IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Enhancement of Heat Transfer Rate of W Pipe Heat Exchanger with Water based Nano fluid using ANSYS Fluent

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Abstract— Nowadays due to increasing temperature conditions the application of different heat exchangers are to be developed to increase its performance. These heat exchangers are used in applications such as refrigeration, air conditioning systems, power plants, chemical processing systems, food processing units, automobile radiators and waste heat recovery units. In this study heat transfer analysis was done on the W Pipe heat exchanger type of coil. This analysis was performed for enhancement of heat transfer in a pipe using Nano fluids as coolants. Nano-particles such as Al_2O_3 and SiO_2 are used along with base fluid water. Different concentrations such as 0.5%, 1%, 1.5% & 2% of nanoparticles are mixed with water. The study is done virtually by using ANSYS 15.0 fluent platform. Properties of Nano fluids are determined by using the formulations followed by base papers. The results such as pressure, velocity and heat transfer coefficient are determined. Results proved that Al_2O_3 has high heat transfer rate and also it is studied that SiO_2 with water has high-pressure increase.

Keywords— **Nano fluids, Nanoparticles, ANSYS, CATIA, Heat Exchangers**

1. Introduction

In order to move heat between two or more fluids, a heat exchanger is utilized. The cooling and heating processes both need the usage of heat exchangers. An example of a heat exchanger is depicted in this illustration. In a study by Salman Al Zahrani et. al. [1] A new flat plate heat exchanger is being investigated to see whether it might improve heat transfer. An improved flat PHE (FPHE) is also being developed as part of this research to improve upon what is already known about its thermal performance. The thermal performance of the FPHE is to be improved by using a new flow arrangement. Heat Transfer Enhancement in Heat Exchangers with Inserts was reviewed by N. C. Kanojiya et al. [2]. Using heat transfer augmentation techniques, the system's total performance can be improved without sacrificing efficiency. Heat Transfer Enhancement in Heat Exchangers by Injecting Air Bubbles was studied experimentally by S L Hashim et al. [3].

In two helical coil heat exchangers, the effect of injecting air bubbles on heat transfer enhancement and pressure drop during turbulent flow was examined experimentally. SiO_2/water nanofluids were used to increase heat transfer in shell and helically coiled tube heat exchangers, according to Amol F. Niwalkar et al. [4]. An average diameter of 17 nm is used for SiO_2 nanoparticles dispersed in water with varying volume percentages (0.05 to 0.15% by volume), all at room temperatures. Nano fluid flows in the helical tube and cold water flows on the shell side of the shell and helically coiled tube heat exchanger In order to determine the heat transfer coefficient for both the tube and shell sides, Wilson plots are used.

In a study by Mahmud H. Ali et al. [5,] the effect of inner pipe twisting on the overall performance of a twin pipe heat exchanger is investigated experimentally. Parallel and contra flow directions are also explored in the fluid to fluid heat exchange. According to the results, heat exchanger performance is improved in both directions of flow when twisting pipes are considered. The use of heat transfer enhancement techniques in the design of heat exchangers was examined by Castro Gómez et al. [6]. The boundary layer theorem proves that a laminar sublayer exists in the flow of a clean fluid through the tube of a heat exchanger. Numerical simulations were performed by Pandey L et al. [7] to examine the effect of a Triangular Perforated Y-Shaped Insert on heat transmission in a Circular Tube Heat Exchanger. Consider air as a fluid with a Reynolds number between 3000 and 21,000 for the analysis. Analysis will be performed on a 1.5-meter circular tube with an outside diameter of 68 millimetres (mm).

