COMPUTATIONAL FLUID DYNAMICS SIMULATION OF PTHE USING WATER AND Al_2O_3

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Abstract: In the current task, ANSYS was used here for quantitative and qualitative analysis of plate type heat exchanger with water and Al_2O_3.CFD simulation has been evolved to predict heat transport in plate type heat exchanger using water and Al_2O_3. Characteristics of heat transfer using H_2O and Nano fluid have been discussed. Also the velocity distribution has been generated using FLUENT for the plate type heat exchanger. It has been perpetrated from the solution that Al_2O_3 which has been used as a Nano fluid is more effective.

Index Terms – PTHE, CFD, Velocity Distribution, FLUENT, Nano Particle, Heat transfer

I. INTRODUCTION

With current advancement in technology, the invention of molecules having sizes of the order of nm (nano particles) can be successfully attained. Due to this ideas have been proposed to mix these nano particles in a base liquid to increase the thermal conductivity. This mixture of nano particles in a base fluid is known as a nano fluid. Classification of heat exchange units includes classification based on flow as well as based on heat transfer mechanism.

Classification by flow arrangement yields four sub-classes. Velocity vectors have both the same direction when the flow is concurrent while for countercurrent flow the directions are opposite (see Figure 1.1). In cross-flow, one fluid flows perpendicular to the other. Nevertheless, in many heat exchangers the arrangement is a combination of the above rather than pure concurrent, countercurrent, or cross-flow.

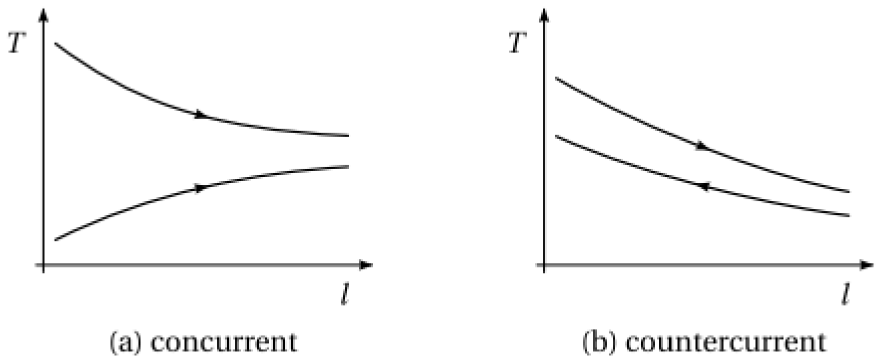

Figure1.1: Typical temperature profiles for concurrent and countercurrent flow arrangements

Classification using heat transfer mechanism is rather straightforward and produces three sub-classes as well – units in which there is no phase change, units in which only one fluid changes phase, and units in which both fluids change phase.

Masuda et al. [1993] investigated the thermo physiological properties of Al_2O_3 and TiO_2 mixed in water. It was investigated that the thermal conductivity increased for about 32% for volume concentration of 4.3percent. Xuan & Li [2000] predicted that thermal conductivity got increased about 11%. Pak et al. [1998] and Xuan & Li [2000] perpetrated that the increase in the thermal conductivity is not normal. This could be because of even mixing of nano particle. Hwanga et al**.** [2008] reported an innovative idea on the homogeneous mixing of nano particles in nano fluids by various methods and these methods are found to be the most effective to get uniform mixing of nano particles. Lee et al. [2008] studied Al_2O_3 and CuO particles mixed in water over a range of temperature between 20-40 ^{o} C. As a result the upsurge in thermal conductivity is noticed about three times. Bhat &Maitra et al. [2009] and Frimpong et al. [2008] used some surfactants namely thiols, oleic acid and laurate salts etc. Wen & Ding [2004] discussed transport of heat which was convective in nature for nano fluids at the entry for the conditions which were suitable for laminar flow.Wongwises et al. [2009] discussed of a nano fluid having H_2O and 0.2 volume percent TiO_2. This had been investigated that the coefficient of heat transfer was up surged slightly. Farajollahi et al. [2010] evaluated that there was a significant increase in the characteristics of heat transport when nano particles were added to the base fluid. Peyghambarzadeh et al.

[2011] explored the heat transport potential of pure H_2O when pure EG was differentiated with their binary mixtures. Ramakoteswaa Rao et al. [2014] showed literature review on critical challenges of uses and the applications of Nano fluids and concluded during the study that the nano fluids were of significant importance because it can be used in most of applications like heat transport, increment of thermal conductivity and other uses.

