International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

A Brief Review on Advances in Design, Material and Working Fluid of Helical Coil Heat Exchangers

Sunita Mohanty[1], Prof. Nishant Saxena[2]

[1]M.Tech. Scholar, Millennium Institute of Technology, Bhopal
[2]HoD (M.E.), Millennium Institute of Technology, Bhopal

ABSTRACT

Heat Exchangers are one of the important parts of many industries including power plants, food industry, leather industry etc. Heat exchangers are used to extract the waste heat and the utilize that to improve the efficiency. There are various types of heat exchangers and there usage depends upon the requirement where they are being used. Helical coil heat exchangers are one of them which are installed where space is less and have good efficiency. In the present work a jist about usage of helical coil heat exchangers has been presented and it can be concluded that they have proved their importance in industrial fields.

Introduction

Heat exchangers are widely used to extract the waste heat of emitted fluid and transmit it to fresh incoming fluid [1]. There are numerous types of heat exchangers which can be used for various works depending upon the limitation and need of the site. Helical coil heat exchangers are being one of the efficient and requiring less space for installation type of heat exchangers. A lot of advances have been taken place in the world. In present work, a brief review of work done worldwide has been discussed which may form preliminary part for doing research on helical coil heat exchangers.

Literature Review

Sheeba et al., [2] did experimental and numerical investigations on a helically coiled double pipe heat exchanger. Its heat transfer and flow characteristics were studied. Parameters affecting heat transfers were studied. Overall heat transfer coefficients were calculated and Wilson plot was used to find the heat transfer coefficients. Validation of numerical work with experimental has also been carried out. It was found that use of helical coil heat leaded to an enhancement in the Nusselt number. But the friction factor is high for helical coil. The overall heat transfer coefficient varied with pitch and there existed an optimum value of pitch. A correlation has also been proposed to estimate Nusselt number in terms of Dean number, Prandtl number and dimensionless pitch.

Hameed and Hamid [3] utilized various techniques to improve the performance of heat exchangers. Triangular fins were fabricated on the outside surface of the longitudinal helical heat exchanger. The performance of the new heat exchanger was investigated experimentally and mathematically. For the considered design, good enhancement ratio was obtained. Effectiveness improved by 11%, Nusselt number improved by 16.5%. It was concluded that adding fins improved the performance of the heat exchanger and makes the exchanger suitable for industrial applications with better performance.

Rafał, and Muszyński [4] presented the usage of shell and coil type of heat exchanger. The usage includes heating, ventilation, nuclear industry, process plant, heat recovery and air conditioning systems industries. It was clarified that these kinds of recuperators have low value of pressure drop and are simple in construction. The authors also developed their own shell and tube heat exchanger with high heat transfer. The surface of the exchanger was modified to enhance the effectiveness. Steady state conditions were considered for the experimental studies. Experimentation was done for laminar and transient conditions with parallel flow and counter flow conditions. Many number of transfer units analysis was carried out to find optimal heat transfer intensification on the shell-side.

Naik and Vinod [5] investigated heat transfer using three non-Newtonian nanofluids (Fe_2O_3, Al_2O_3 and CuO nanoparticles in aqueous carboxymethyl cellulose base fluid) for shell and helical coil heat exchanger. Nano fluid wqas prepared using nano particles in the concentration range of 0.2- 1.0% by weight. Nanofluid and water were used on shell side and tube side respectively. Overall heat transfer was found out. Parameters such as Nusselt number, at different conditions such as flow rate of cold water (0.5–5 lpm), shell side fluid (nanofluid) temperature (40–60 °C) and stirrer speeds (500–1500 rpm) were varied. It was found out that Nusselt number increase with increasing nanofluid concentration. It was also found that the CuO/CMC-based nanofluid showed better heat transfer than Fe_2O_3 and Al_2O_3 fluids.

Zhend et al., [6] experimentally and numerically studied performance of a high-density polyethylene helical coil heat exchanger which was adopted by a seawater-source heat pump system. Numerical studies for Correlation between Nusselt and Reynolds number were found out to be in agreement with experimental values. Various inlet conditions such as inlet temperature, velocity of intermediate medium, pipe length and diameter, temperature of seawater and icing outside the pipes were varied to study their effect. It was concluded that mathematical models are helpful in designing and optimizing seawater-source heat pump system.

Zarei et al. [7] investigated cold thermal energy storage (CTES) using a helical coil heat exchanger modified with bubble injection. Experimental studies were carried out to examine the impact of bubble injection on Nusselt number, the temperature differences in the storage tank, exergy degradation in the evaporator, and cycle coefficient of performance. It was found out experimentally that bubble injection significantly improved the COP and heat transfer rate from the storage tank, as well as the exergy destruction and Nusselt number.

Bhanvase, et al., [8] enhanced heat transfer with the use of water based PANI (polyaniline) nanofluid for vertical helical coiled tube heat exchanger. Nanofibers were prepared using ultrasound assisted emulsion polymerization method. Then they were dispersed in base fluid with varying concentration to get the desired working fluid. It was found out that heat transfer increased by 10.52% at 0.1% concentration.

