Journal of Advanced Mechanical Sciences (JAMS)
ISSN: 2583-3790 (Online)
"J. Adv. Mech. Sci., vol. 2, no. 1, pp. 26-30, March 2023"

Studies on the Enhancement of Heat Transfer in the Counter-Flow Heat Exchanger(HX)- A Review

Monu Sharma*
Department of Mechanical Engineering, National Institute of Technology, Tiruchirappalli.
**Corresponding Author Email: 211321015@nitt.edu*
Article received: 10/02/2023, Article Revised: 17/03/2023, Article Accepted: 20/03/2023
Doi: 10.5281/zenodo.7789306

Abstract

Due to the higher requirement for energy in recent times, the most important industry for power generation is the thermal power plant. Due to the higher requirement of heat transfer without any loss from one fluid to another fluid counter-flow heat exchangers play a very important role. In past decades, many researchers attempted to find an effective way to increase the transfer rate from one fluid to another. In this study, we are more focused toward increase the heat transfer rate in the counter-flow heat exchanger (CFHX). In addition, the summary is provided information related to the increased heat transfer rate in counter flow HX.

Keywords: *Heat exchanger, Efficiency, Heat transfer rate, Counter flow HX.*

1. INTRODUCTION

Nowadays heat exchanger is very important not just in thermal power plants but also in chemical, oil, food, cryogenic industry, and waste heat recovery industries also. There are many design aspects associated with an enhancement of heat transfer rate in counterflow(HX) such as the effectiveness of HX, inlet and outlet temperature, efficiency, the material used, number of the transfer unit, overall heat transfer rate, surface area, etc. heat exchanger also used extended surfaces internally and outside due to its higher rate of heat transfer property. When we look back to the twenty-first century. Following that we concentrate mainly onincreasing the heat transfer rate. The study conducted by Vignesh et al [1] for use of nanofluid particles in the counter-flow heat exchanger(CFHX) compared the performance of the heat exchanger with ordinary water, nanoparticles like Al_2O_3(aluminum oxide), and MgO(Magnesium oxide) and they concluded that the heat transfer rate enhancement can be achieved while using nano fluids. In a heat exchanger device, the most important thing is the material used for the construction of the heat exchanger because the material property is also an important property to increasing heat transfer rate this property is known as thermal conductivity which tells us about the transport of energy from one location to another location. Use of heat exchangers also in an electric vehicle, HX are commonly utilized in automobile battery cooling systems, so the classic heat exchanger is frequently installed in it. Due to more size, the heat exchanger used in an electric vehicle is a compact heat exchanger which balances both the condition one is provided cooling to electric appliances, and compact size makes the vehicle low weight so the performance of electric vehicles increases. The main property of the heat exchanger is the outlet temperature of fluids used in the heat exchanger. If the outlet temperature of both fluids is the same, then their performance is also good, which is the prime reason for preferring the counter flow heat exchanger.

2. REVIEW

Vignesh et al. [1]investigated the increase of heat transfer rate with the use of nanoparticles rather than ordinary water in counter-flow heat exchange. The use of mano particles in the water which is about 5% in cold fluids increases the heat transfer rate. The very important conclusion we get from this paper is the mass flow rate of 0.1 kg/sec of aluminum oxides and magnesium oxide has the highest heat transfer rate and also has higher effectiveness. Also the use of nanoparticles of aluminum oxide and magnesium oxide increase effectiveness by about 6-10% good results as compared to ordinary water. Li et al. [2] performed a comparison study between DCPHE and TCPHE. In a TCPHE kind of heat exchanger, the contact between the fluid is more so there is more chance of heat transfer from one fluid to another the reason for higher heat transfer is that the third pipe used in the TCPHE system because it provides higher heat transfer area as compared to DCPHE. In the TCPHE system, another benefit is that it also allows three fluids to transfer heat between them which results in good heat transfer.