II. OBJECTIVES

1. To develop a CFD simulation in PTHE using water and Al_2O_3.
2. To compare and analyze the characteristics of heat transport using water and Al_2O_3

III. GEOMETRY

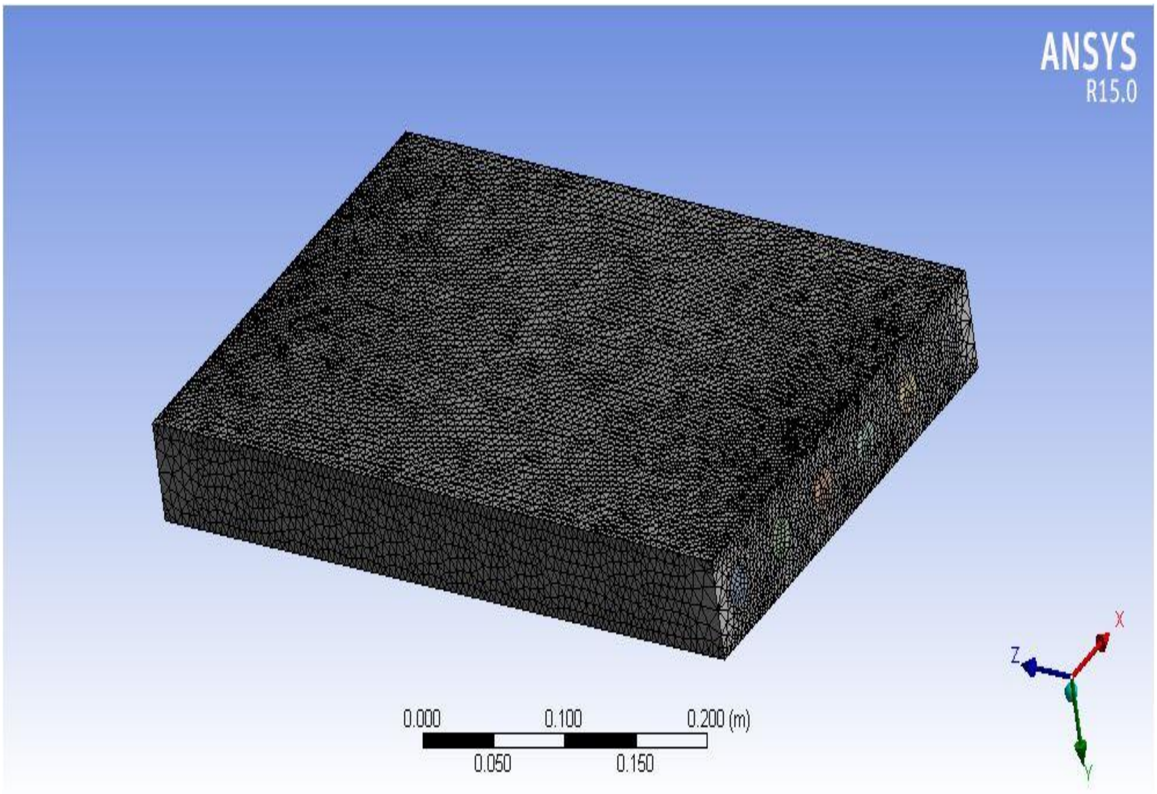

Figure 3.1: Design of PTHE

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IV. METHODOLOGY

FLUENT is used for the simulation of PTHE. Geometry is drawn in solid works and simulation is performed in fluent.
Geometry was drawn
Meshing was done in FLUENT
Boundary conditions
Solution
Post Processing