Mohamed H. Mousa et. al. [8] conducted review of heat transfer enhancement strategies for single phase flows. Modern society relies heavily on the exchange of thermal energy between a flowing fluid and its confinement channel. According to the authors, Akarsh Kumar and others [9] Using a double pipe heat exchanger, the twisted tape is introduced. The length of the tape was perforated with holes of diameters 1mm, 3mm, and 5mm at regular intervals. Assuming hot fluid flows through the inner pipe and cold fluid flows through the annulus, a numeric model of a two-pipe heat exchanger with holes twisted tape was developed. On the thermo-hydraulic performance of the Heat Exchanger Tube with a solid and perforated circular disc as well as an embedded twist tape, Alok Kumar et al. [10] conducted an experimental analysis. Researchers have found that improving heat transfer in heat exchangers by utilising a passive method has shown to be an extremely useful tool.

Khadheyer S. Mushatet and colleagues [11] There were three different twist ratios examined, as well as three different Reynolds numbers (Re = 5000 to 25000) for the same 1 m long by 0.033 m diameter triangle-twisted tube. The momentum, continuity, and energy equations regulate the study of the flow field and heat transfer. Finite volume methods are employed in the calculation of turbulent flow and heat transfer in ANSYS Fluent 17.1. Numerical and heat transfer analyses of shell and tube heat exchangers with circular and elliptical tubes were performed by J. Bala Bhaskara Rao et al. [12]. For a single shell and multiple pass heat exchangers with varied tube geometries, such as circular tubes to elliptical tubes, experimental and numerical simulations are carried out. Circular tubes at 600 tube orientation were used in the experiment with a 25 percent baffle cut and heated fluid on one side, cold fluid on the other.

2. Methodology

A heat pipe with a specific cross-section is taken and an analysis is done on it. The results of analysis are compared with the results obtained with the previous researches. It helps us in proving enhancement of cooling performance in any heat exchanger equipment. Today's refrigeration machines require more cooling technologies due increasing temperatures. Nano fluids with nano particles such as Aluminium Oxide (Al_2O_3) and Silicon Dioxide (SiO_2) with different concentration of 0.5%, 1%, 1.5% and 2% is being taken into consideration. Horizontal W Pipe Section from a coil is taken into consideration and analysis is done to study the performance of various parameters such as velocity, pressure and heat transfer coefficient. The point to be noted here is that temperature is assumed constant for all the cases. Coolants with different nano particle concentration mixed with them is helpful in enhancing the cooling rate in a heat exchanger.

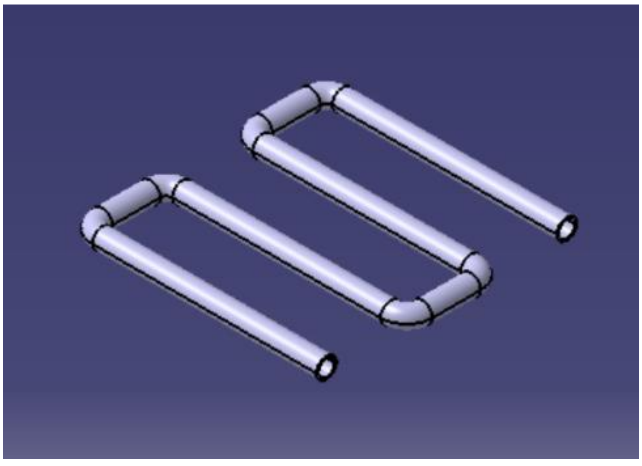

Fig. 1 3D Isometric view of the pipe

3. Analytical Work

Analyzing the heating coil is done using the Ansys software tool. Al_2O_3, SiO_2, and water as base fluid and 1% Al_2O_3, are all fed into the heating coil in various concentrations. The Nano fluid travels at a speed of $0.5 ms^{-1}$.

