CFD Analysis on Forced Convection Flow of Nano fluid in Triangular Corrugated Channel

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Abstract- **Heat exchangers that are more efficient, compact and less expensive, heat transfer enhancement has gained great momentum. For this purpose, two techniques have been identified: passive and active. Convective heat transfer can be enhanced passively by changing flow geometry. The symmetrical corrugated channel is one of several devices employed for enhancing the heat and mass transfer In this study, heat transfer rate for semi oval corrugated channel has been investigated through CFD. Computational Fluid Dynamics (CFD) simulations of heat transfer and friction factor analysis in a turbulent flow in semi-oval corrugated channels with Al2O3-water nanofluid is presented in this study. Simulations are carried out at Reynolds number range of 10000-30000, with nanoparticles volume fractions 6% and constant heat flux condition. The results for corrugated channels are examined and compared to those for straight and semi-circle channels. Results show that the Nusselt number increased with the increase of roughness of corrugated channel and Reynolds number.**

Index Terms- Single phase heat exchanger, CFD, Nusselt number, Heat transfer, Reynolds number.

INTRODUCTION

Due to the increasing demand by industries for heat exchangers that are more efficient, compact and less expensive, heat transfer enhancement has gained great momentum. For this purpose, two techniques have been identified: passive and active. Convective heat transfer can be enhanced passively by changing flow geometry. The symmetrical corrugated channel is one of several devices employed for enhancing the heat and mass transfer. Enhancement techniques based on artificial roughness are used in numerous applications. Rough walls exist in all flow systems, where they may lead to either deterioration or improvement of the desired functionality. Wall roughness can be increased to promote mixing of the fluid or reduced to eliminate flow disturbances. In view of their turbulence promoting ability, corrugated surfaces have been used widely to improve the rate of forced convection heat and mass transfer in equipment such as heat exchangers, solar collectors, electrochemical and catalytic reactors and membrane processes. The ability of a fluid medium to transfer a large amount of heat across a small temperature gradient enhances the efficiency of energy conversion, as well as improves the design and performance of heat exchangers. Therefore, research on enhancement technique in such channels has become very prominent. For this purpose, using nanofluids as a cooling fluids in corrugated channels instead of traditional fluids can enhance thermal conductivity of the base fluids and thereby a further improvement in thermal performance of heat exchangers with a more compact design.

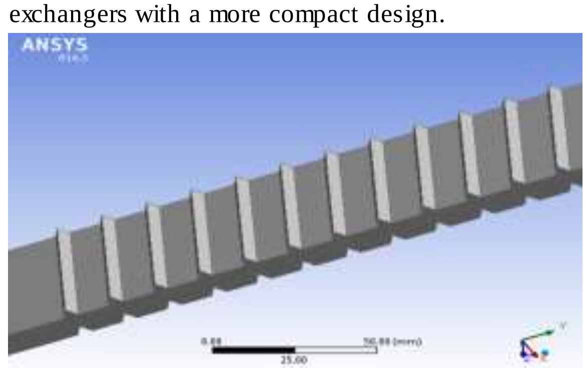


Figure 1.1: Plate fin heat exchanger

LITERATURE REVIEW

R K Ajeel1 and W S I W Salim1(2017): Simulations are carried out at Reynolds number range of 10000-30000, with nanoparticles volume fractions 0-6% and constant heat flux condition. A CFD study on turbulent forced convection flow of Al2O3- water nanofluid in semi circular corrugated channel.

Caihang Liang, Xiaoman Tong (2017)
Optimal Design of an Air-to-Air Heat Exchanger with Cross-Corrugated Triangular Ducts by Using a Particle Swarm Optimization Algorithm. In this study, the thermal hydraulic mathematical model of the air-to-air heat exchanger with cross-corrugated triangular ducts is developed and verified.

K. Rahmani, A. Al-Kassir, (2017)
Simulation of fluid flow and heat transfer inside a heat exchanger corrugated channels. The results show that the number of local Nusselt varies accordingly with the amplitudes and number of periods. This explains that the modified wall is affected locally by a pure conduction.

GAO XiaoMing, LI WeiYi (2014)
Heat transfer and flow characteristics in a channel with one corrugated wall. The present study numerically investigates the characteristics of three-dimensional turbulent flow and heat transfer in the channel with one corrugated wall heated with constant temperature by means of large eddy simulation.

E.A.M. Elshafei (2010)
Heat transfer and pressure drop in corrugated channels. The convective heat transfer and pressure drop characteristics of flow in corrugated channels have been experimentally investigated. Experiments were performed on channels of uniform wall temperature and of fixed corrugation ratio over a range of Reynolds number, 3220 Re 9420.