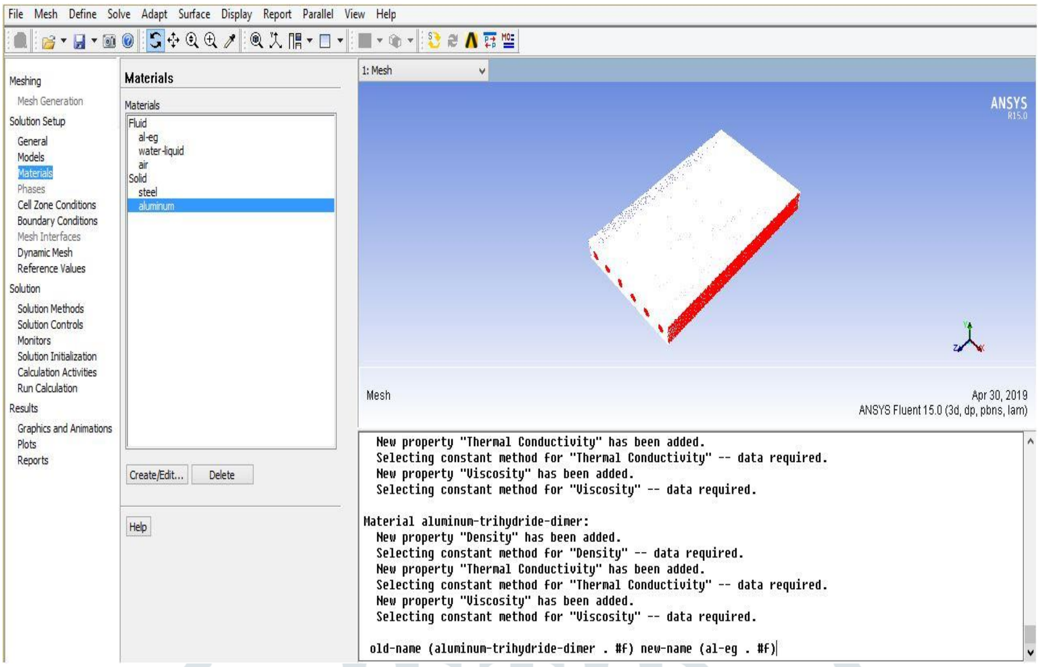

Figure 4.1: Meshing Diagram

V. SCRIPT FILE

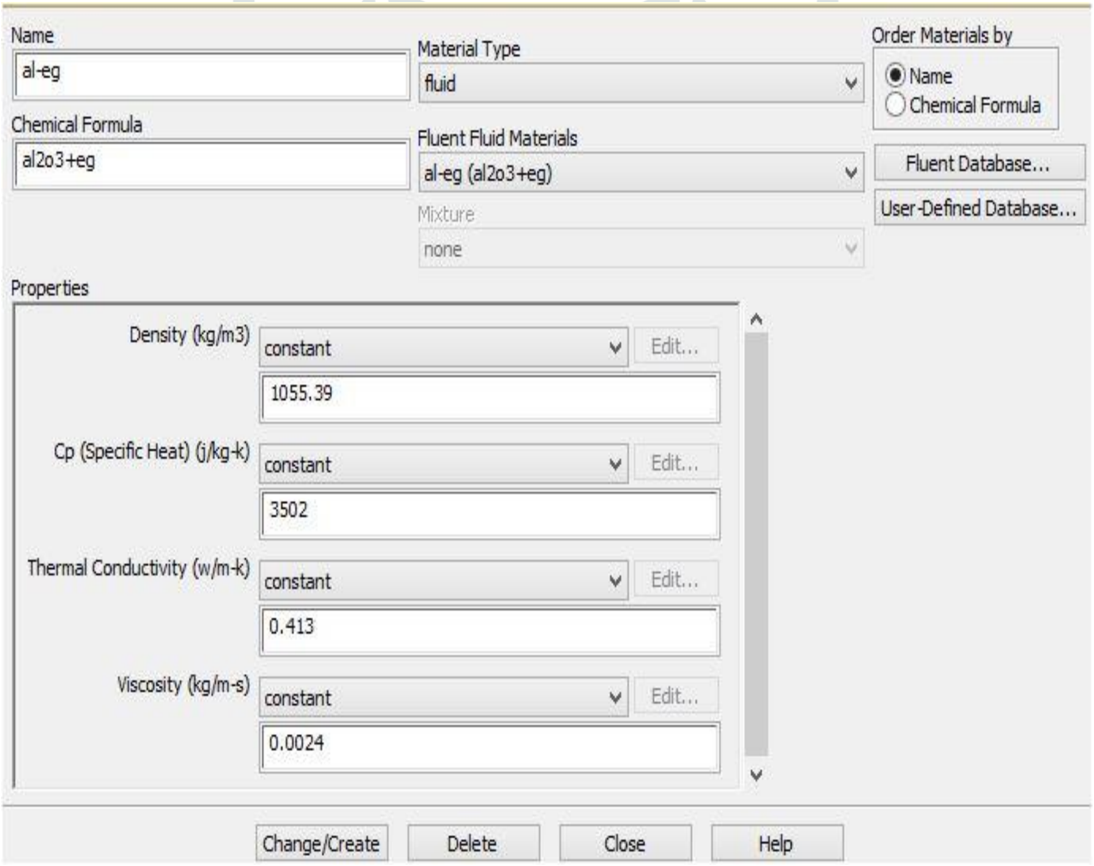

Figure 5.1: Input Properties for Aluminum Oxide (Al_2O_3)