Omidi et al., [9] numerically investigated the flow characteristics and heat transfer applications of a helical coil with four different lobed cross sections. Reynolds number has been varied for constant temperature of helical coils (373 K). It was found that exchanger with 6 coils had highest Nusselt number and lowest friction coefficient. It was concluded that coil diameter was the most important parameter which affected the performance of heat exchanger. Nusselt number also increased by 28% on using Al_2O_3-Water nanofluid.

Nilay et al., [10] presented CFD simulation for helical coil heat exchanger for varying mass flow rates. Inlet water was kept at constant temperature. For various geometric variations, parameters such as temperature drop, heat transfer rate, heat transfer coefficient and Nusselt number were found out and compared. It was concluded that heat transfer increased with increase in coil diameter and flow rates.

Reddy et al. [11] discussed the usage of helical coil heat exchangers because of their compactness, larger heat transfer area and high heat transfer capabilities. Helical coil heat exchangers are currently being also used in many industries such as food, power, electronics, environmental, etc. Helical coils are extensively used as heat exchangers due to higher heat and mass transfer coefficients.

Kumar et al., [12] investigated the heat transfer and pressure drop double helical coiled heat exchanger using water nano-fluids with ANSYS 14.5. Laminar flow conditions were used for the analysis for varying concentrations of nano-fluids. The results of simulation were compared with the experimental data. It was found that simulation data was in good agreement with the experimental data. . The common deviation between the Nusselt number and pressure drop of CFD data and the Nusselt number and pressure drop of experimental data are found to be 7.2% and 8.5% respectively.

Conclusion

Computational Fluid Dynamics is one of the best ways to predict the performance of heat exchangers in design phase. Helical coil heat exchangers are one of the most promising kinds of heat exchangers where heat transfer needs to be done in compact places. There is further scope of research for experimental as well as numerical simulation for helical coil heat exchangers for varying parameters and working fluids.

References

1. Nag P. K., Basic and Applied Thermodynamics, Tata McGraw-Hill, 4th Edition, 2014.
2. Sheeba, A., C. M. Abhijith, and M. Jose Prakash. "Experimental and numerical investigations on the heat transfer and flow characteristics of a helical coil heat exchanger." International Journal of Refrigeration 99 (2019): 490-497.
3. Hameed, Vinous M., and Fatima J. Hamad. "Implementation of novel triangular fins at a helical coil heat exchanger." Chemical Engineering and Processing-Process Intensification 172 (2022): 108745.
4. Andrzejczyk, Rafał, and Tomasz Muszyński. "Performance analyses of helical coil heat exchangers. The effect of external coil surface modification on heat exchanger effectiveness." archives of thermodynamics 37.4 (2016): 137-159.
5. Srinivas, T., and A. Venu Vinod. "Heat transfer intensification in a shell and helical coil heat exchanger using water-based nanofluids." Chemical Engineering and Processing: Process Intensification 102 (2016): 1-8.
6. Zheng, Wandong, et al. "Numerical and experimental investigation of a helical coil heat exchanger for seawater-source heat pump in cold region." International journal of heat and Mass transfer 96 (2016): 1-10.
7. Zarei, Ahmad, et al. "Experimental investigation of the heat transfer from the helical coil heat exchanger using bubble injection for cold thermal energy storage system." Applied Thermal Engineering 200 (2022): 117559.
8. Bhanvase, B. A., et al. "Experimental investigation on intensified convective heat transfer coefficient of water based PANI nanofluid in vertical helical coiled heat exchanger." Applied thermal engineering 128 (2018): 134-140.
9. Omidi, Mohamad, Mousa Farhadi, and A. Ali Rabienataj Darzi. "Numerical study of heat transfer on using lobed cross sections in helical coil heat exchangers: effect of physical and geometrical parameters." Energy conversion and management 176 (2018): 236-245.
10. Nilay, Abhishek, Vishal Gupta, and Samarjeet Bagri. "Performance Analysis of Helical Coil Heat Exchanger Using Numerical Technique." International Journal of Scientific Research in Science, Engineering and Technology 3.5 (2017): 152-156.
11. Reddy, K. Vijaya Kumar, et al. "CFD analysis of a helically coiled tube in tube heat exchanger." Materials Today: Proceedings 4.2 (2017): 2341-2349.
12. Kumar, PC Mukesh, and M. Chandrasekar. "CFD analysis on heat and flow characteristics of double helically coiled tube heat exchanger handling MWCNT/water nanofluids." Heliyon 5.7 (2019): e02030.

13. Deshmukh .P, Patil V.D, Devakant.B, 2016. CFD Analysis of Heat Transfer In Helical Coil Tube In Tube Heat Exchanger. 3 Pp 01-08.
14. Pakdaman.M.F, Behabadi.M.A.A, Razi.P, 2013. An empirical study on the pressure drop characteristics of nanofluid flow inside helically coiled tube. 65. Pp 206-213.