A Review of Heat Pipe with Helical Intensifier on Inner Surface using ANSYS Software

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Abstract

Today, the use of various intensifiers is widespread, which are used under certain conditions and heater flow rules. For the development of heat transfer in the shells and tubes of the heat exchanger, circular blades of various types are used: ring, helical, dimple, etc. Rectangular columns are used less often, due to greater hydraulic resistance. The purpose of this work is to do a numerical study on the effect of different heat transfer coefficients on shell and tube heat exchangers, revealing the laws of different coefficients depending on the flow regime. Heat exchangers are used in many heating and cooling processes within different industries. Heat exchanger performance depends in part on the flow and heat transfer characteristics of the fluids within the heat exchanger.

Keywords- heat transfer; numerical study; with twisted-tape inserts; Helical Intensifier.

1 INTRODUCTION

The development of heat transfer allows for more compact heat exchangers or heat exchangers with more power in the same dimensions, but in the development of modern heat exchangers we need to consider the design and size of reinforcements, as well as the flow rules of the heater. In other works, **Bahiraei et al.** studied the dynamics and hydrothermal properties of a three-tube heat exchanger with a hybrid nanofluid containing graphene nanoplatelet–platinum powder. The heat exchanger was equipped with fins mounted on the outside of the inner tube. Based on the heat transfer performance, the height of the upper ribs and the height of the lower ribs were suggested. Also, **Bahiraei et al.** studied the heat transfer and flow of a hybrid nanofluid in a microchannel heat sink equipped with rectangular ribs and secondary channels. The results showed that using nanofluid, ribs and secondary channels improves the heat sink performance.

Bahiraei et al. explored the benefits of using two methods to improve heat transfer simultaneously. These techniques include, using a nanofluid based on biological graphene and using twisted rotating coaxial tapes to improve heat transfer inside the tubes. Optimizing heat transfer in different types of heat exchangers can lead to better heat exchanger performance and thus lowering system cost and size. Different techniques are used to improve heat transfer such as fluted, separate finned and micro, louvered, wire brushes, braided wires, and twisted tapes. The installation of twisted tape in pipes is widespread and is used to improve the transfer of heat to heaters. Use of CFD method can be informative in studying the flow behavior of internal flows that are difficult to obtain with conventional experimental tests. Different studies have been done to achieve the best design and the best heat transfer performance. **Eiamsa-ard et al.** published results from a study to evaluate the thermal performance of a fixed-tube heat exchanger by installing constant-gap twisted tapes as rotating generators. The article also presents a comparison of the results obtained with a full-length twisted tape installation and the development of a mathematical model to simulate the oscillations caused by the constant gapped twist.

Heat transfer efficiency, which plays an important role in reducing CO_2 emissions and saving energy, has received much attention recently. For turbulent pipe flows, commonly encountered in various industrial heating systems, techniques to enhance convective heat transfer include passive, active, and compound types. Passive strengthening methods are more popular than the other two types because of their low cost and efficiency and relatively high temperature. From this point of view, these installations can also be considered as passive flow control strategies. Generating flow fields induced by swirling flow has been suggested as a promising method to enhance heat transfer in pipe flow based on previous theoretical investigations. However, the use of these fittings or flow control techniques can cause high pressures without enhancing turbulent heat transfer if the fittings are not properly designed and placed in the pipe.

A heat exchanger is a device used to transfer heat energy between two or more fluids, at different temperatures. They are used in both, cooling and heating processes.