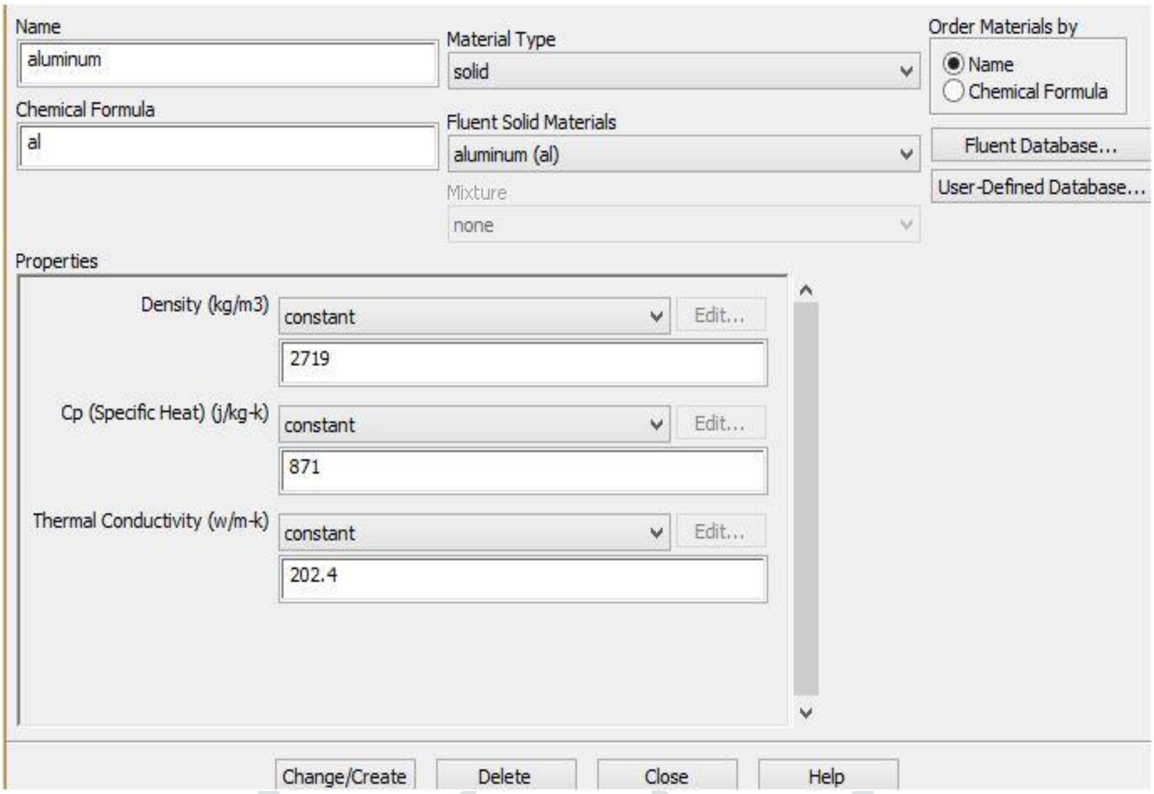

Figure 5.2: Input Properties for Heat Exchanger Material

VI. RESULTS AND DISCUSSION

6.1 Velocity distribution across heat exchanger

The velocity Contours plots across the section, along the length of heat exchanger will give an idea of the flow in detail.

