International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 4 Issue 6, September-October 2020 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Numerical Analysis of Corrugated Type Heat Exchanger with Variation in Corrugation Angle

Mukesh Kumar Pandey[1], Himanshu Pandey[2]

[1]Research Scholar, [2]Assistant Professor,
[1,2]Department of Mechanical Engineering, Mansarovar Global University, Bhopal, Madhya Pradesh, India

ABSTRACT
Heat transfer is one of the main concerns in industries. Corrugated type heat exchangers are one of the best options available for heat transfer in less space. Many researchers have worked for corrugated plate heat exchanger with configuration corrugation angle of 30°. In the present work, corrugated plate heat exchanger with 30° corrugation angle has been modeled and results have been compared with that of the base paper. Further the corrugation angle has been changed to 45°. The boundary conditions have been kept same as that for 30°. Heat transfer rate, Nusselt number, Reynolds number, Friction factor, Paclet number and their variation have been found out for the new geometry. Graphical plots, variation in temperature and water velocity streamlines have also been found out.

***KEYWORDS:** Corrugated heat exchanger, heat transfer rate, Friction factor, Nusselt number, corrugation angle*

***How to cite this paper**:* Mukesh Kumar Pandey | Himanshu Pandey "Numerical Analysis of Corrugated Type Heat Exchanger with Variation in Corrugation Angle" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-4 | Issue-6, October 2020, pp.405-409, URL: www.ijtsrd.com/papers/ijtsrd33369.pdf

IJTSRD33369

INTRODUCTION

Heat may be transferred in industries using corrugated type heat exchangers where less space is available. Both, hot and cold fluids in heat exchanger passes through the separating walls, the temperature of hot and cold fluid vary along the length of heat exchanger as they flow. Corrugation in the heat exchanger increases turbulence in the working fluids leading to improved heat transfer rates. With the help of CFD, corrugated type heat exchangers can also be optimized for their performance.

LITERATURE REVIEW

Durmuş, Aydın, et al. [1] discussed the cost aspect of the heat exchangers. Gerard, Claude, et al. [2] has patented design of a plate type heat exchanger having corrugated fin with partial offset. Abou Elmaaty et al. [3] discussed the recent researches being done by various researchers across the globe in the fied of corrugated type heat exchangers. Stasiek, J. A. [4] suggested use of LC sheets and true colour processing techniques for improving design of all compact type of heat exchangers. Faizal and Ahmed [5] experimented for small temperature differences in corrugated type heat exchanger. Kondepudi and Dennis [6] experimentally investigated thermal performance of fin tube heat exchanger with corrugated fins. Khan, T. S., et al. [7] experimentally found out heat transfer for sinle phase flow for various corrugation angles. Hussain et al. [8] discussed about the various research work being carried out to increase the heat transfer rate of heat exchangers. Hussain et al. [9] numerically found out performance analysis of corrugated type heat exchanger. Kanaris et. al. [10] used CFD code for simulating and finding out the performance of plate heat exchanger. Goodarzi, Marjan, et al. [11] experimentally investigated the thermo-physical properties of carbon nano-tube. Kabeel, et al. [12] have considered nano-fluids for performance prediction of plate heat exchangers. Islamoglu and Cem [13] experimentally determined the friction factor and convective heat transfer coefficient for plate heat exchanger. Hasanpour et al. [14] experimentally studied heat transfer and friction factor for double pipe heat exchanger with corrugated tubes. Han, Xiao-Hong, et al [15] used simulation for 3 D temperature, pressure and velocity fields for chevron corrugated type heat exchanger.

GEOMETRY, DESCRITISATION AND BOUNDARY CONDITIONS
Geometry of pressure vessel has been modeled in Solid works and meshing has been done in ANSYS.