M. Gradeck et,al. (2005)
Local analysis of heat transfer inside corrugated channel. Experiments are performed to study effects of hydrodynamic conditions on the enhancement of heat transfer for single phase flow.

David R Sawyers (1998)
Heat transfer enhancement in three dimensional corrugated Channel flow. The effect of three dimensional hydrodynamics on the enhancement of steady laminar heat transfer in corrugated channels is studied using a combination of analytical and numerical techniques Reynolds numbers are considered in the range of 0<Re<250 to avoid unsteady flow.

Methodology: The designed model of corrugated plate heat exchanger is meshed in ICEM Meshing. The meshing type have done is tetrahedral. The numbers of nodes that are used are 1429 and the numbers of elements that are used are 4268 in this design model. The mesh model of corrugated plate heat exchanger is shown below:

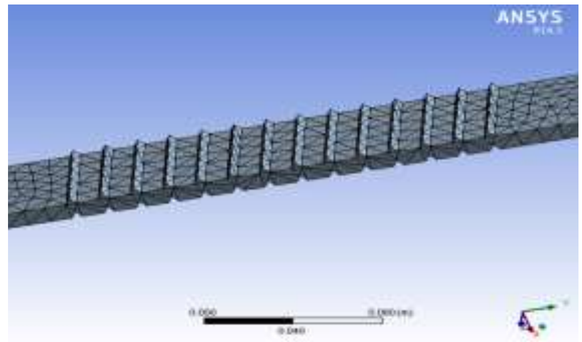


Figure 1.2 Mesh view of corrugated channel

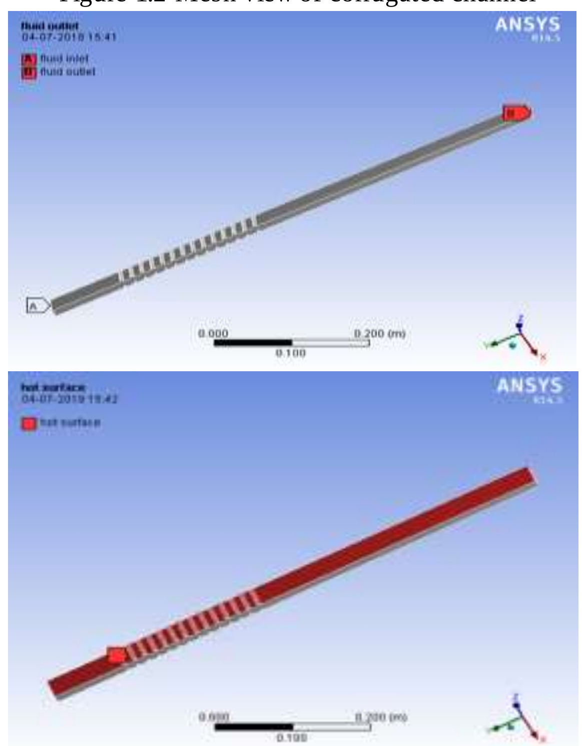


Figure 1.3 Name selection of corrugated plate heat exchanger for fluid inlet, outlet and hot surface.

Table 1.1 Thermo physical properties of nanoparticle and base fluid at T=300 K

Material	Density ρ (Kg/m^3)	Dynamic viscosity μ ($N\text{-}s/m^2$)	Thermal conductivity K(W/m-K)	Specific heat C_P (J/Kg-K)
Water	998.2	0.001243	0.6	4182
Al_2O_3	3600	---------	36	765

Effect of Reynolds number at 6% Al_2O_3 nanoparticles volume fraction

The effect of Reynolds number i.e. 10000, 20000, 30000 and 40000 is expressed in the terms of contours.