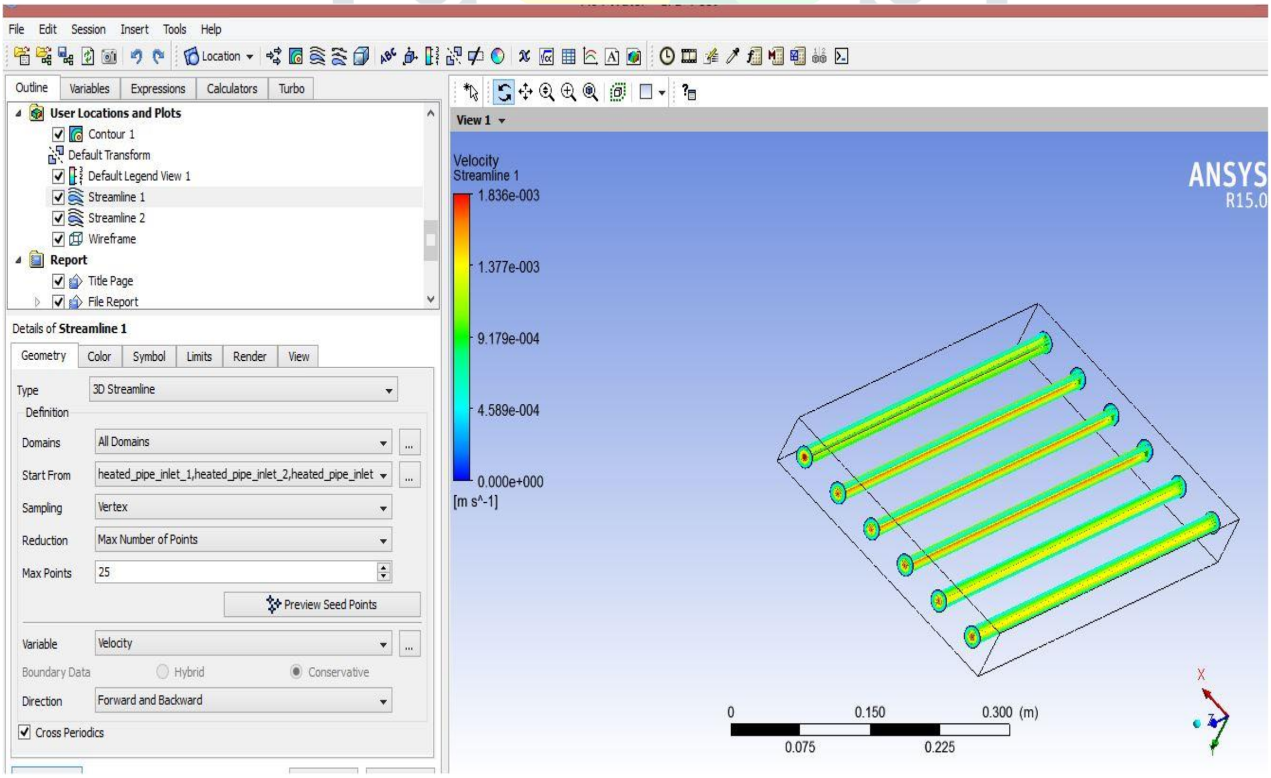

Figure 6.1: Velocity distribution access heat exchanger (Water)

The velocity contours plots along the length of heat exchangers is given in the figure above. The maximum velocity is 1.836m/s and minimum velocity is 0.1m/s. The various inlet velocities are 1.8, 1.75, 1.33, 1.63 and 1.72 m/s along the various pipes from 1 to 5 respectively

