common nanofluids as measured experimentally, the enhanced processes found or predicted, the models utilised for properties & heat transfers characteristics, & the uses of nanofluids for boosting heat transfers. The artificial neutral networks concept is highlighted in detail. Applications to energy systems, buildings technologies, & cooling technology were described in depth. New solutions for improving heat transmission are required due to advances in technological miniaturization and rising power density. Since the term "Nanofluid" was coined in 1995, improving heat transfer by using nanofluids has become a hot topic of research & development, primarily since this thermodynamic property of nanofluid in many reports in the literature displayed superiority or improved performance over their base fluids, but might not be able to satisfy the requires of the current cutting-edge technology. K.r. aglawe,et al.,conducted study on the advancement of nanofluids for outcomes in both theory and experiment. Also, several intriguing perspectives on using nanofluids for cooling electrical components were presented. Almost all investigations have shown that, as contrasted with base fluids, nanofluids display the preferable thermal behaviour for electronic cooling. Furthermore, the field's challenges & the path for future improvements are given & addressed. One of the main difficulties with current generation technology is the cooling of electrical gadgets. Because to its remarkable properties, that may be used to efficiently cool devices & increase energy efficiency, nanofluids have increased interest in numerous technical sectors. The use of nanofluids in different equipment & phenomena is being studied by researchers all over the globe, & choosing an appropriate heat transfer fluid is crucial for the proper thermal management of electronics systems. Many investigations have been conducted in the past to learn how different nanofluids flow in various electronic cooling applications affect thermal performances(Aglawe et al., 2020).

Roger R. Riehl,et al., conducted research on to fulfil present demands for both active & passive thermal regulation, improvements in heat transmission, new technologies, & creative solutions are needed. The amount of heat fluxes which need to be dispersed has significantly increased, necessitating alternative design strategies, particularly for those intended for defense. Because of elements including operating in hostile conditions and the large thermal density of electronics which requires its temperatures to be managed, which calls for new designs, traditional designs are not adequate for the growth in heat dissipation demands. In these circumstances, the use of nanofluids may significantly help to allow designers greater creative flexibility to meet the project's needs(Riehl, 2019). This article's focus is on a surveillance system for the military industry that must disperse significant heat loads. In order to facilitate the thermal management of up to 50 kW of heat, which is being dissipated to the environments by a fan cooling systems, a single stage forced circulating loops has been constructed for the current inquiry. Eric C. Okonkwo, et al., this study looks back on the year 2019 by examining the advancements achieved in the creation of nanofluids& their use in a variety of heat transfer systems, including solar collectibles, heat exchangers, refrigerants, radiator, thermal storage technologies, & electronics. In addition to underlining the difficulties & potential of nanofluids as the next-generation heat transfers fluids, this study seeks to inform readers of current developments(Okonkwo et al., 2021).

PankajKhatak, et al., Experimental studies on heat transfers throughout spray cooling were conducted utilising water & a ZnOnanofluids. A spray nozzle infringing fluids normally onto the flat end of a copper-heated surfaces was used in several experimentations (copper cylinder 20 mm diameters). By measuring temperatures gradients along the target length while it is in a steady state, the heat flux & surfaces temperatures were calculated. The water flow rate in this experiments ranged from 15 to 25 ml/min. ZnOnanofluids was sprayed under the identical tests to contrast the outcomes with water and nanofluids at a flow rate of 20 ml/min. The surface temperatures were found to be below the maximal operating temperatures limit of the micro-electronic components at 180 W heat input & 15–25 ml/min flow rates(Khatak & Kumar, 2008). According to Lazarus Godson et al., the distinguishing characteristics of nanofluids include a considerable enhancement in liquid thermal conductance, liquids viscosity, & liquid heat transfers coefficients. It is well knowledge that solid-phase metals have greater thermal conductivities than fluids do at normal temperatures(Godson et al., 2010).

W. Escher, et al., The reduction of high heat fluxes is a significant design problem for electronic gadgets of the future. The popular solution to those large heat fluxes is to directly integrate microchannel arrays into the electrical component that generates the heat. Water is often recommended for use as a single-phase coolant in conjunction using microchannel heat sinks for cooling electronics because it has the best thermal & hydrodynamics transports characteristics within the necessary operating temperatures ranges. Yet, compared to most metals & metal oxides, water's thermal conductivity is 2 to 3 orders of magnitudes lower(Escher et al., 2011).

Valery Ya et al., examined study on a base fluid & nanoparticles make up the 2 phases of a nanofluids. Water, organic liquids (glycols, oils, biological liquids, etc.), & polymers solutions were examples of common carrier fluids. Typically, chemically stable metal nanoparticles & its oxides make up the scattered solids phases(Rudyak & Minakov, 2018)

Methodology

Procedure of Experiment to be Performed:

Experimental setup consists of three test section of copper tubes of inner diameter of 4mm, 9mm & 13.5mm.

3.2.1 For Water:

Firstly, fill tank with water. Initially all valves are closed. Now open the valve of first test section so that water flows through first test section of 13.5mm inner diameter and start the water pump. During this, valves of second and third test section is closed. Now set proper current and voltage by varying dimmerstat for first test section so that it gives constant heat flux to the tube (Test Section). Then adjusting the flow

rates of fluids which is fixed for experimentation work are at 4 LPM, 6 LPM, 8 LPM & 10 LPM. The setup run continuously up to steady state conditions achieve. Initially take readings for water, after achieving steady state conditions take readings of wall temperatures of test section and then inlet and outlet temperature of test section from Digital temperature indicator (DTI). This procedure is repeated for varying flow rates.

Now open the valve of second test section of 9 mm inner diameter so that water flows through it. During this, valves of first and third section is closed. Again take readings of all the temperatures for varying flow rates after steady state is achieved. Repeat same for third test section of inner diameter 4 mm.

3.2.2 For Al_2O_3/water:

Al_2O_3/water nanofluid with vol. Concentration of 0.1%, 0.3%, 0.5% and 0.7% is used. Initially Al_2O_3/water nanofluid with vol. Concentration of 0.1% is passed through first test section of inner diameter 13.5 mm. During this valves of first test section is open and other are closed. Note all readings for varying flow rates after attaining steady state condition. Now same steps are repeated for various test section and for various concentrations.

3.2.3 For MWCNT/water:

MWCNT/water nanofluid with vol. Concentration of 0.1%, 0.3%, 0.5% and 0.7% is used. Initially MWCNT/water nanofluid with vol. Concentration of 0.1% is passed through first test section of inner diameter 13.5 mm. During this valves of first test section is open and other are closed. Note all readings for varying flow rates after attaining steady state condition. Now same steps are repeated for various test section and for various concentrations.

Equations for Nano fluids:

Density of Nanofluid, $\rho_{nf} = (\emptyset \times \rho_{np}) + (1-\emptyset)\rho_{bf}$

iscosity of Nanofluid, $\mu_{nf} = \mu_{bf}(1 + 2.5\emptyset)$

Specific heat of nanofluid, $Cp_{nf} = \frac{\emptyset(Cp_{np} \times \rho_{np}) + (1-\emptyset)(Cp_{bf}.\rho_{bf})}{\rho_{nf}}$

Thermal conductivity of nanofluids, $K_{nf} = K_{bf}\left[\frac{K_{np} + 2K_{bf} + 2(K_{np} - K_{bf})(1+\beta)^3.\emptyset}{K_{np} + 2K_{bf} - 2(K_{np} - K_{bf})(1+\beta)^3.\emptyset}\right]$

Heat gained by nanofluid,

$Q = (\rho_{nf}.U.A)\, Cp_{nf}\, (Tout - Tin)$

Mass flow rate = $\rho_{nf} x\ (4 \times 10^{-3})/60$

= 0.066 kg/s

Convection heat transfer rate, $Q = h_{nf}\, A_s\, (T_w - T_b)$

Results &Discussion

5.1 Graphs:

Various graphs are plotted for calculated results of heat transfer coefficient Vs Reynolds number, Nusselt number Vs Reynolds number.