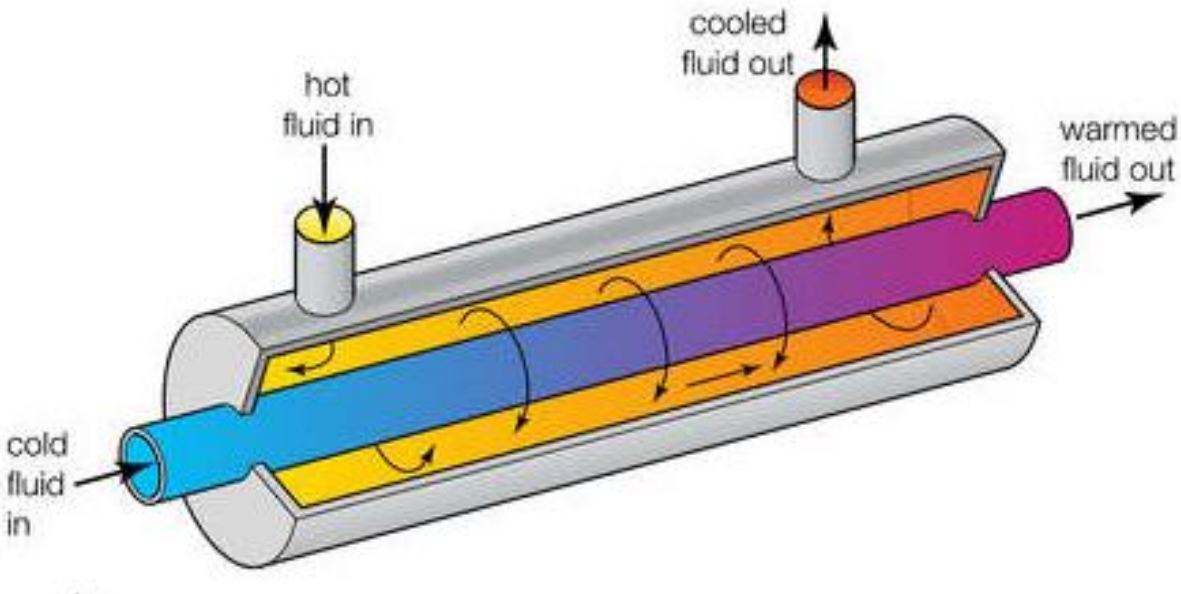

Figure 1 Heat exchanger

2 CLASSIFICATION OF HEAT EXCHANGER

Heat exchangers are devices used to transfer thermal energy from one fluid to another without mixing the two fluids. Fluids are usually separated by a solid wall (with high thermal conductivity) to prevent mixing, or they may mix directly. A classic example of a heat exchanger is found in an internal combustion engine where the engine coolant flows through the radiator coils and air flows past the coils, cooling the coolant and heating the incoming air. In power engineering, common applications of heat exchangers include steam generators, fan coolers, cooling water heat exchangers, and condensers. For example, a steam generator is used to convert feed water into steam from the heat generated in the core of a nuclear reactor. The steam produced drives a turbine.

Heat transfer in a heating system usually involves convection in each fluid and heat conduction through a wall separating the two fluids. In the analysis of heat exchangers, it is often convenient to work with the overall heat transfer coefficient, known as the U-factor. The U-factor is defined by an expression like Newton's law of cooling. Heat exchangers are classified according to the flow system and the type of construction. A simple heat exchanger is one in which hot and cold fluids move in the same or opposite direction. This heat exchanger consists of two fixed pipes of different diameters.

1. Parallel-flow arrangement- In a parallel flow system, hot and cold fluids enter at the same end, flow in the same direction, and leave at the same end.
2. Counter-flow arrangement- In a counter flow system, the hot and cold fluids enter at opposite ends, flow in opposite direction, and leave at opposite end.

Under comparable conditions, the heat is transferred through the counter-flow system is more than the parallel flow heat exchanger. The temperature profiles of the two heat exchangers show a large relative flow anomaly. The heat transfer area in the heat exchanger can be arranged in several ways. Therefore, heat exchangers are also classified as:

2.1 DOUBLE PIPE HEAT EXCHANGERS

Two-pipe heat exchangers are cheap in both design and maintenance, making them a good choice for small industries. In these heat exchangers, one fluid flows inside the tube and the other fluid flows outside. Although they are simple and cheap, their low efficiency coupled with the large space taken up on large scales, has led modern industries to use high efficiency heat exchangers such as shell and tube heat exchangers.

2.2 SHELL AND TUBE HEAT EXCHANGERS

Shell and tube heat exchangers in their various construction configurations are probably the most common and commonly used basic heat exchangers in the industry. Shell-and-tube heat exchangers are further classified according to the number of shells and tubes involved. Shell and tube heat exchangers are generally used for high-pressure applications (with pressures greater than 30 bar and temperatures greater than 260 °C). This is because shell and tube heat exchangers can withstand high pressures due to their shape. In this type of heat exchanger, number of small perforated pipes are placed between two tube plates and the main fluid flows through these tubes. The tube bundle is placed inside the shell and the secondary fluid flows through the shell and over the tubes. In nuclear engineering, this design of heat exchangers is widely used as a steam generator, which is used to convert feed water into steam from the heat generated in the core of a nuclear reactor. To increase the amount of heat transfer and the energy produced, the area of the heat exchanger should be increased. This is achieved by using tubes. Each steam generator can contain anywhere from 3,000 to 16,000 tubes, each approximately 19 mm in diameter.

2.3 PLATE HEAT EXCHANGERS

A plate heat exchanger is a type of heat exchanger that uses metal plates to transfer heat between two fluids. This system is popular for variables using air or gas and low velocity fluid flow. A classic example of a heat exchanger is found in an internal combustion engine where the engine coolant flows through the radiator coils and air flows past the coils, cooling the coolant and heating the incoming air. Compared to shell and tube heat exchanger, the stacked plate arrangement generally has lower volume and cost. Another difference between the two is that plate exchangers generally provide low to medium pressure fluids, compared to the medium and high pressures of shell and tubes.