6.2 Velocity distribution access heat exchanger

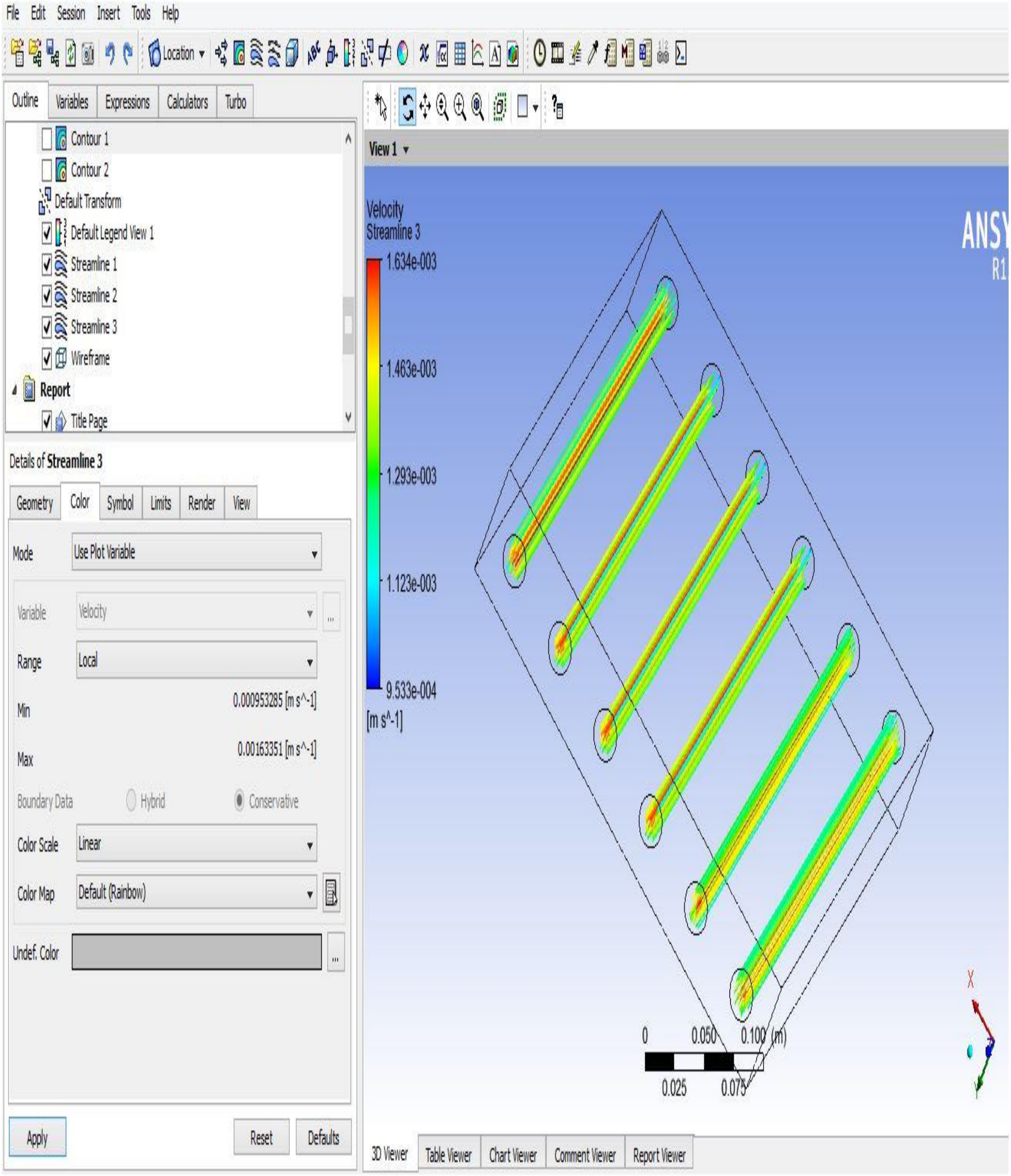

Figure 6.2: Velocity distribution access heat exchanger (Nano fluid)

The velocity contours plots along the length of heat exchangers is given in the figure above. The maximum velocity is 1.626m/s and minimum velocity is 0.1m/s. The various inlet velocities are 1.62, 1.42, 1.21, 1.32 and 1.67 m/s along the various pipes from 1 to 5 respectively.

6.3 Velocity Comparison

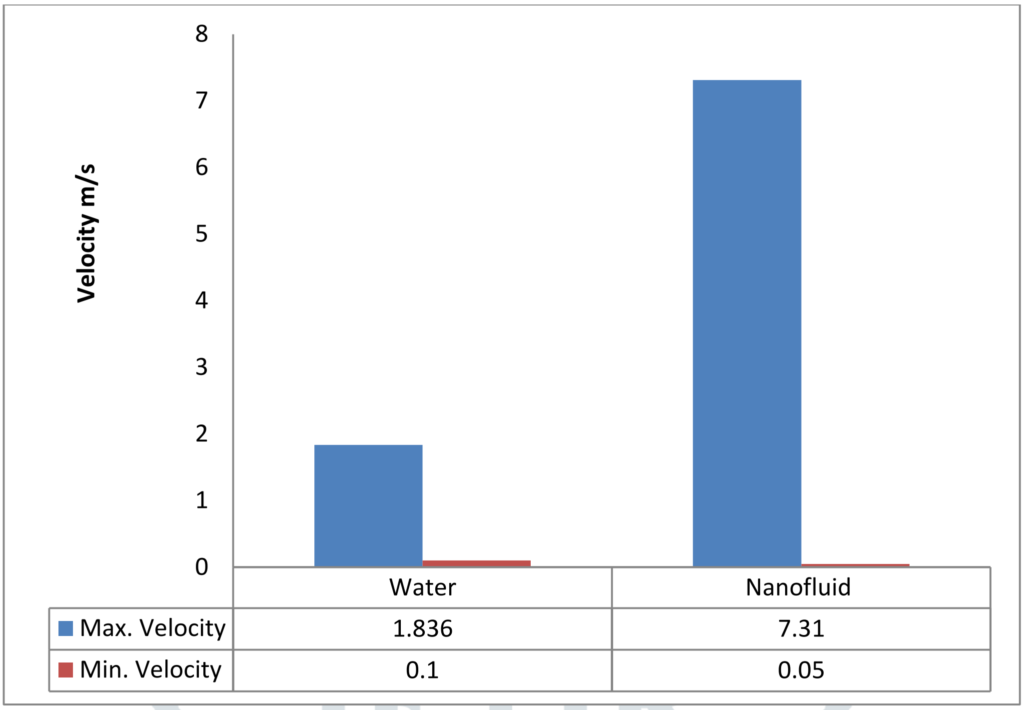

Figure 6.3: Velocity Differentiation between water and Al_2O_3

Figure 5.11 shows the velocity differentiation between the H_2O and Al_2O_3**.** The simulations show that the maximum velocity is obtained in using the nano fluids.