Reynolds number, Nusselt number Vs Reynolds number.

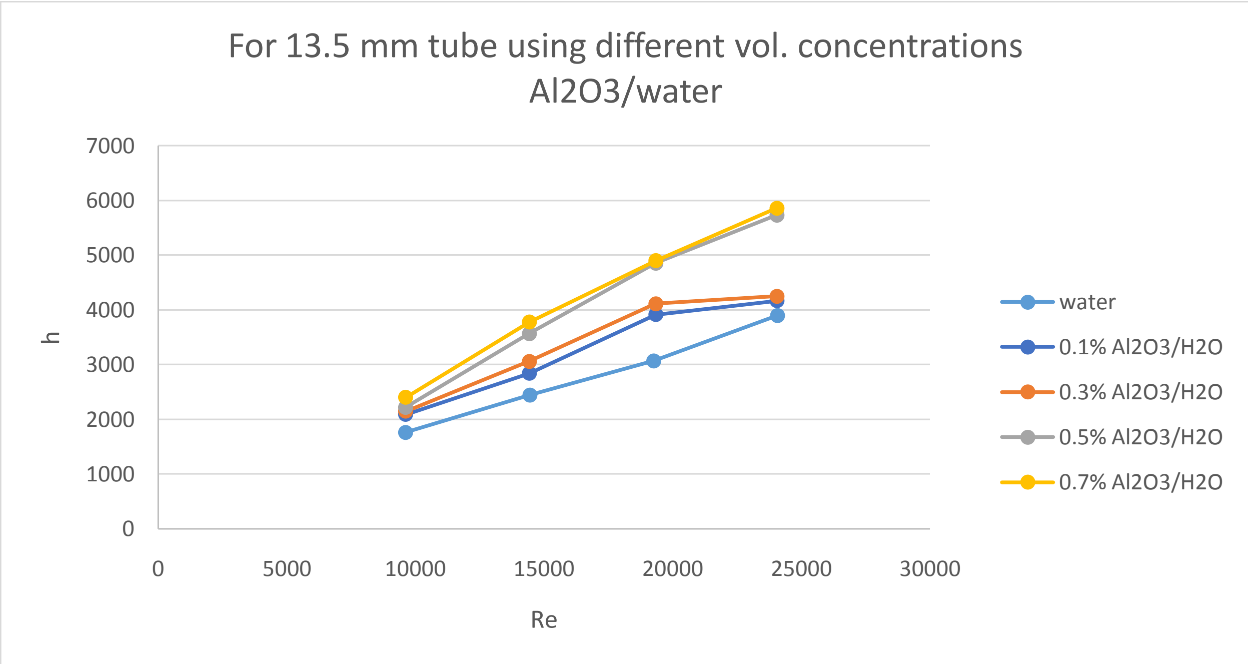


Fig. 5.1 Heat transfer coefficient Vs Reynolds no. for water and Al_2O_3/water for all concentrations

Above graph shows that as the heat transfer coefficient increases with increase in Reynolds no. as we increase the volume concentration of Al_2O_3/water Nano fluid. Also heat transfer coefficient of Al_2O_3/water Nano fluid is higher than that of water.

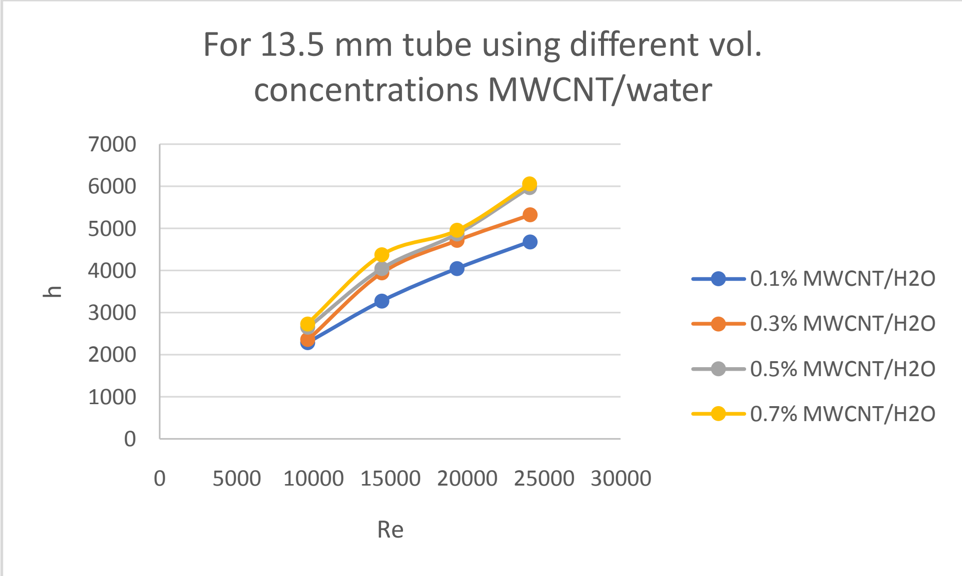


Fig. 5.2 Heat transfer coefficient Vs Reynolds no. for water and MWCNT/water for all concentrations

Similarly, above graph shows increase in heat transfer coefficient with increase in volume concentration of MWCNT/water Nano fluid. Increase in concentration increases the thermal conductivity due to Brownian motion of nanoparticles.

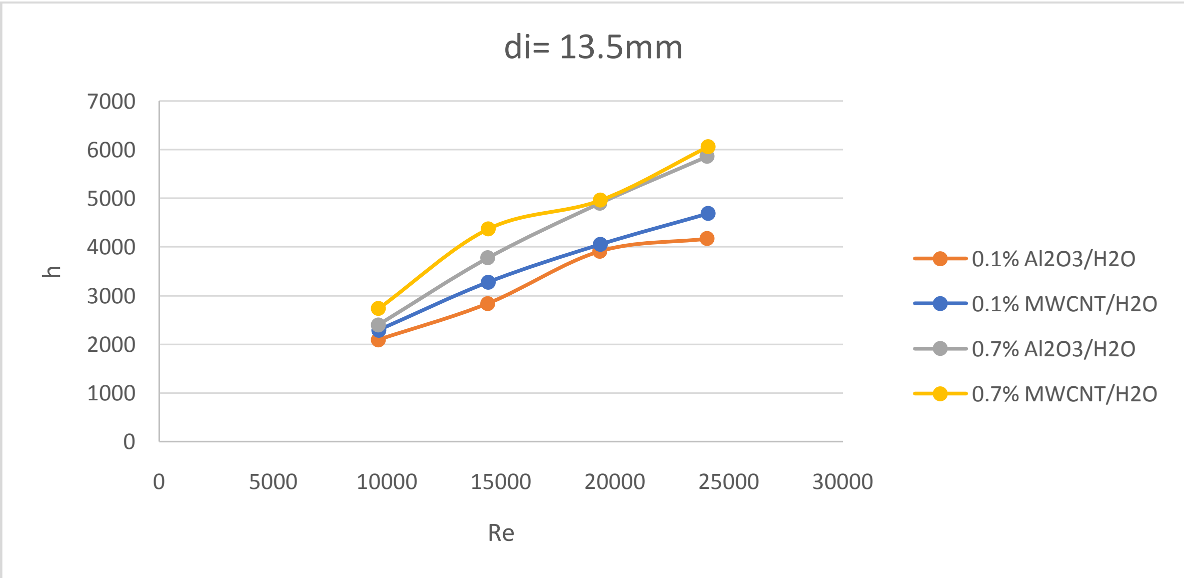


Fig. 5.3 Heat transfer coefficient Vs Reynolds no. for Al_2O_3/water and MWCNT/water for 0.1% and 0.7% vol. concentration

Above graph shows the heat transfer coefficient is more for MWCNT/water Nano fluid than Al_2O_3/water Nano fluid as the thermal conductivity of MWCNT/water Nano fluid is much higher than the Al_2O_3/water Nano fluid.