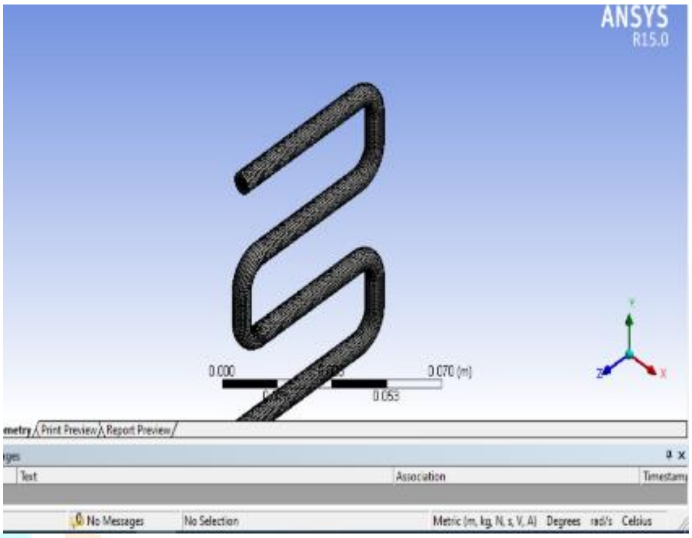

Fig. 2 Meshing.

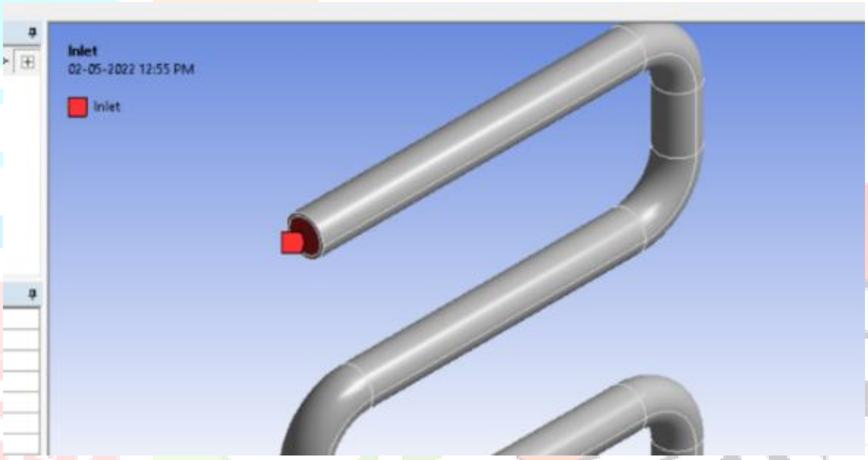

Fig. 3 Inlet

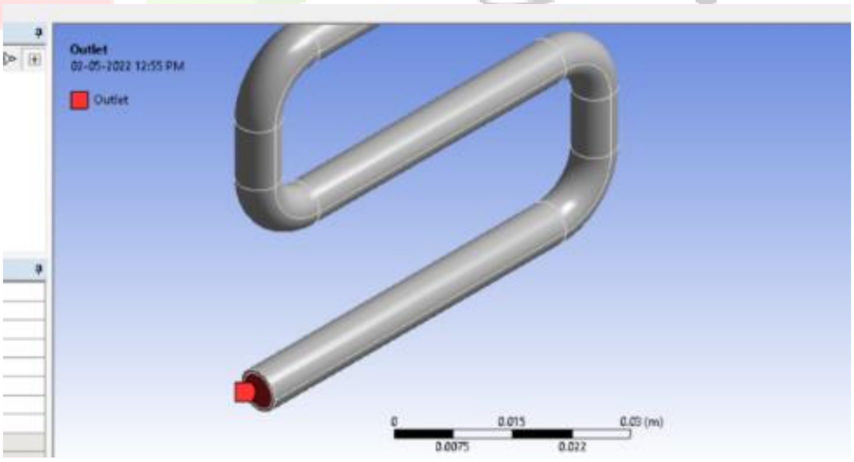

Fig. 4 Outlet

4. Results and Discussions

In this section, the results that are obtained from analytical and numerical formulations are displayed here. The properties of Nano fluid are derived from empirical relations taken from base papers given by [1] and [2]. The formulae are used to evaluate the properties like pressure, density, velocity and heat transfer coefficient. Using this formulation analysis was done and results formed are displayed below.