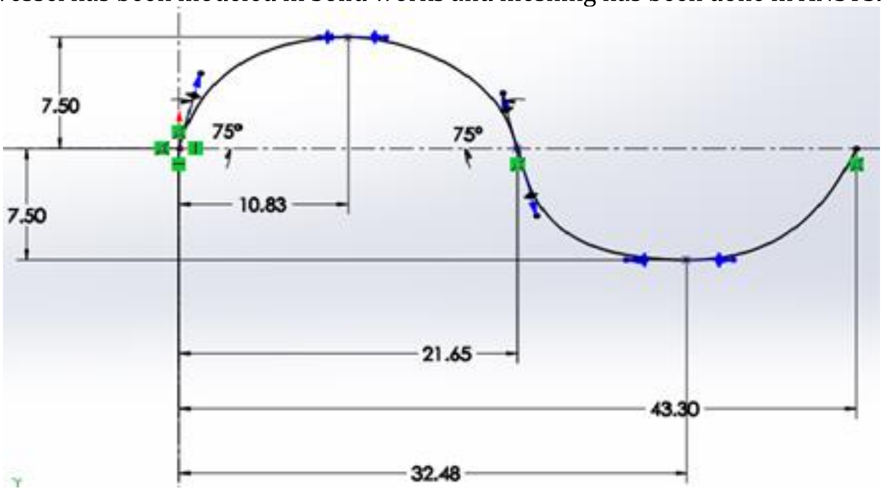

Fig 1: Sketch of corrugated type heat exchanger

After creation of geometry the mesh of the pressure vessel has been generated using the default values.

Boundary Conditions
Outer surface has been considered to be adiabatic. Hot fluid inlet temperature has been considered at 353 K with mass flow rate ranging from 2 to 5 lpm. Cold fluid inlet temperature has been taken as 303 K with mass flow rate of 2 lpm. Outlet pressure for both the fluids is considered to be at atmospheric pressure.

RESULTS AND DISCUSSIONS
Validation of Result
For validation of results geometry with 30 degree corrugation angle has been analysed and results are found to be in good agreement.

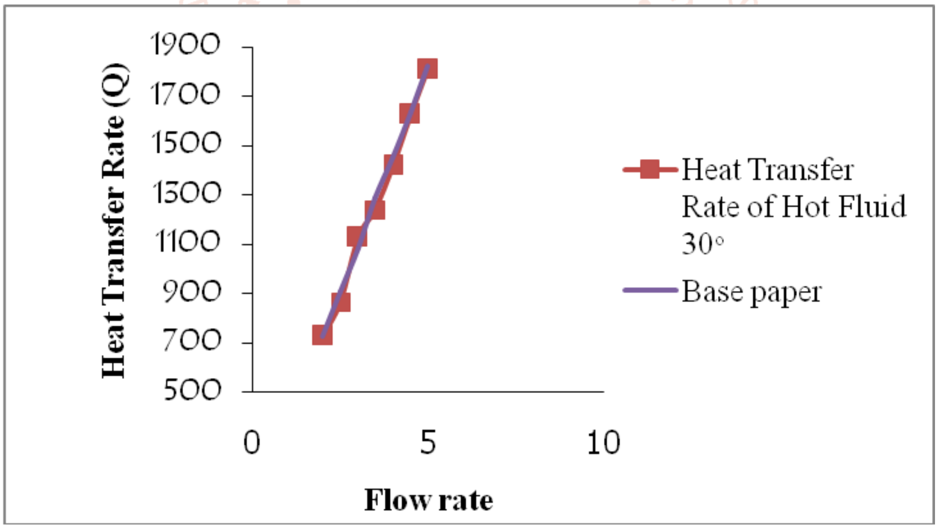

Fig 2: Variation in heat transfer rate of hot fluid with variation in volumetric flow rate

After validation of result for 30° corrugated plate heat exchanger, the corrugation angle has been modified. New angle of corrugation which has been considered is 45̊.