6.4 Heat Transfer Rate Differentiation

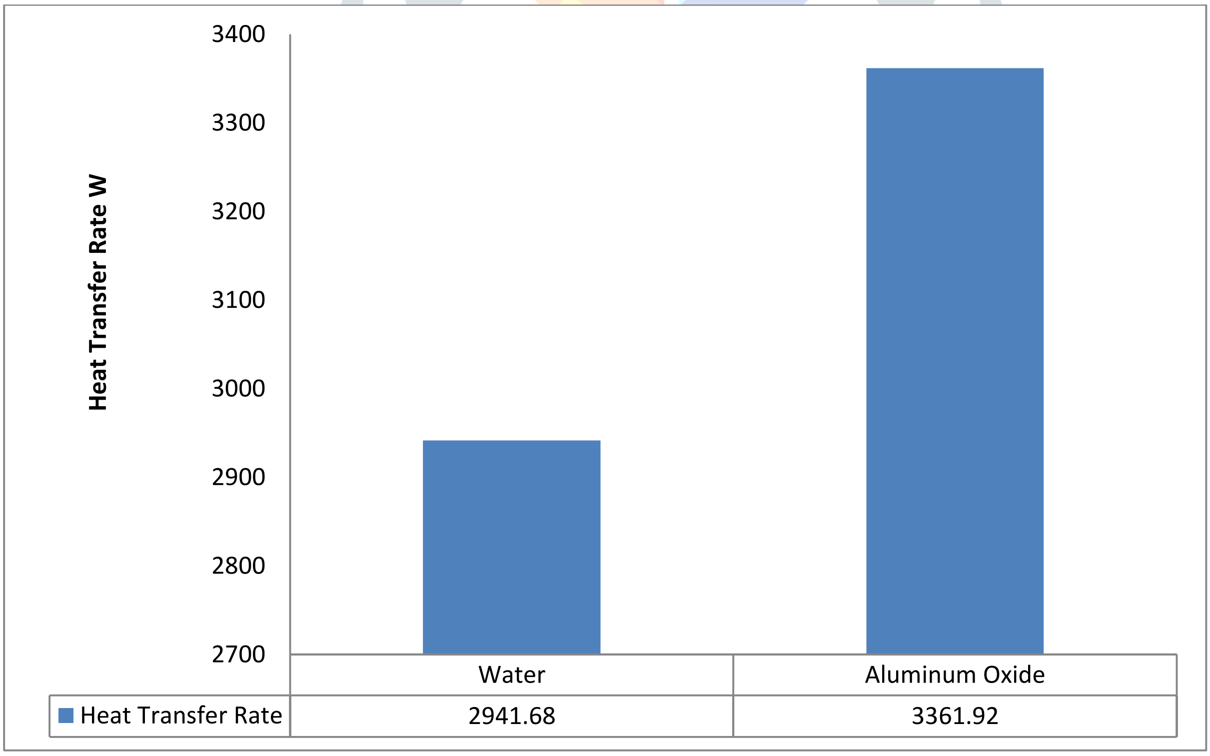

Figure 6.4: Heat transfer rate comparison

The results are taken for two cases one with using water as coolant and the other using Aluminum Oxide. The heat transfer rate is been calculated and the same is been represented in the graph.

VII. CONCLUSION

ANSYS FLUENT was used for quantitative and qualitative analysis of PTHE with water and Al_2O_3.The variation of velocity was studied. Also the variation of heat was shown both in case of water and nano fluid. A comparison was made for heat transfer in case of water and nano fluid. It was found from the results that the nano fluid is having high heat carrying capacity as compared to water due to high thermal conductivity.