4.1 Pressure distribution for Al_2O_3 + Water

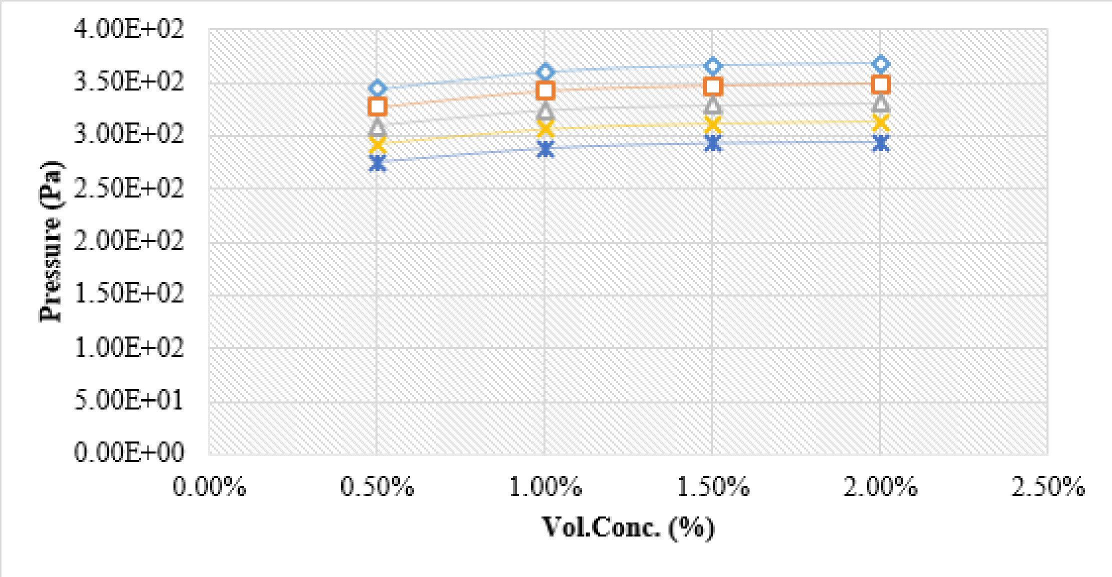

Fig. 5 Volume Concentration (vs) Pressure for $Al_2O_3 + H_2O$.

Figure 5 indicates the pressure contour for 0.5% $Al_2O_3 + H_2O$. Here the highest pressure of 3.44e+02 Pa is observed at inlet. As the Nano fluid is passed through the pipe the pressure started decreasing giving minimum value at the point of outlet. When the volume concentration is increased to 1% the pressure also got increased by approximately 0.2Pa. Similarly, when the concentration is increased by another 0.5% the pressure also increased by approximately by 0.2Pa.