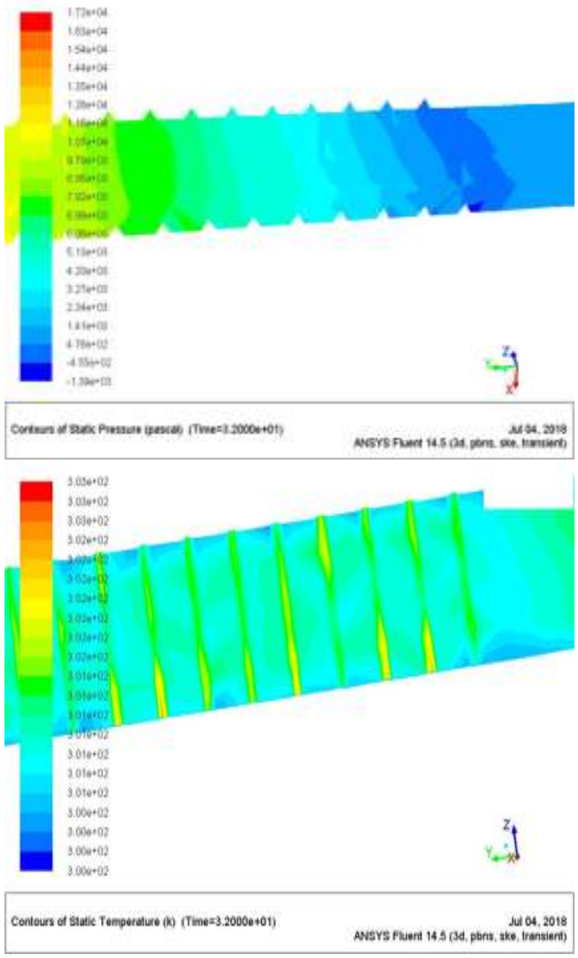
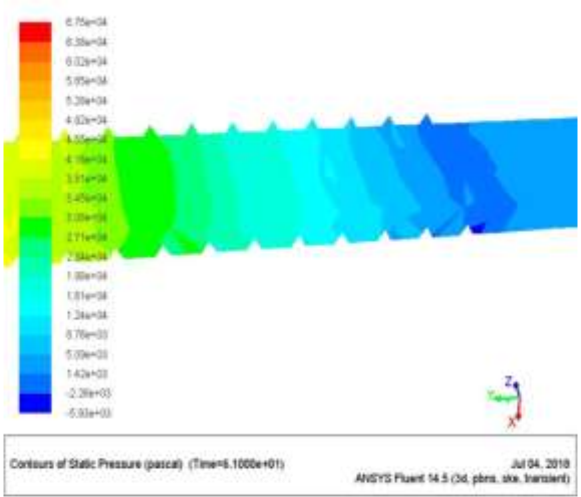


Figure 1.4 Contours of static Temperature and pressure for triangular corrugated at Re=10000



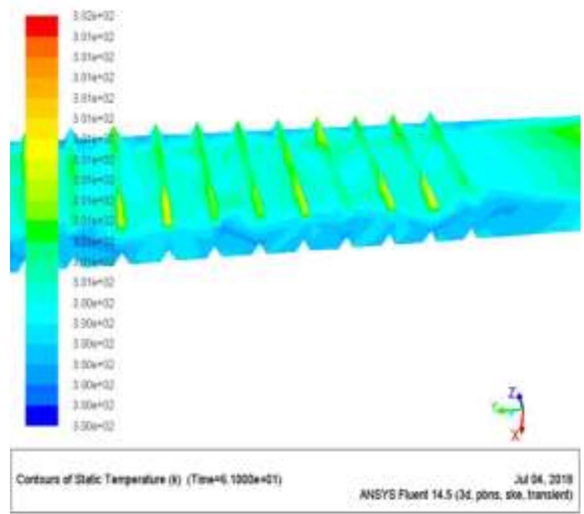


Figure 1.5 Contours of static Temperature and pressure for triangular corrugated at Re=20000