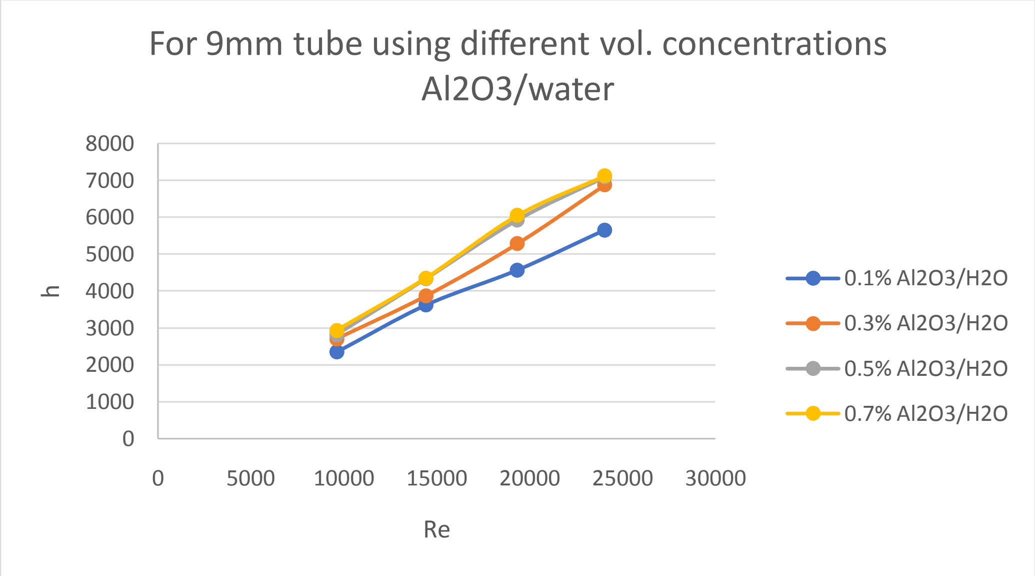


Fig. 5.4 Heat transfer coefficient Vs Reynolds no. for Al_2O_3/water for all concentrations.

Above graph and Fig 5.5 shows that the heat transfer coefficient increases with increase in volume concentration of Al_2O_3/water Nano fluid and MWCNT/water Nano fluid respectively. Increase in concentration increases the thermal conductivity due to Brownian motion of nanoparticles.

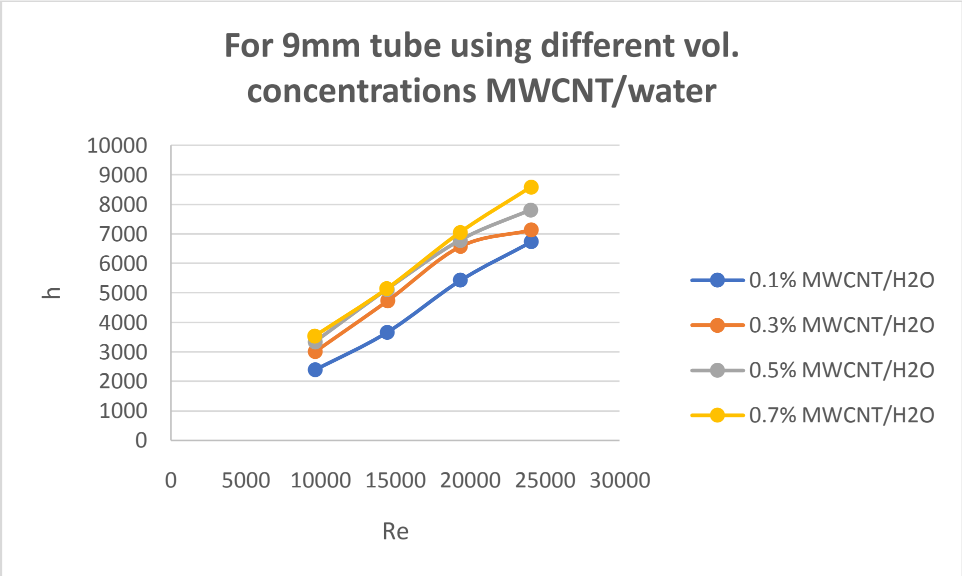


Fig. 5.5 Heat transfer coefficient Vs Reynolds no. for MWCNT/water for all concentrations.

Above figure shows that the heat transfer coefficient increases with increase in volume concentration of Al_2O_3/water Nano fluid and MWCNT/water Nano fluid respectively. Increase in concentration increases the thermal conductivity due to Brownian motion of nanoparticles.

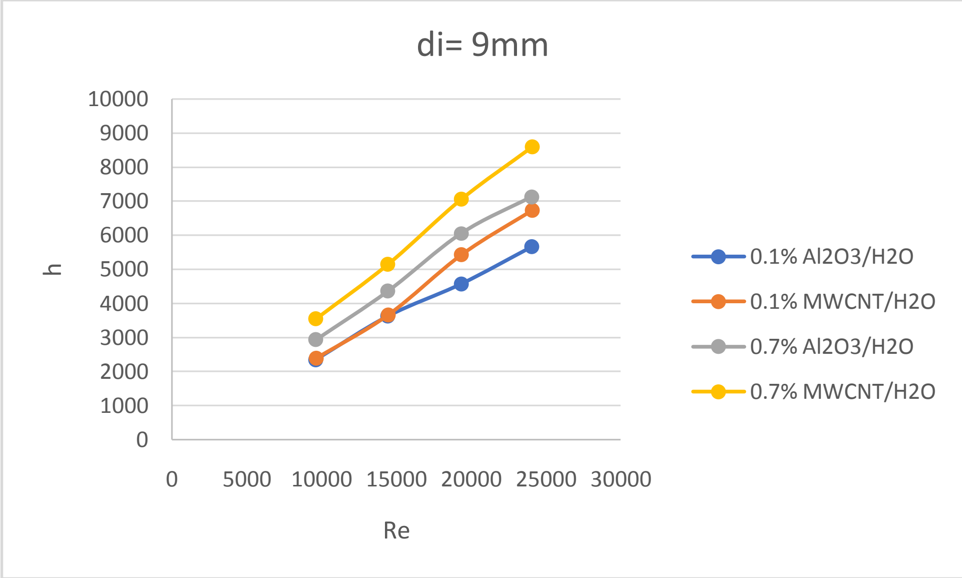


Fig. 5.6 Heat transfer coefficient Vs Reynolds no. for Al_2O_3/water and MWCNT/water for 0.1% and 0.7% vol. concentration

Above graph compares the heat transfer coefficient for Al_2O_3/water Nano fluid and MWCNT/water Nano fluid for 0.1% and 0.7% volume concentrations. It shows that heat transfer coefficient associated with MWCNT/water Nano fluid is higher than Al_2O_3/water Nano fluid.