4.2 Velocity Distribution for $Al_2O_3 + H_2O$

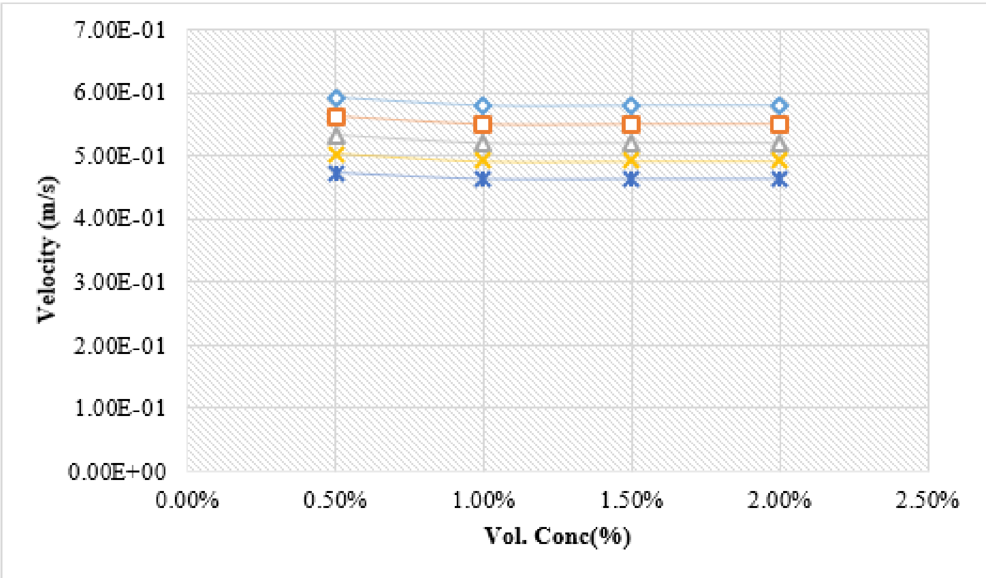

Fig. 6 Volume Concentration (vs) Velocity for $Al_2O_3 + H_2O$

Figure 6 indicates the velocity contour for 0.5% $Al_2O_3 + H_2O$. Here the highest velocity of 5.66e-01 m/s is observed at inlet. When the volume concentration is increased to 1% the pressure also got increased by approximately 0.1m/s. Similarly, when the concentration is increased by another 0.5% the velocity also increased by approximately by 0.2m/s.

4.3 Heat Transfer Coefficient distribution for $Al_2O_3 + H_2O$

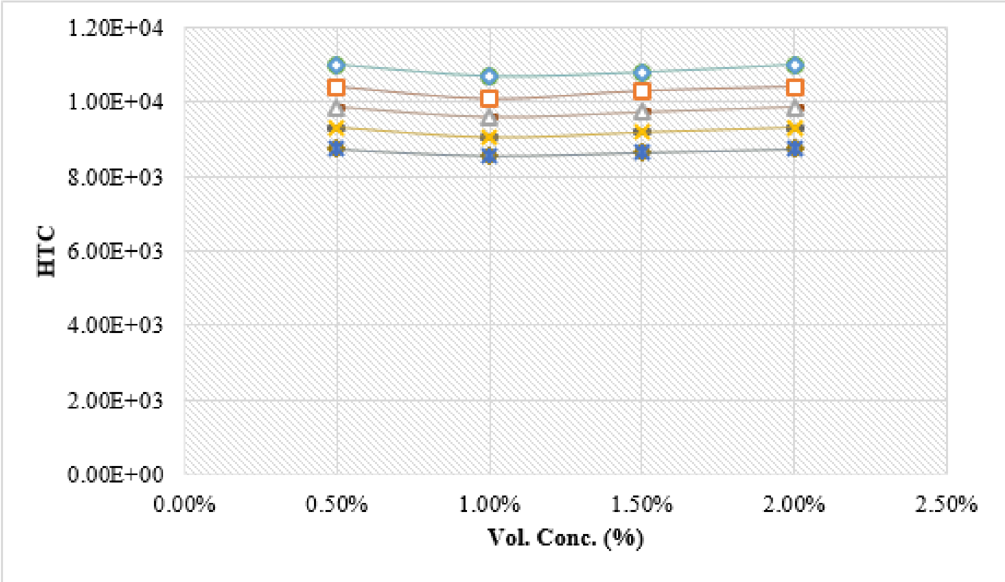

Fig. 7 Volume concentration Vs Heat Transfer Coefficient for $Al_2O_3 + H_2O$

Figure 7 indicates the Heat Transfer Coefficient contour for 0.5% $Al_2O_3 + H_2O$. Here the highest HTC of 1.08e+04 is observed near the wall. When the volume concentration is increased to 1% the HTC also got increased by approximately 0.1. Similarly, when the concentration is increased by another 0.5% the HTC also increased by approximately by 0.1.