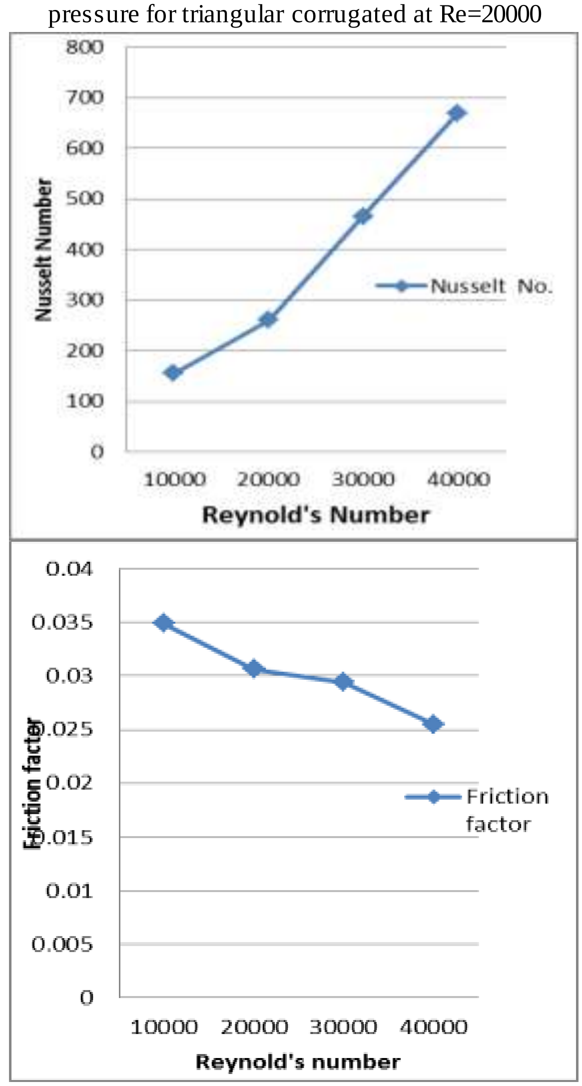


Figure 1.6 Variation in Nusselt number and Friction factor at different Reynold's number

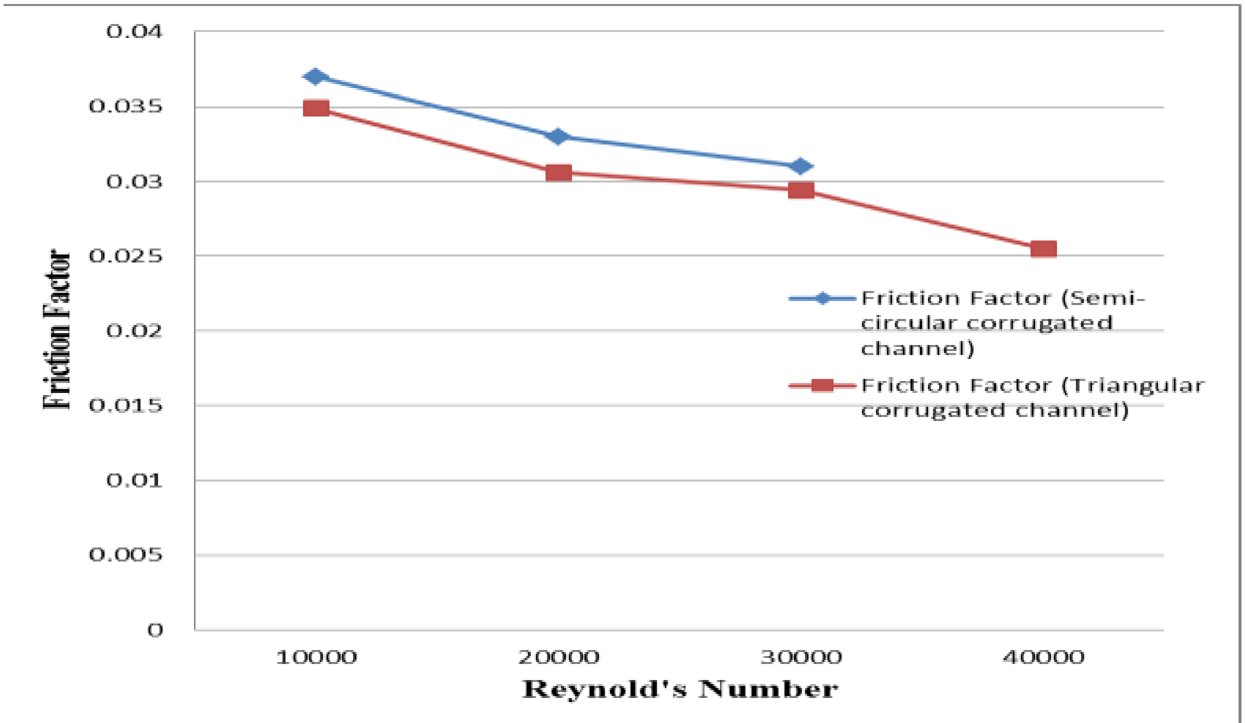


Figure 1.7 Comparison of Friction Factor at different Reynold's number for Semi-circular and triangular corrugated plate heat exchanger

CONCLUSION

CFD simulations of turbulent forced convection heat transfer in a triangular corrugated channel subjected to uniform heat flux were carried out. The computations were performed for a symmetrical triangular corrugated channel with varying Reynolds numbers (10000 ≤ Re ≤40000), volume fractions (6%).Based on the results obtained by the CFD calculations it is found that:

- The results of CFD solution showed that Nu increasing with increase in Reynold's number while Friction factor decreases with increase in Reynold's number.
- From the CFD analysis it has been observed that in case of triangular corrugated plate heat exchanger the Nusselt number increased by 10.71 % as compared to semi-circular corrugated plate heat exchanger.
- From the CFD analysis it has been observed that in case of triangular corrugated plate heat exchanger the Friction factor decreased by 5.67 % as compared to semi-circular corrugated plate heat exchanger.

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