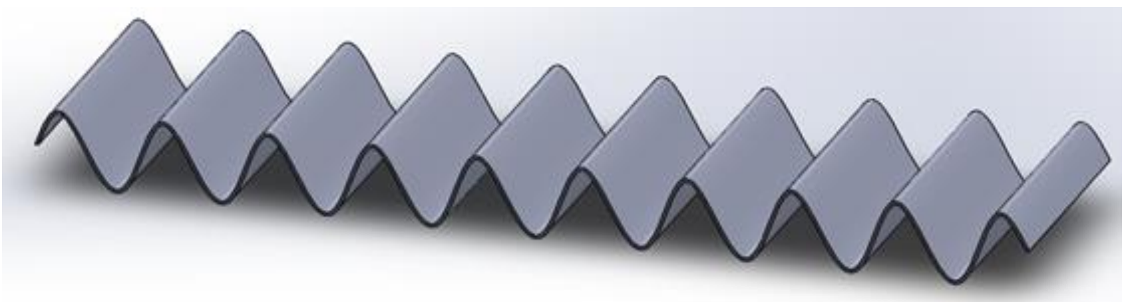

Fig 3: 3 D view of modified plate

Graphical Plots

Graphical plots have been obtained for temperature to visualize the effect of variation in flow rates.

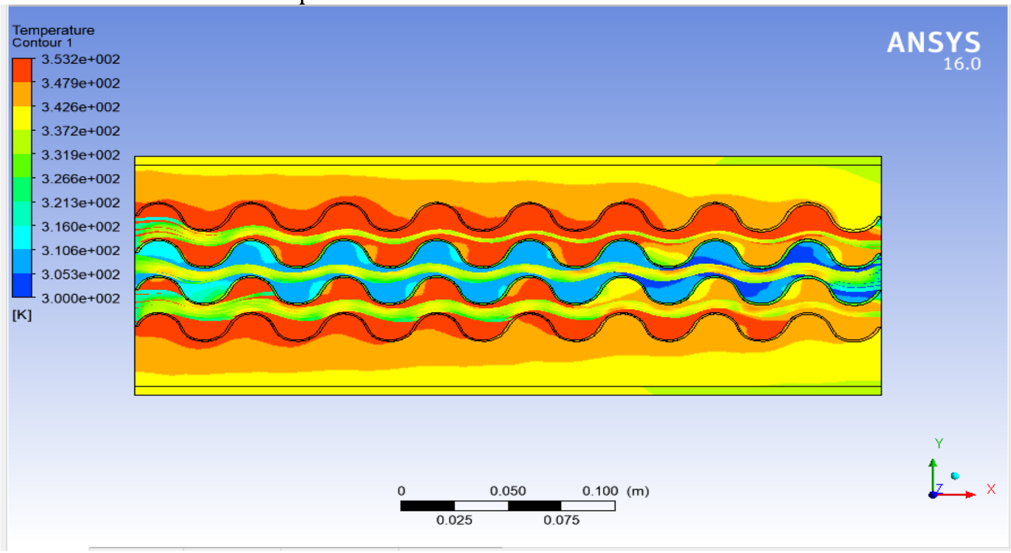

Fig. 4: Temperature contour for 2LPM

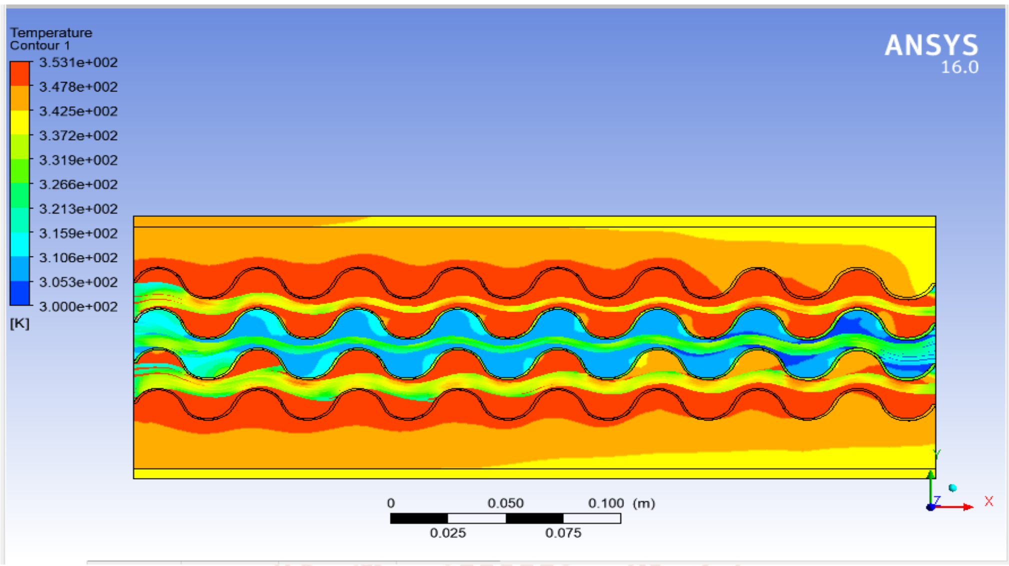

Fig.5: Temperature contour for 3LPM

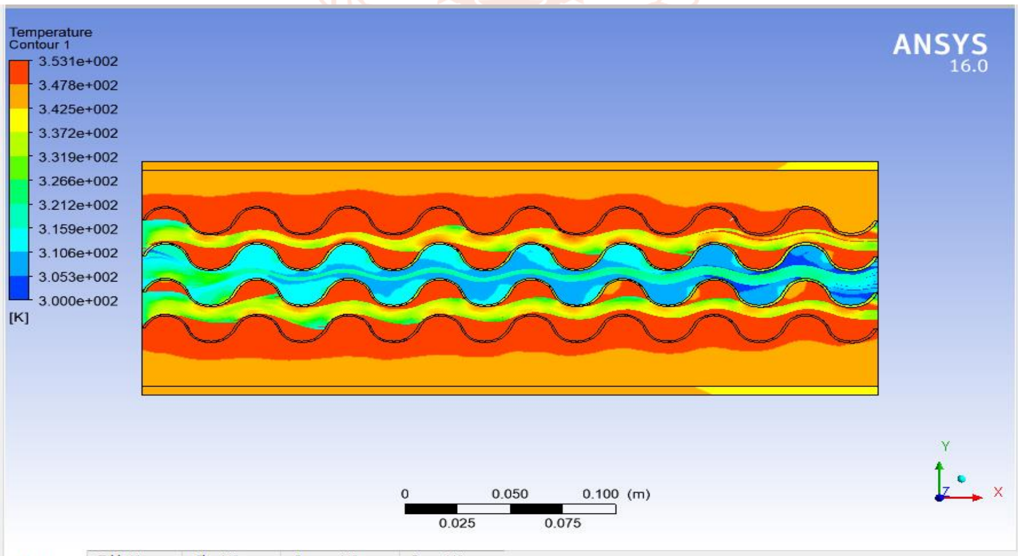

Fig. 6: Temperature contour for 4LPM

From the above temperature contours, it is observed that on increasing flow rate, the higher temperature is obtained on the surface near the exit of the hot fluid. As the flow of hot fluid increases, temperature of the cold fluid rises rapidly than at lower flow rates. Increase in turbulent kinetic energy with the increased hot water velocity can be the possible reason for that.

Velocity Streamlines

Velocity streamlines have been obtained for variation in flow velocity for all the cases