4.3 Pressure distribution for SiO_2 + Water

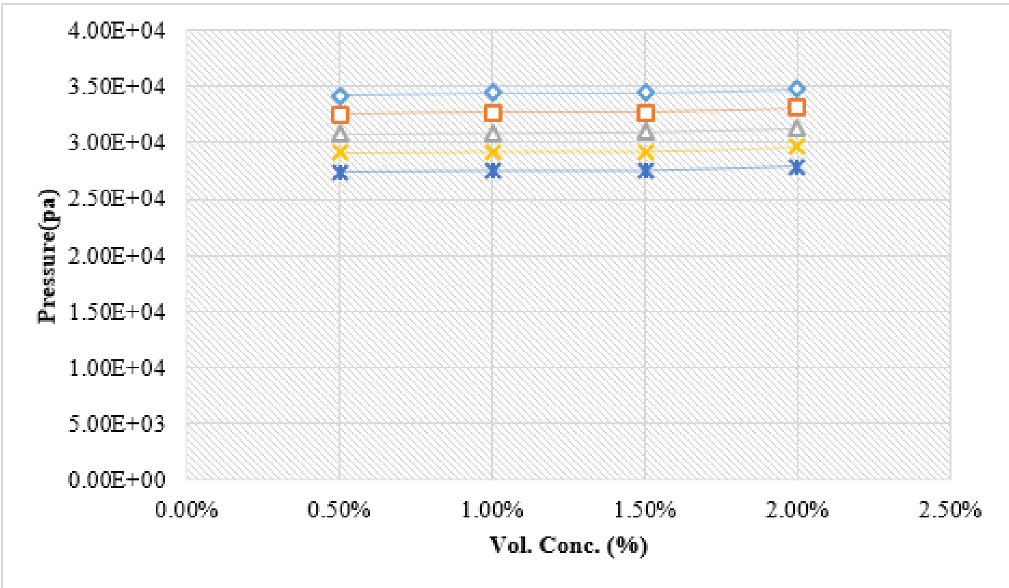

Fig. 8 Volume Concentration (vs) Pressure for $SiO_2 + H_2O$.

Figure 8 indicates the pressure contour for 0.5% $SiO_2 + H_2O$. Here the highest pressure of 3.48e+04 Pa is observed at inlet. As the Nano fluid is passed through the pipe the pressure started decreasing giving minimum value at 0.5% volume concentration of nanoparticle. When the volume concentration is increased to 1% the pressure also got increased by approximately 0.02Pa. Similarly, when the concentration is increased by another 0.5% the pressure also increased by approximately by 0.2Pa.

4.4 Velocity distribution for SiO_2 + Water

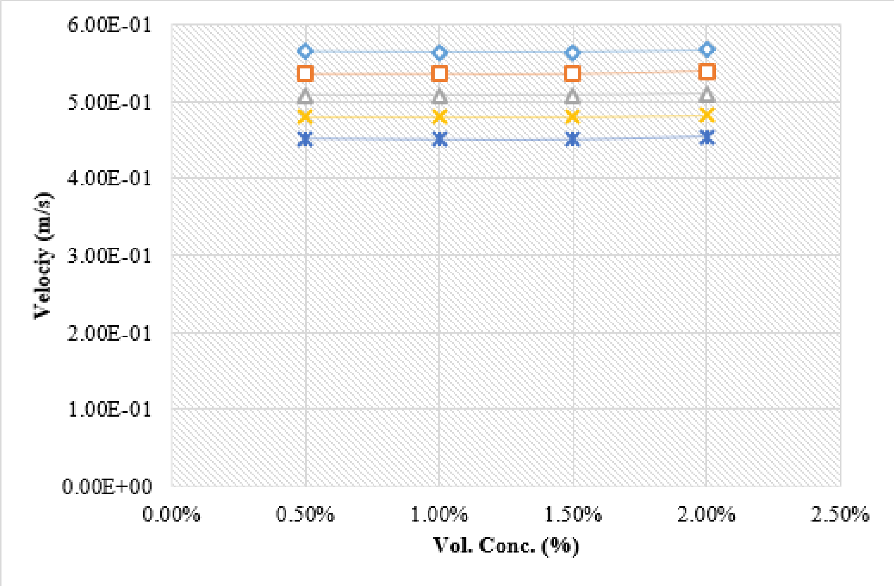

Fig. 9 Volume Concentration (vs) Velocity for SiO_2 + H_2O.