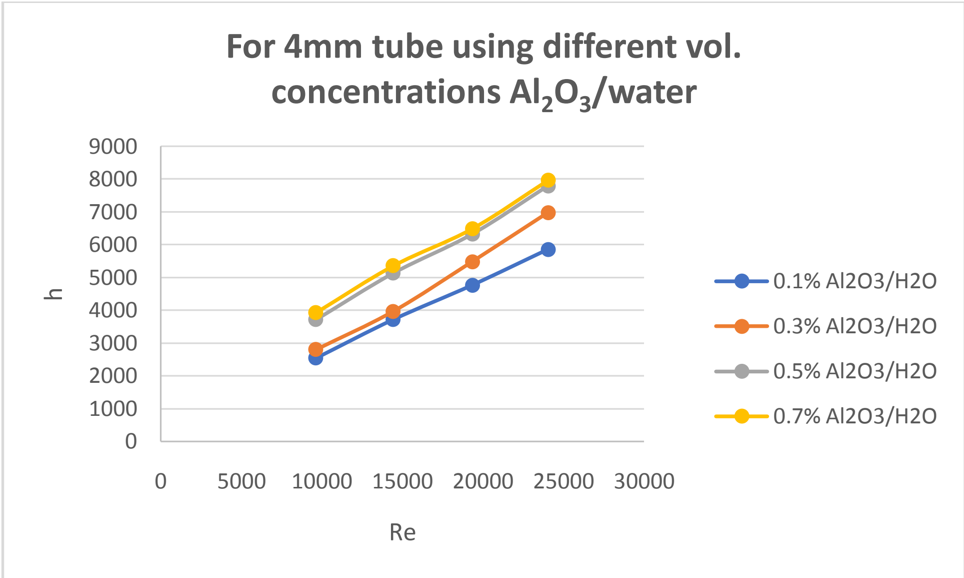


Fig. 5.7 Heat transfer coefficient Vs Reynolds no. for Al_2O_3/water for all concentrations

Above graph and Fig. 5.8 shows that the heat transfer coefficient increase with increase in Reynolds no. as we increase the volume concentration of Al_2O_3/water Nano fluid.

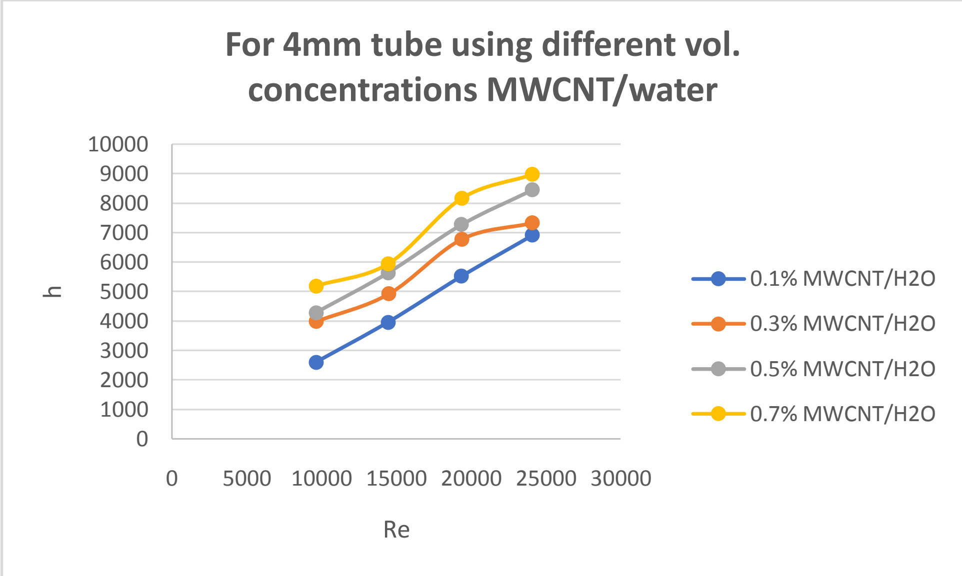


Fig. 5.8 Heat transfer coefficient Vs Reynolds no. for MWCNT/water for all concentrations

Fig. 5.8 shows that the heat transfer coefficient increase with increase in Reynolds no. as we increase the volume concentration of MWCNT/water Nano fluid.

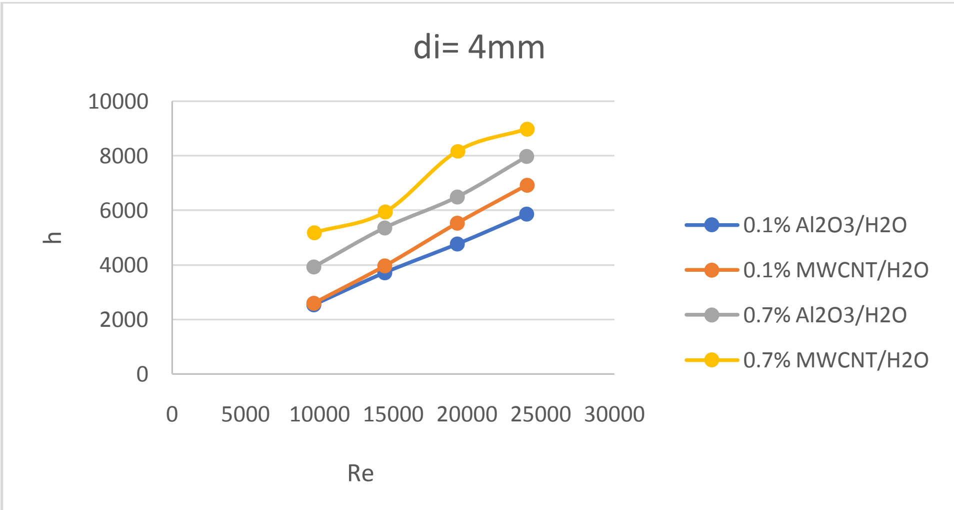


Fig. 5.9 Heat transfer coefficient Vs Reynolds no. for Al_2O_3/water and MWCNT/water with 0.1% and 0.7% vol. concentrations.

Above graph shows that the coefficient of heat transfer using MWCNT/water Nano fluid is greater than Al_2O_3/water Nano fluid.

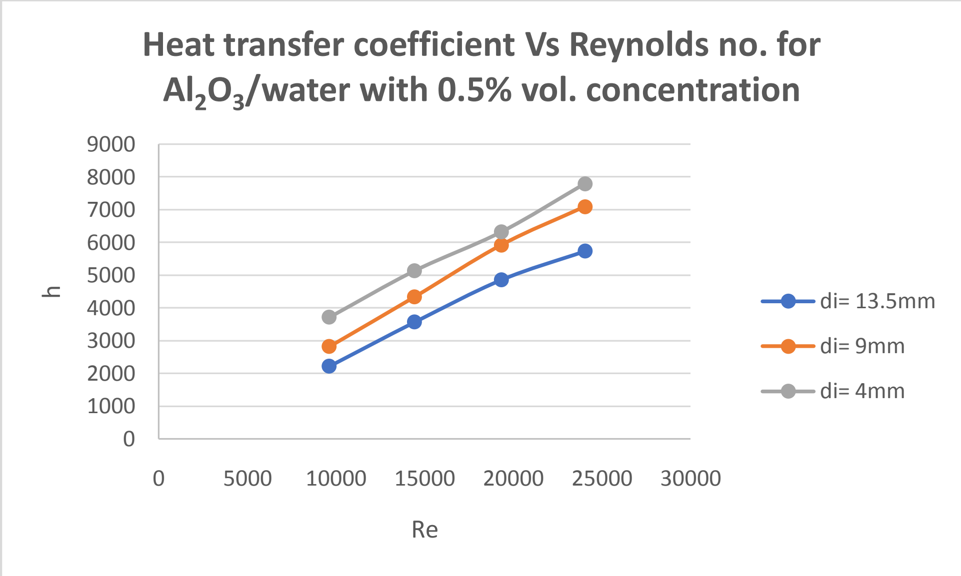


Fig. 5.10 Heat transfer coefficient Vs Reynolds no. for Al_2O_3/water with 0.5% vol. concentration

Above graph shows the effect of tube diameter on heat transfer coefficient for 0.5% vol. concentration of Al_2O_3/water Nano fluid. It is found that heat transfer enhancement for Reynolds no. 9624.12 is67.5%and for Reynolds no.24047.95 is36.05% if tube diameter is decreased from 13.5 mm to 4 mm.