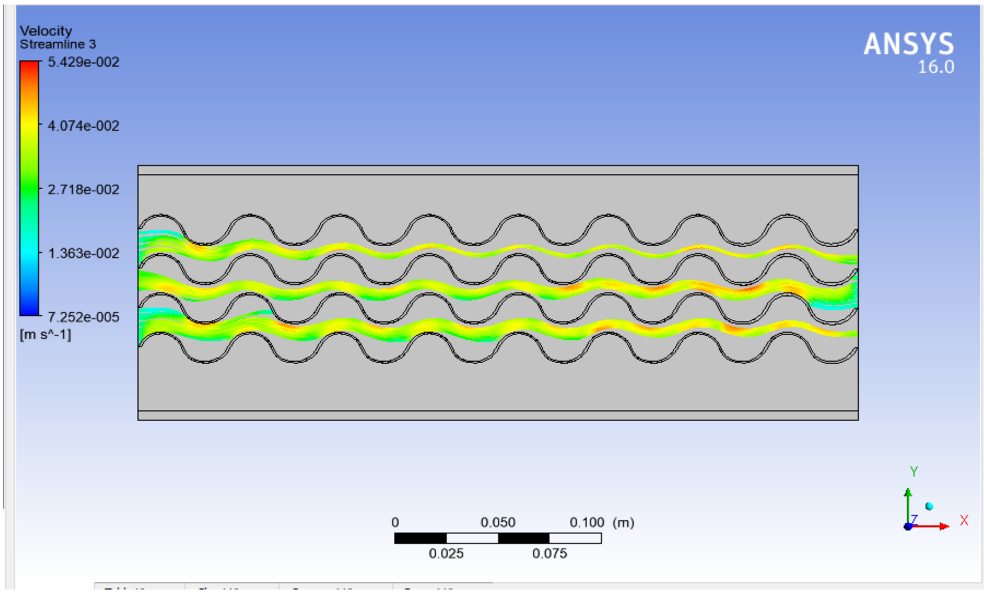

Fig. 7: Water velocity streamline for 2LPM

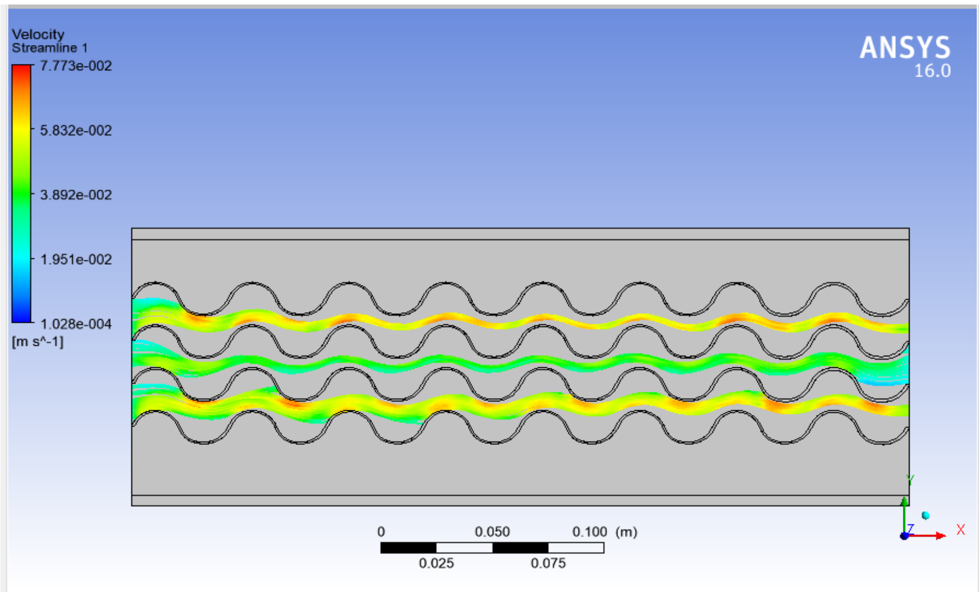

Fig. 8: Water velocity streamline for 3 LPM

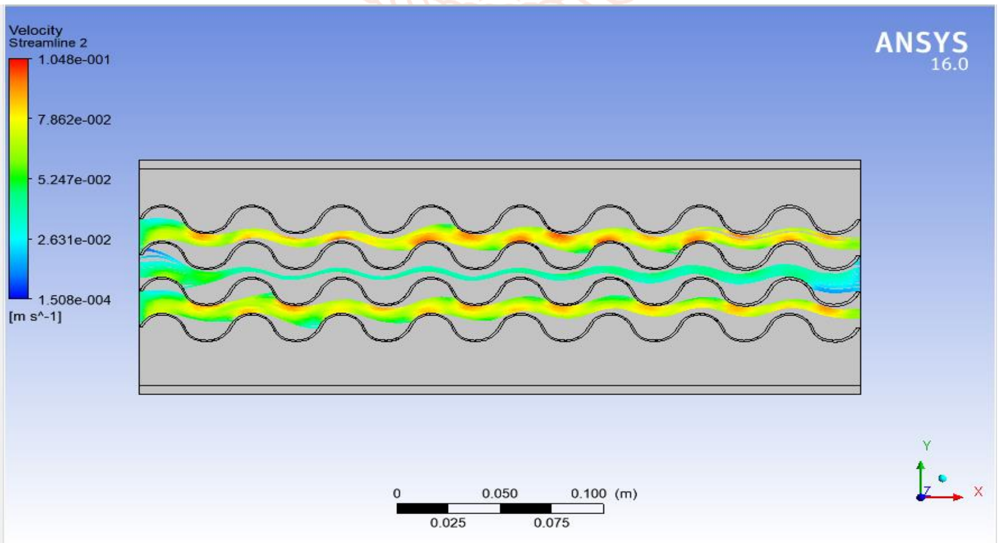

Fig. 9: Water velocity streamline for 5LPM

With increase in flow rates, water velocity increases. It can be observed from water velocity streamlines that water leaves the heat exchanger with lower velocity as compared to the velocity of water at inlet. This can be due to loss of velocity due to friction while flowing from inlet to outlet. With the help of function calculators all the parameters at desired locations have been found out. The obtained values have been shown in figures.

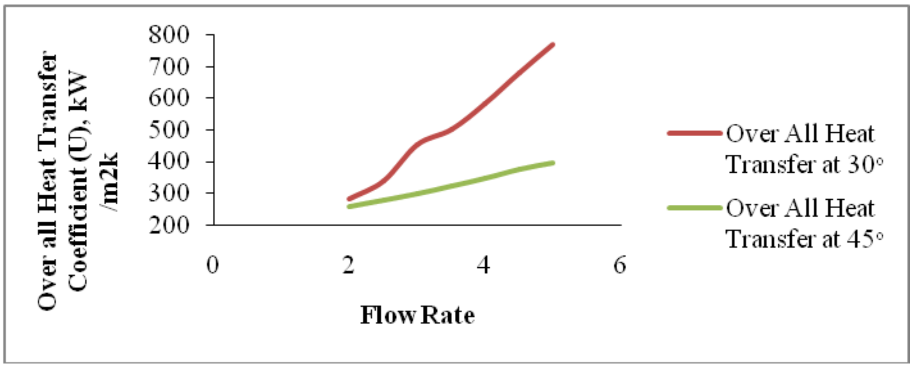

Fig. 10: Change in overall heat transfer with volumetric rate of hot fluid