Baba et al. [3] studied the uses of the internal fin with nanoparticle fluids that have more heat transfer properties. The results get out from this is only 0.4% use of nanoparticles increases heat transfer rate in the counter-flow heat exchanger by about 95% as compared to ordinary water and plain tube heat exchanger with the condition that the convection process is forced type. The reason to use nanoparticles in heat exchangers is due to their higher thermal conductivity which increases the thermal conductivity of base fluid by about 20-30%. The enhancement of heat transfer using nanoparticles is the nanoparticles having higher thermal conductivity. Raj et al. [4]studied nanofluid particles to enhance the heat transfer rate. The use of nanofluid particles also has the benefit is that it also reduces the pumping power. This shows the results that with the use of nanoparticles, the thermal conductivity increased up to

2-3%. Also, use different types of nanoparticle material to compare with ordinary water. But there is one important characteristic associated with that we also monitor the drop of pressure that takes place in the heat exchanger. So here we are more interested in getting results from different nanoparticles and comparing the results. Chodankar and Seetharamu[5]investigated the performance of a counterflow heat exchanger carried out for a cryogenic counter-flow heat exchanger. The results come out from this study is the number of heat exchanger size. If the number of heat exchanger sizes lies in the range between 9-10 its performance is more efficient. it also tells us about the resistance between fluids must be in the range between 1 and 10 to enhance the heat transfer rate. do Nascimento et al. [6]performed the numerical study of HX in water heat transfer operation. It gives the relation between the performance of the heat transfer surface and the Reynolds number that shows how the flow affects the performance of the heat exchanger. And to compare the results in different types of HX.

Khoshvaght-Aliabadiet al. [7]investigated the improvements in thermal management in mechanical heat exchangers just to central interruption in the tiny channel. The simulation report tells us about the observed experimental data are in good such good agreement that the largest deviation for Nu and friction factor is about 4.1% and 8.8%, respectively. Yadav and Sahu [8]experimentally studied the influence of the Reynold number and Nusselt number on the performance of the counter-flow heat exchanger. These results employ using HSDTs inside an annulus to analyze the heat transmission and features of smooth tube DPHE. The highest performance was found using HSDTs. Khatawate et al. [9] performed the numerical analysis of shell and tube type counter flow heat exchangers (STHX). When compared to ethylene glycol-based heat transfer fluid, the temperature of outlet fluids in shell and tube-type heat exchangers rise up to 227%.Hosseinizadeh et al. [10] developed the numerical model to investigate and simulation is also run in the counterflow heat exchanger. In this study performance of triple pipe heat exchangers subjected to a magnetic field with varying values of Reynold number and magnetic field intensity and nanoparticle volume fraction is also altered in to get data and compare results to increase the heat transfer rate. The performance index rises with an increase in the magnetic field intensity.Aasi and Mishra [11] studied the influence of ambient conditions on the performance of cryogenic three-fluid cross-flow heat exchangers. When this data is compared with insulating conditions the steady-state is experienced at a considerably faster rate under ambient ingression.Mohamed Mousa et al.[12] presented a review paper on the strategy to increase the heat transfer rate in heat exchangers. In this study, the enhancement of heat transfer is altered by deflecting the boundary of a fluid, and increasing the Reynold number means more toward turbulence. The higher the prevalence of these elements the greater the heat transfer takes place.Yao et al. [13] In this study the increased heat transfer rate using molten salt and supercritical carbon-di-oxide because the fluid property is direct alters the performance of the heat exchanger. For higher thermal conductivity the heat transfer coefficient is higher for mild steel than that of SCO_2, therefore heat transfer is close to SCO_2 using this material in ordinary water.A model was proposed by Alaqel et al. [14] in order to conduct an investigation into the direct contact counter flow particle to air heat exchanger. The investigation was carried out with the assistance of two models: one of which involved mixing, and the other of which was a straightforward model. According to the findings of this research, the performance of the heat exchanger may be improved by using a novel design that incorporates a particle-to-air combination. Nguyen and Ahn [15] studied the microscopic or nanoscopic models that increase the heat transfer rate. As we know that heat transfer is more effective in phase transfer compared to the single-phase model. The perspective revealed that single-phase HTC had a maximum enhancement of 95%, while DWC and evaporation had enhancements of more than 8 times and 3 times respectively.

3. CONCLUSION

As a result, from the literature review discussed above the different conditions that will be covered in this study are as follows.

- Nanofluid has a higher effect on heat transfer rate due to its higher thermal conductivity.
- As Reynolds number increases its means that the flow must be turbulent so that an increase in Nusselt number implies an increase in heat transfer coefficient.
- Use of an optimal coolant combination also plays an important role to increase the heat transfer rate.