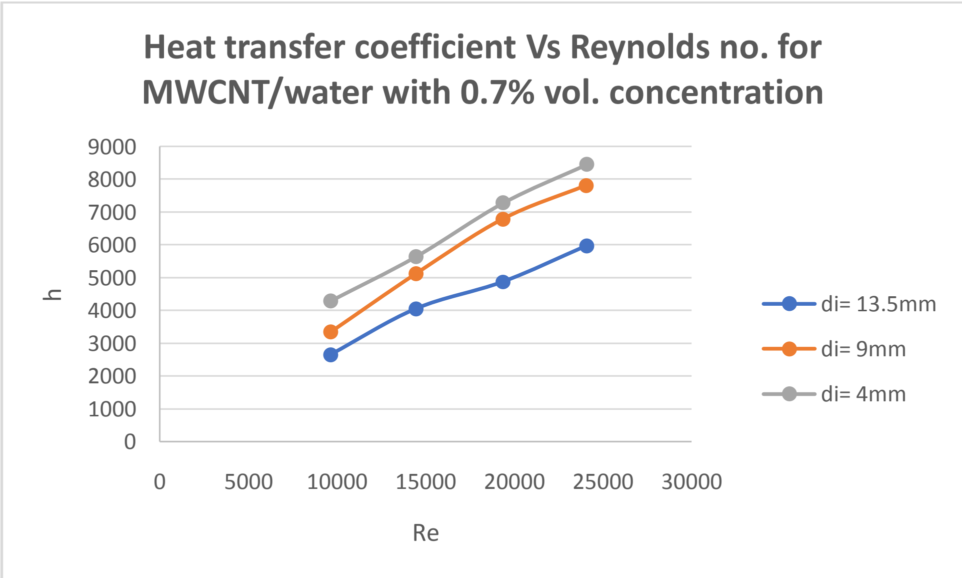


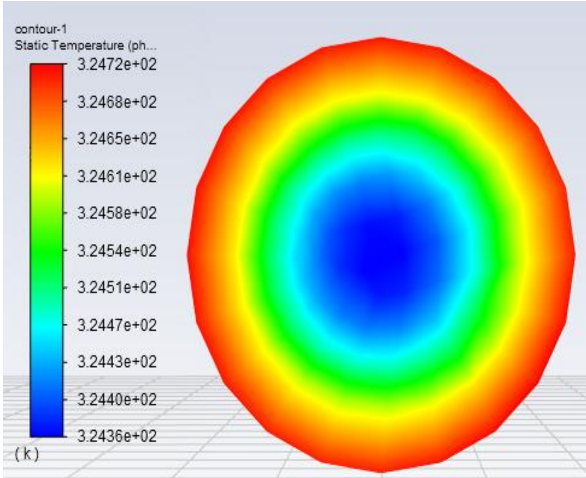
Fig. 5.11 Heat transfer coefficient Vs Reynolds no. for MWCNT/water with 0.7% vol. concentration

Above graph shows the effect of tube diameter on heat transfer coefficient for 0.7% vol. concentration of Al_2O_3/water Nano fluid. It is found that heat transfer enhancement for Reynolds no. 9624.12 is 63.6% and for Reynolds no. 24047.95 is 35% if tube diameter is decreased from 13.5 mm to 4 mm.

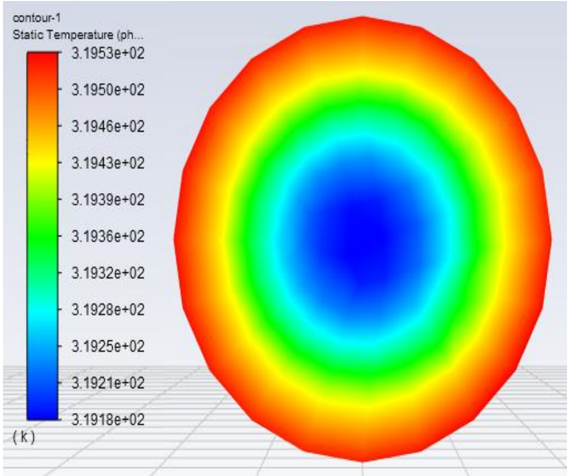
CFD analysis results:

Al2O3:

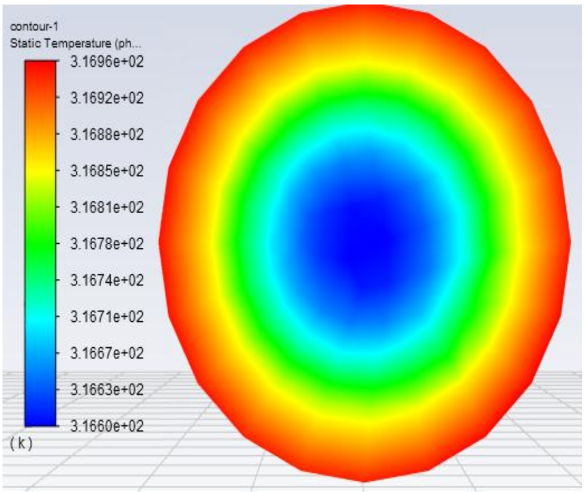
Tube Diameter = 4 mm

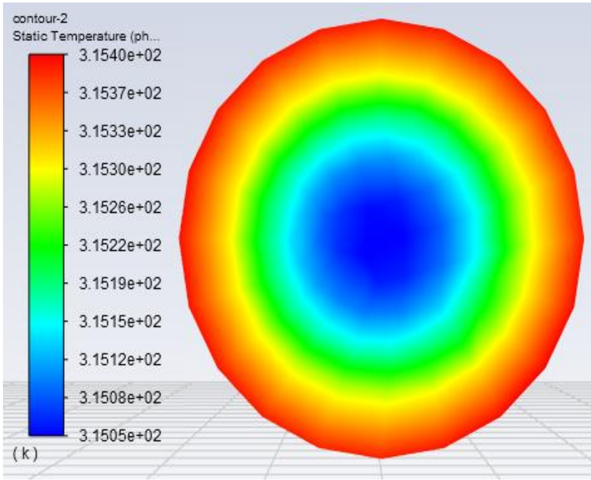


Temperature Contour of Water with 0.7% Al_2O_3 at Outlet for Tube Diameter = 4 mm and Discharge = 4 LMP



Temperature Contour of Water with 0.7% Al_2O_3 at Outlet for Tube Diameter = 4 mm and Discharge = 6 LMP





Temperature Contour of Water with 0.7% Al_2O_3 at Outlet for Tube Diameter = 4 mm and Discharge = 8 LMP	Temperature Contour of Water with 0.7% Al_2O_3 at Outlet for Tube Diameter = 4 mm and Discharge = 10 LMP
Tube Diameter = 9 mm	

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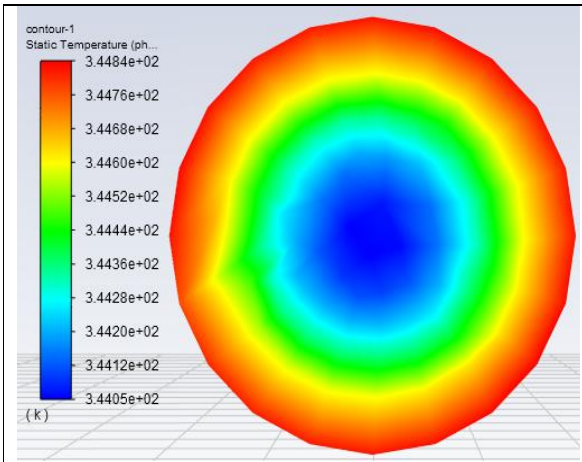
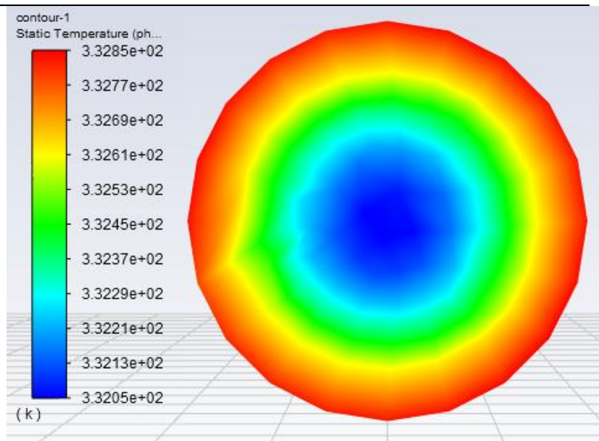