Figure 9 indicates the velocity contour for 0.5% SiO_2 + H_2O. Here the highest velocity of 5.65e-01 m/s is observed at outlet. When the volume concentration is increased to 1% the velocity also got increased by approximately 0.02m/s. Similarly, when the concentration is increased by another 0.5% the velocity also increased by approximately by 0.02m/s.

4.5 Heat Transfer Coefficient distribution for SiO_2 + Water

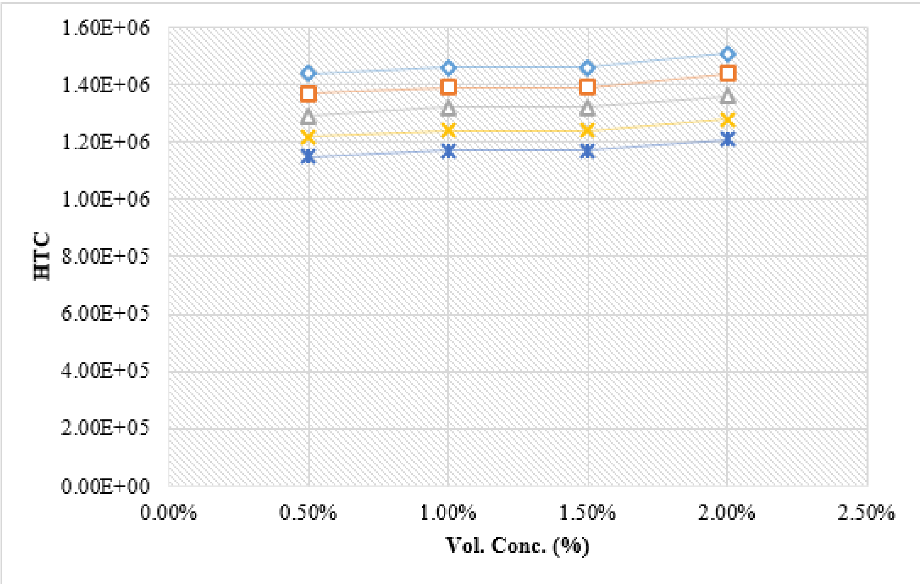

Fig. 10 Volume Concentration (vs) Heat Transfer Coefficient for SiO_2 + H_2O

Figure 10 indicates the HTC for 0.5% SiO_2 + H_2O. Here the highest HTC of 1.51e+06 is observed at wall surface. As the Nano fluid is passed through the pipe the HTC started decreasing giving minimum value at 0.5% volume concentration of nanoparticle. When the volume concentration is increased to 1% the HTC also got increased by approximately 0.5.

5. Conclusions

In this project, analytical investigations on the horizontal W Pipe was made using ANSYS 15.0 Workbench. Different output parameters such as pressure drop, velocity and heat transfer coefficient were obtained. In this research the horizontal W Pipe is designed using CATIA, a 3D modelling software taking the pipe reference dimensions such as pipe diameter, pitch of the pipe and pipe thickness. Different nanofluids such as Al_2O_3 and SiO_2 are considered with different concentrations such as 0.5%, 1%, 1.5% and 2%. The base fluids considered here are water and ethylene glycol. From the results it can be concluded that Aluminium Oxide and Water can be used for effective transfer of energy through the heat pipe. Hence, Aluminium Oxide can be considered as the best nanoparticle among Aluminium Oxide and Silicon Dioxide. The plotted graphs show us that there is a considerable increase in pressure in the case of Aluminium Oxide and Water mixture. A slight increase is found in case of Silicon Dioxide mixed with Water. In case of velocity a slight increase can be found in both Aluminium Oxide and Water and Silicon Dioxide and Water combination. An increase in heat transfer coefficient can be seen in all the cases except when Aluminium Oxide and Water are mixed.

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