Acknowledgement/Funding Acknowledgement

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

REFERENCES

[1] Vignesh, T., Gurusami, K., Dhanalakshmi, A., Prasad, A. R., Puthilibai, G., & Suresh, M. (2020). Heat transfer enhancement analysis of Al2O3 and MgO through counter flow in heat exchanger. *Materials Today: Proceedings*, *33*, 4412-4416.

[2] Li, H., Wang, Y., Han, Y., Li, W., Yang, L., Guo, J., ... & Jiang, F. (2021). A comprehensive review of heat transfer enhancement and flow characteristics in the concentric pipe heat exchanger. *Powder Technology*, 117037.

[3] Baba, M. S., Raju, A. S. R., & Rao, M. B. (2018). Heat transfer enhancement and pressure drop of Fe3O4-water nanofluid in a double tube counter flow heat exchanger with internal longitudinal fins. *Case studies in thermal engineering*, *12*, 600-607.

[4] Raj, V. R., Chitradevi, S., Muruganandam, D., Puthilibai, G., Sivaprasad, R., & Dhanalakshmi, A. (2020). Study on nano particles of aluminium oxide and magnesium oxide used counter flow heat exchanger heat transfer, effectiveness enhancement. *Materials Today: Proceedings*, *33*, 4586-4591.

[5] Chodankar, V. A. V. L., &Seetharamu, K. N. (2022). Improved effectiveness of a cryogenic counter-current parallel flow-Three fluid heat exchanger with three thermal communication due to Joule Thomson pressure drop. *International Journal of Thermal Sciences*, *172*, 107267.

[6] do Nascimento, C. A. R., Mariani, V. C., & dos Santos Coelho, L. (2020). Integrative numerical modeling and thermodynamic optimal design of counter-flow plate-fin heat exchanger applying neural networks. *International Journal of Heat and Mass Transfer*, *159*, 120097.

[7] Khoshvaght-Aliabadi, M., Abbaszadeh, A., Salimi, A., &Ghodrati, P. (2022). Effects of central cut on performance intensification of counter-flow integral heat sinks. *Chemical Engineering and Processing-Process Intensification*, *172*, 108811.

[8] Yadav, S., & Sahu, S. K. (2019). Heat transfer augmentation in double pipe water to air counter flow heat exchanger with helical surface disc turbulators. *Chemical Engineering and Processing-Process Intensification*, *135*, 120-132.

[9] Khatawate, V. P., Banapurmath, N. R., Hosmath, R. S., Sanjeevannavar, M. B., &Golabhanvi, S. M. (2022). Experimental and Numerical studies on the Heat transfer characteristics of Small Shell and Tube Heat Exchanger. *Materials Today: Proceedings*, *59*, 1163-1167.

[10] Hosseinizadeh, S. E., Majidi, S., Goharkhah, M., &Jahangiri, A. (2021). Energy and exergy analysis of ferrofluid flow in a triple tube heat exchanger under the influence of an external magnetic field. *Thermal Science and Engineering Progress*, *25*, 101019.

[11] Aasi, H. K., & Mishra, M. (2022). The impact of ambient heat ingression on performance of cryogenic three-fluid cross-flow compact heat exchanger. *International Journal of Thermal Sciences*, *176*, 107494.

[12] Mousa, M. H., Miljkovic, N., & Nawaz, K. (2021). Review of heat transfer enhancement techniques for single phase flows. *Renewable and Sustainable Energy Reviews*, *137*, 110566.

[13] Yao, Y., Ding, J., Zhang, Y., Wang, W., & Lu, J. (2022). Heat transfer performance of pillow plate heat exchanger with molten salt and supercritical carbon dioxide. *International Journal of Heat and Mass Transfer*, *183*, 122211.

[14] Alaqel, S., Saleh, N. S., Saeed, R., Djajadiwinata, E., Sarfraz, M., Alswaiyd, A., ... &Khayyat, A. (2022). Particle-to-fluid direct-contact counter-flow heat exchanger: Simple-models validation and integration with a particle-based central tower system. *Case Studies in Thermal Engineering*, *33*, 101994.

[15] Nguyen, D. H., & Ahn, H. S. (2021). A comprehensive review on micro/nanoscale surface modification techniques for heat transfer enhancement in heat exchanger. *International Journal of Heat and Mass Transfer*, *178*, 121601.