Temperature Contour of Water with 0.7% Al_2O_3 at Outlet for Tube Diameter = 9 mm and Discharge = 4 LMP



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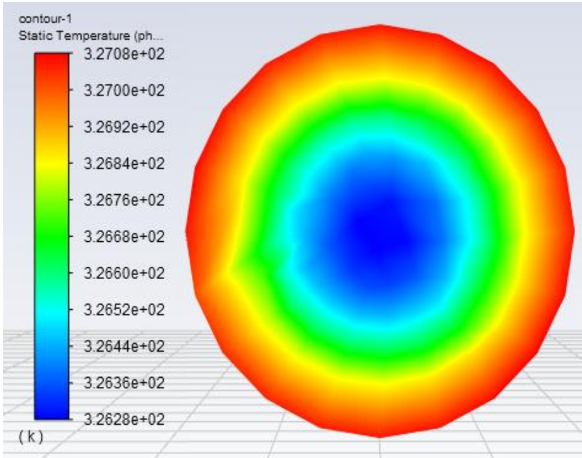
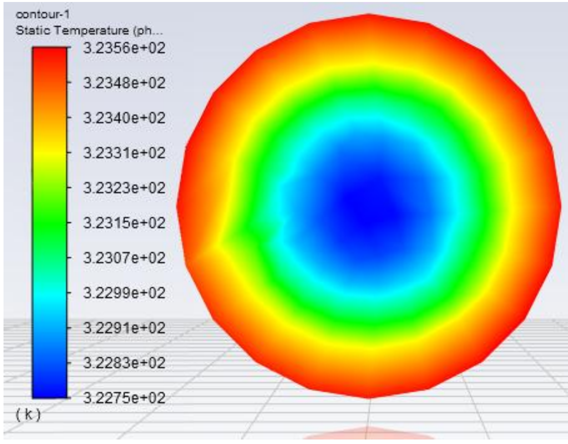
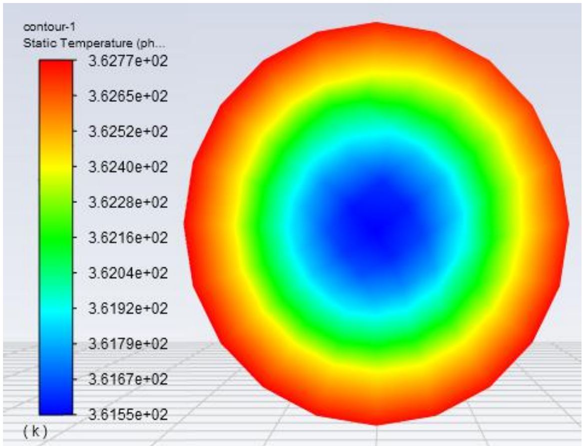


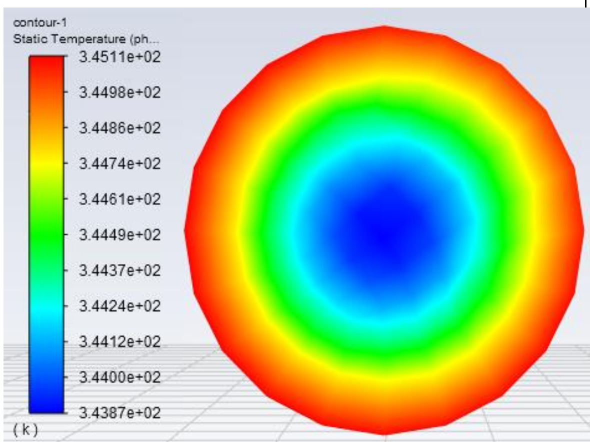
Temperature Contour of Water with 0.7% Al_2O_3 at Outlet for Tube Diameter = 9 mm and Discharge = 8 LMP



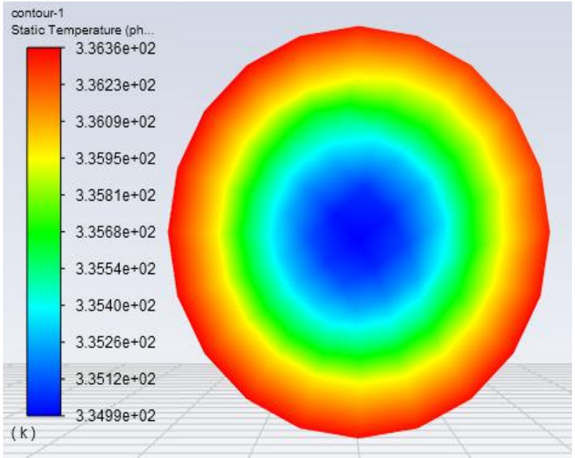
Temperature Contour of Water with 0.7% Al_2O_3 at Outlet for Tube Diameter = 9 mm and Discharge = 10 LMP

Tube Diameter = 13.5 mm





Temperature Contour of Water with 0.7% Al_2O_3 at Outlet for Tube Diameter = 13.5 mm and Discharge = 4 LMP	Temperature Contour of Water with 0.7% Al_2O_3 at Outlet for Tube Diameter = 13.5 mm and Discharge = 6 LMP



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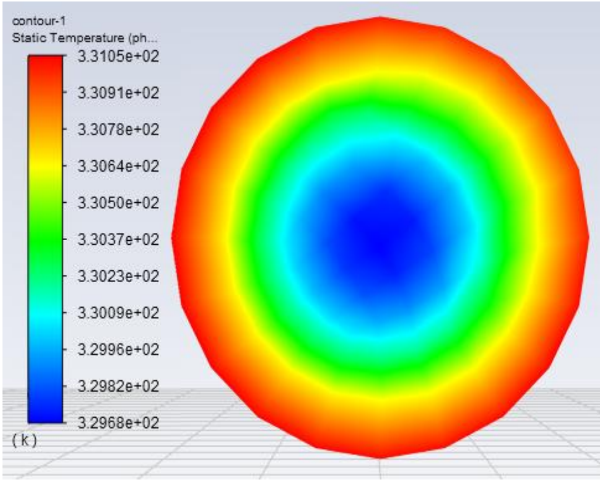
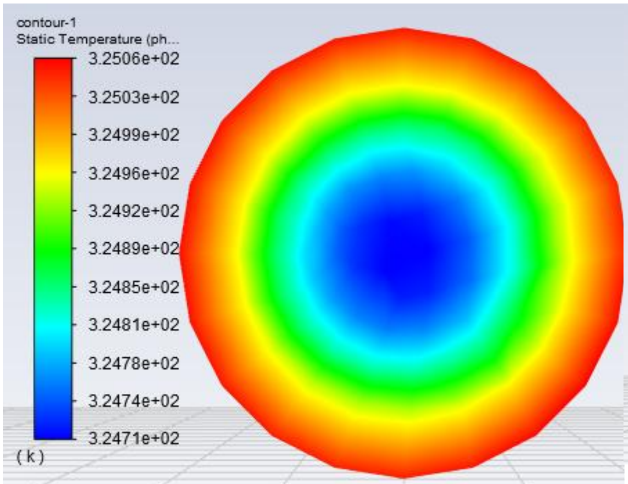
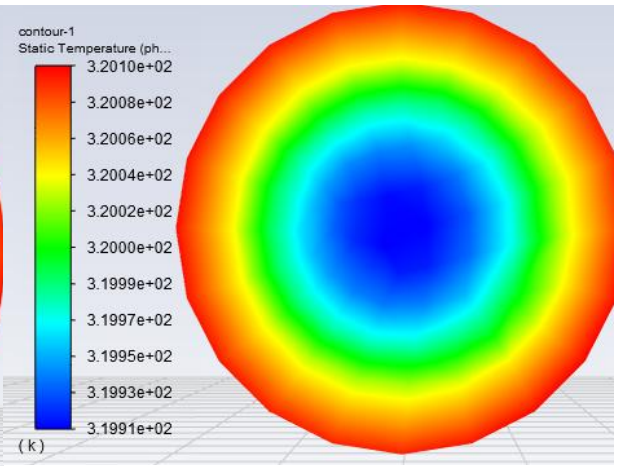