There is high overall heat transfer coefficient from hot fluid to cold fluid for 30° corrugation angle than 45° corrugation angle.

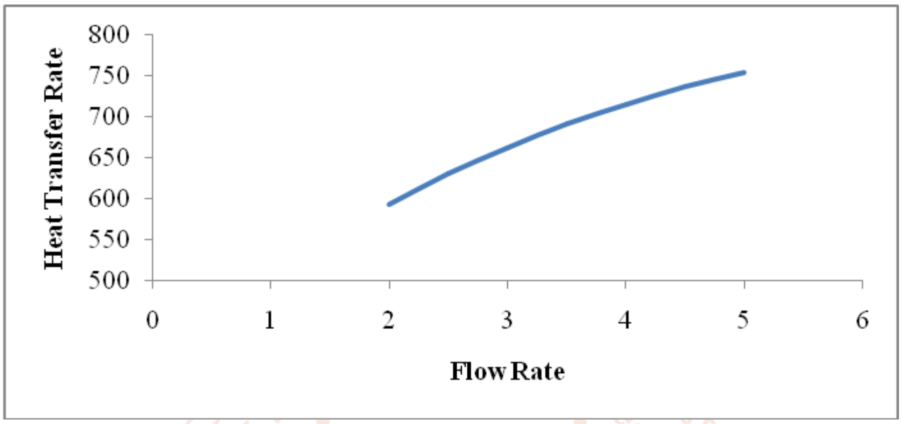

Fig. 5.11- Variation of heat transfer rate with hot water volumetric flow rate

On increasing the flow rate of hot fluid heat transfer coefficient rises. Similar trend has been observed for variation in heat transfer coefficient by Pandey and Nema [12].

CONCLUSIONS

For increase in mass flow of hot fluid, heat transfer rate increases. Heat transfer rate of 45° corrugated plate heat exchanger is lower than heat transfer rate of 30° corrugated plate heat exchanger. Friction factor of 45° corrugated plate heat exchanger is higher than friction factor of 30° corrugated plate heat exchanger. Higher corrugation angle leads to higher turbulence but reduces the effectiveness of the heat exchanger.

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