VIII. ACKNOWLEDGMENT

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REFERENCES

1. Butterworth, David, 2002. Design of shell-and-tube heat exchangers when the fouling depends on local temperature and velocity. Applied Thermal Engineering, pp.S1359-4311(02)00025-X
2. Yin, J. & Jensen, M.K., 2003. Analytic model for transient heat exchanger response. International Journal of Heat and Mass Transfer, vol.46, pp.3255-3264.
3. Kara,Y.A. & Guraras,O., 2004. A computer program for designing of shell-and-tube heat exchangers. Applied Thermal Engineering, vol.24, pp.1797-1805.
4. Benveniste, Y., 1997.Effective Thermal Conductivity of Composites with a Thermal Contact Resistance between the Constituents: Non dilute Case. Journal of Applied Physics, vol. 61, pp.2840-2843.
5. Vengateson, U., 2010. Design of multiple shell and tube heat exchangers in series: E shell and F shell. 88 (5-6), pp.725-736.
6. Bhat, S. & Maitra,U., 2009. Facially amphiphilicthiol capped gold and silver nano particles. Journal of Chemical Sciences, vol.120, no.6, pp.507-513.
7. Reynolds, F.A. & Zach, H.J., 2008. Poly (nisopropylacrylamide)- based hydrogel coatings on magnetite nano particles via atom transfer radical polymerization. Nanotechnology, vol.19, no.17, pp.123-131.
8. Pak, B.C & Cho, I.Y., 1998. Hydrodynamic and heat transfer study of dispersed fluids with sub-micron metallic oxide particles. Experimental Heat Transfer, vol.11, pp.151-170.
9. Xuan, Y. & Li, Q., 2000. Heat transfer enhancement of nano fluids. International Journal of Heat and Fluid Transfer, vol.21, pp.58-64.
10. Yujin H., Leea J.K., Leec J.K., Cheonga J,Y.M., Ahnb Y.C. & Kim S.H., 2008.Production and dispersion stability of nano particles in nano fluids. Powder Technology, vol.186, no.2, pp. 145-153.
11. Masuda, H., Ebata, A., Teramae, K. & Hishinuma, N., 1993. Alteration of Thermal Conductivity and Viscosity of Liquid by Dispersing Ultra- Fine Particles (Dispersion of Al2O3, SiO2 and TiO2 Ultra-Fine Particles). Netsu Bus-sei (Japan), 7(4), pp.227-233.
12. Lee, J.H., Hwang, K.S., Jang, S.P., Lee, B.H., Kim, J.H., Choi, S.U.S. & Choi, C.J., 2008. Effective viscosities and Thermal Conductivities of Aqueous Nano fluids Containing Low Volume concentrations of Al_2O_3 Nano particles. International Journal of Heat and Mass Transfer, vol.51, pp.2651-2656.
13. Wen, D. & Ding, Y., 2004. Experimental investigation into convective heat transfer of nano fluids at the entrance region under laminar flow conditions. International Journal of Heat and Mass Transfer, vol.47, pp.5181-5188.
14. Farajollahi, B., Etemad, S.G.H. & Hojjat, M., 2010.Heat transfer of nano fluids in a shell and tube heat exchanger. International Journal of Heat & Mass Transfer, vol.53, pp.12-17.
15. Duangthongsuk, W. & Wongwises, S., 2009. Heat Transfer Enhancement and Pressure Drop Characteristics of TiO2-Water Nano fluid in a Double-Tube Counter Flow Heat Exchanger', International Journal of Heat and Mass Transfer, 52(7-8), pp. 2059-2067.

16. Amani, J. & Abbasian Arani, A.A., 2014. Experimental Study on Heat Transfer and Pressure Drop of TiO_2- Water Nano fluid. Amirkabir Journal of Science & Research (Mechanical Engineering).
17. Rao, R.K., N, Gahane, L. & Ranganayakulu, S.V., 2014. Synthesis, Applications and Challenges of Nano fluids – Review. IOSR Journal of Applied Physics (IOSR-JAP) e-ISSN: 2278-4861, pp.21-28.
18. Strelow, O., 2000. A General Calculation Method for Plate Heat Exchangers. Int. Journal of Thermal Sciences, vol.39, pp.645-658.
19. Song.C.1-1, Lee, D.Y. and Ro.S.T., 2003. Cooling Enhancement in an Air-Cooled Finned Heat Exchanger by Thin Water Film Evaporation. Int. Journal of Heat and Mass Transfer, vol. 46, pp. 1241-1249.
20. Picon-Nunez. M., Polley. G. T., Torres-R.E. and Gallegos-Munoz. A., 1999. Surface Selection and Design of Plate-Fin Heat Exchangers. Applied Thermal Engineering, vol. 19, pp. 917-931
21. Wen, J. and Yanzhong L.I., 2004. Study of Flow Distribution and its Improvement on the Header of Plate - Fin [feat Exchanger. Cryogenics, vol. 44, pp. 823-83 I.
22. Kulkarni. T., Bullard.C.W. And Cho.K. 2004. Header Design Tradeoffs in Micro channel Evaporators. Applied Thermal Engineering, vol. 24, pp. 759-776.
23. Wen, J. and Yanzhong, L.I., 2004. Study of Flow Distribution and its Improvement on the Header of Plate - Fin [feat Exchanger. Cryogenics, vol. 44, pp. 823-83 I.