Temperature Contour of Water with 0.7% Al_2O_3 at Outlet for Tube Diameter = 13.5 mm and Discharge = 10 LMP

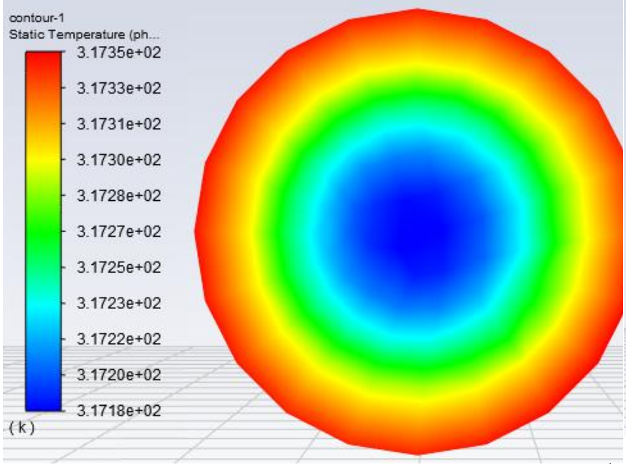
MWCNT:
Tube Diameter = 4 mm



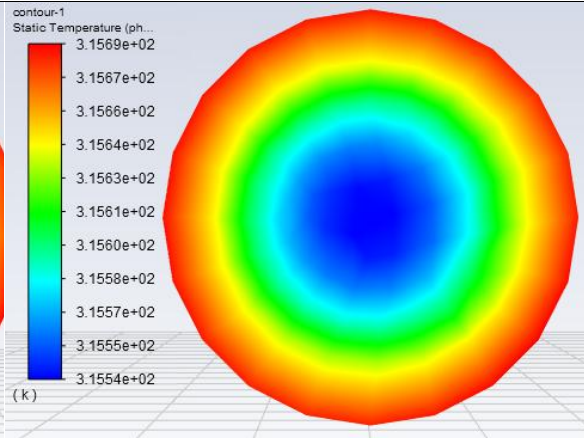
Temperature Contour of Water with 0.7% MWCNT at Outlet for Tube Diameter = 4 mm and Discharge = 4 LMP



Temperature Contour of Water with 0.7% MWCNT at Outlet for Tube Diameter = 4 mm and Discharge = 6 LMP

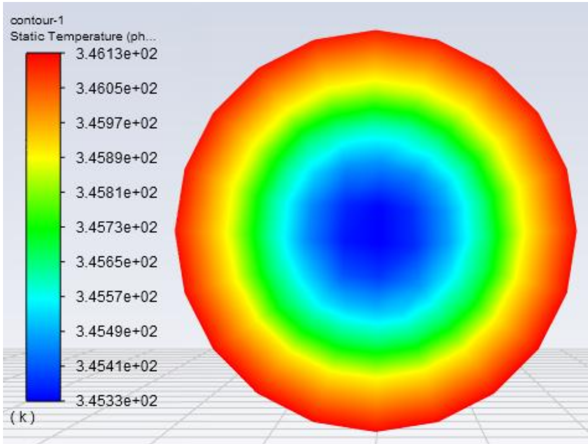


Temperature Contour of Water with 0.7% MWCNT at Outlet for Tube Diameter = 4 mm and Discharge = 8 LMP

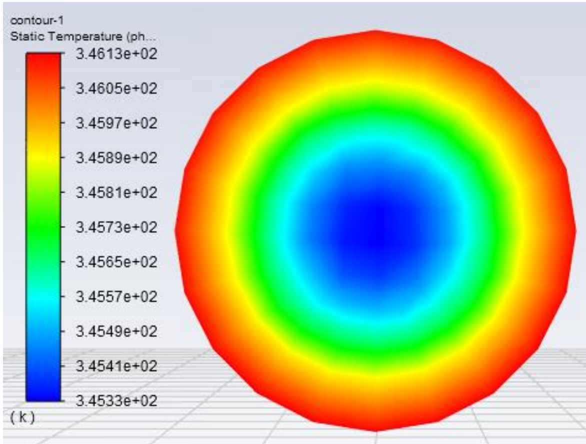


Temperature Contour of Water with 0.7% MWCNT at Outlet for Tube Diameter = 4 mm and Discharge = 10 LMP

Tube Diameter = 9 mm



Temperature Contour of Water with 0.7% MWCNT at Outlet for Tube Diameter = 9 mm and Discharge = 4 LMP



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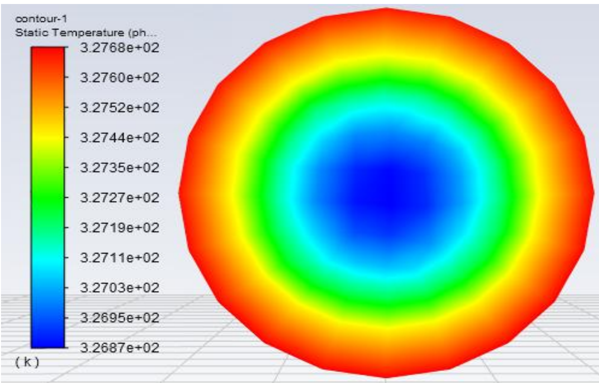
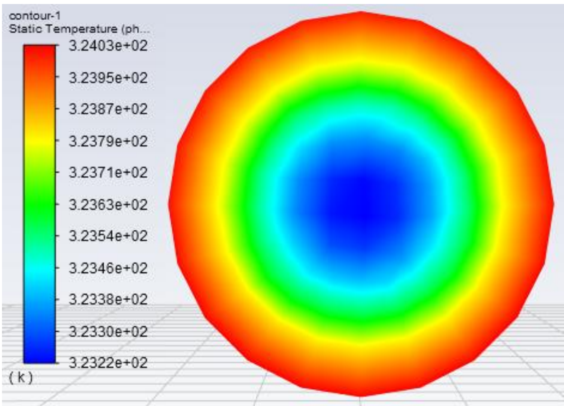


Temperature Contour of Water with 0.7% MWCNT at



Temperature Contour of Water with 0.7% MWCNT at

<table>
<tr><td>Outlet for Tube Diameter = 9 mm and Discharge = 8 LMP</td><td>Outlet for Tube Diameter = 9 mm and Discharge = 10 LMP</td></tr>
<tr><td>Tube Diameter = 13.5 mm</td><td></td></tr>
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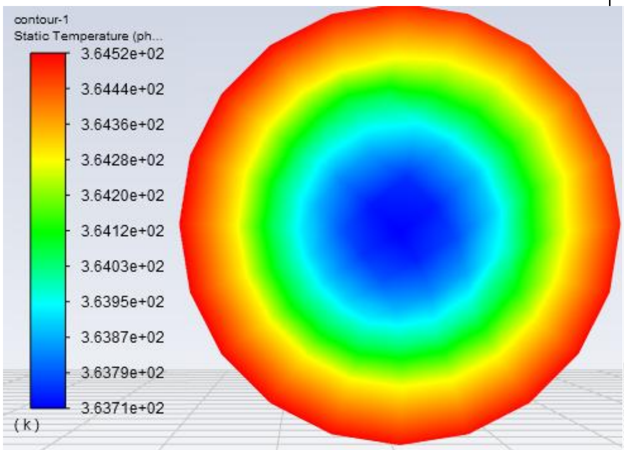

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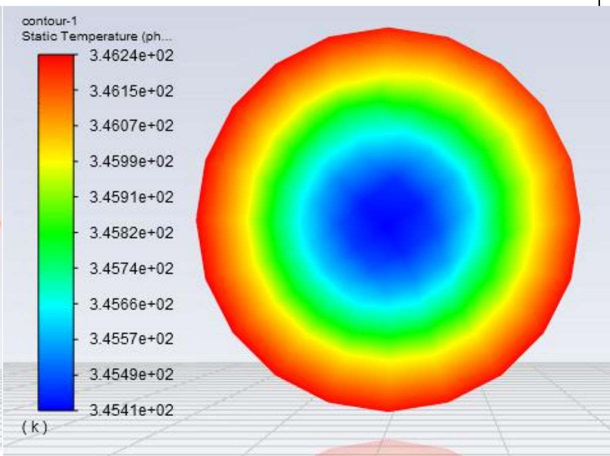

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<tr><td>Temperature Contour of Water with 0.7% MWCNT at Outlet for Tube Diameter = 13.5 mm and Discharge = 4 LMP</td><td>Temperature Contour of Water with 0.7% MWCNT at Outlet for Tube Diameter = 13.5 mm and Discharge = 6 LMP</td></tr>
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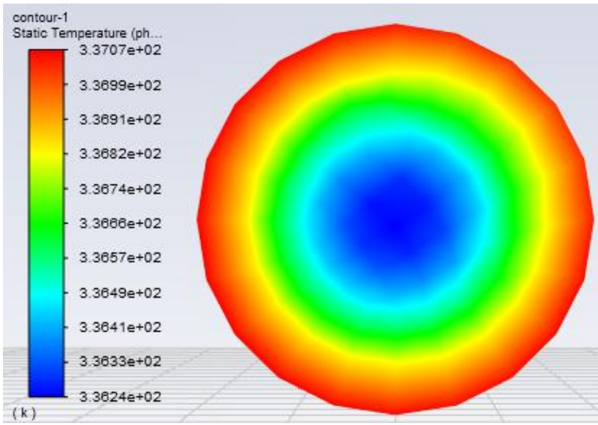

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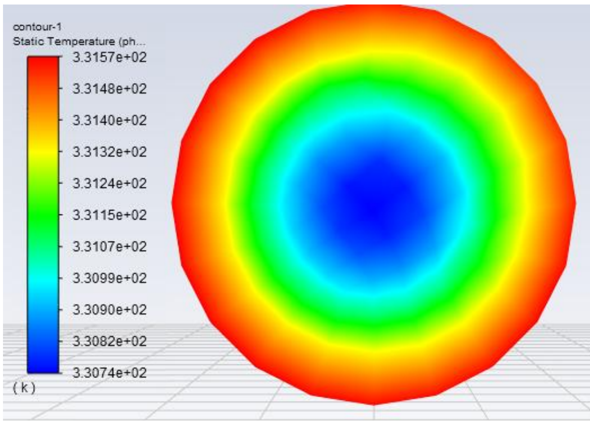

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<tr><td>Temperature Contour of Water with 0.7% MWCNT at Outlet for Tube Diameter = 13.5 mm and Discharge = 8 LMP</td><td>Temperature Contour of Water with 0.7% MWCNT at Outlet for Tube Diameter = 13.5 mm and Discharge = 10 LMP</td></tr>
</table>

Conclusion

The experimentation work on three different test sections with water, Al_2O_3/water Nano fluid and MWCNT/water Nano fluid has been done successfully. The heat transfer coefficient was calculated for 0.1%, 0.3%, 0.5% and 0.7% volume concentrations of Al_2O_3/water and MWCNT/water Nano fluids and also for water at different flow rates for all three test sections. It has been found that, the experimental setup includes three test sections made of copper tubes with inner diameters of 4 millimeters, 9 millimeters, and 13.5 millimeters respectively. Nano fluids including Al2O3/water and MWCNT/water are used, and the volume concentrations of these fluids range from 0.1% to 0.7%. First, an Al2O3/water Nano fluid with a vol. concentration of 0.1% is run through the first test section, which has an inner diameter of 13.5 mm. At this time, the valves of the first test part are open while the valves of the other sections are closed. After reaching a steady state condition, make a note of all of the data for the different flow rates. Now the previous stages are repeated for each of the different test sections and for each of the different concentrations. According to the findings of the research, the thermal conductivity of MWCNT/water Nano fluid is much higher than that of Al2O3/water Nano fluid, which leads to the conclusion that the heat transfer coefficient is greater for MWCNT/water Nano fluid than for Al2O3/water Nano fluid. The coefficient of heat transfers for both Al2O3/water Nano fluid and MWCNT/water Nano fluid at volume concentrations of 0.1% and 0.7% respectively. It has been shown that the heat transfer coefficient associated with MWCNT/water Nano fluid is greater than that related with Al2O3/water Nano fluid. As compared to Al2O3/water Nano fluid, the coefficient of heat transfer utilizing MWCNT/water Nano fluid is much higher. The influence of tube diameter on the heat transfer coefficient for a Nano fluid containing 0.5% volume Al2O3 and water. If the diameter of the tube is reduced from 13.5 millimeters to 4 millimeters, the augmentation in heat transmission for Reynolds number 9624.12 is determined to be 67.5%, whereas for Reynolds number 24047.95 it is 36.05%. The influence of tube diameter on the heat transfer coefficient for a Nano fluid containing 0.7% volume Al2O3 and water. If the diameter of the tube is lowered from 13.5 millimeters to 4 millimeters, the augmentation in heat transfer for Reynolds number 9624.12 is found to be 63.6%, and for Reynolds number 24047.95, it is found to be 35%. Heat transfer coefficient has found to be more in MWCNT/water Nano fluid as compared to Al_2O_3/water for 0.1%, 0.3%, 0.5% and 0.7% vol. concentration for all the three test sections due to higher thermal conductivity of MWCNT nanoparticles than Al_2O_3nanoparticles. Also heat transfer coefficient increases with decrease in diameter of test section.

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Symbols

I	Current (Amp)
V	Voltage (V)
q	Heat Flux (W)
T_b	Properties at bulk mean temperature (^{0}C)
ρ_w	Density of water (kg/m^3)
μ_w	Absolute viscosity (N-s/m^2)
	Thermal conductivity of water (W/m-K)
	Specific heat of water (J/kg-K)
A	Area of tube (m^2)
m	Mass flow rate (kg/sec)
V	Velocity (m/s)
Q	heat transfer rate (W)
h	heat transfer coefficient (W/m^{2-}K).

A_s	Heat transfer surface area (m^2)
T_{in}	Inlet temperature of Water (^0C)
T_{out}	Outlet temperature of Water (^0C)
T_w	Average tube surface temperature (^0C)
Nu	Nusselt No.
ρ_{nf}	Density of Nano fluid (kg/m^3)
μ_{nf}	Viscosity of Nano fluid (N-s/m^2)
Cp_{nf}	Specific heat of Nano fluid (J/kg-K)
K_{nf}	Thermal conductivity of Nano fluids (W/m-K)
Re	Reynolds No.