3 LITERATURE REVIEW

Ibrahim et al. 2014, reported the thermohydraulic performance of a tube equipped with conical-ring bundles of three different forms: convergent, convergent-divergent and divergent conical-rings. They observed that the ideal temperatures of these tubes were up to 3.3, 4.19 and 7.65 times those of the empty tube. Additionally, the highest thermohydraulic performance index, 1.29, was achieved by using different conical-rings with d/D = 0.4 and PR = 2.0 at a Reynolds number (Re) of 6000. They report that it is a circular type turbulator with a pitch ratio (PR) of 2.0 and angle ratio of 0.125 resulted in higher heat transfer rate and friction factor, which were 4.16 and 5.11 times respectively of the hollow tube while the thermohydraulic performance index was as high as 2.9 times.

Yadav and Sahu, 2015, investigated the influence of helical surface disc turbulators on thermohydraulic performance characteristics. The turbulators used in this work had diameter ratios of 0.42, 0.475 and 0.54, and helix angles of 20◦, 30◦ and 40◦. The turbulator with the smallest diameter ratio (0.42) and the largest helix angle (40◦) gave the highest heat transfer ratio. The thermohydraulic performance factors of all tubes with helical surface disc turbulators were greater than unity, indicating energy saving potential.

Nalavade et al. 2015, reported the heat transfer rate of heat tubes with flow divider type turbulators installed. The results of pitch ratios (0.54, 0.72 and 1.09) and twist angles (45◦, 30◦ and 90◦) were evaluated. They found that turbulators with twist angles of 30◦ and 45◦ increased the heat transfer by about 1.6 and 1.46 times that of the bare tube, respectively. **Vaisi et al. 2015**, studied the heat transfer behavior of tubes with continuous and discontinuous twisted turbulators installed. They reported that the discontinuous turbulator had better heat transfer enhancement with lower pressure loss than the continuous turbulator.

Rinat Misbakhov et al. In 2015, reported on strengthening heat transfer research with numerical methods, Research on numerical modeling of shells and tubes heat exchanger with helical, dimple, ring, and semiring breaks was carried out. The use of intensifiers result in an increase in heat flow throughout the heater's flow range. The greatest effect of intensifiers is seen in ring intensifiers, but they also increase hydraulic resistance. The heat flux enhancement for helical, dimple, and semiring intensifiers are nearly identical.

Alimoradi et al. 2016, reported the improvement of heat transfer in rectangular channels where curved turbulators were installed. They found that 90◦ turbulators gave thermohydraulic performance factors of up to 1.62. **Sheikholeslami et al. 2016,** investigated heat transfer rates in a circular tube in which multiple helical tapes were inserted. In this study, the tapes helped to reduce thermal irreversibility by up to 90% at a barrier ratio of 0.098. **Keklikcioglu et al. 2016,** analyzed the entropy production of a heat exchanger tube equipped with diverging/converging-diverging/converging wire wrapped by using ethylene glycol and water mixtures as test fluids. Their results showed that the heat exchanger tube equipped with flexible coiled wires gave higher values of entropy generation than other coiled wires. They also reported that a low entropy generation number of 0.42 was obtained by using pure water as the test fluid in a heat exchanger tube mounted on a coiled deflector wire.

Mangrulkar et al. 2017, reported the development and improvement of the thermal performance of the flow heat exchanger by combining the vortex generator (VG), fin embedding and tube cross-section modification. **Lu et al. 2017,** investigated the effect of surface roughness on the heat transfer characteristic and flow structure in a microchannel with different types of wavy, square and dimple channels. They reported that the dimple channel resulted in higher heat transfer and pressure loss than other types of channels. **Outokesh et al. 2017,** conducted experiments to study the heat transfer and thermal performance of a circular tube lined with curved tapes with various lengths of curved tapes. Their results showed that the highest thermal efficiency of 28% was for the curved tape with a 5 mm curve operating at a Reynolds number of 20,000.

Masoud Outokesh, et al. 2020, reported numerical evaluation of the effect of using a twisted tape with a curved profile as a turbulator on the improvement of heat transfer in a pipe, A study was conducted to investigate the thermal performance of turbulent fluid flow and heat transfer through a circular tube with curved tapes. The geometric parameters considered are length and height ratio and curvature of the curved tapes. It was seen that by increasing the height of the twist, the swirl flow increases the strength of the tube, and the heat transfer increases. Increasing the pitch ratio, increases the heat transfer but the pressure drop is a problem. Optimum curvature is preferred for better heat transfer.

M. Pimsan, et al. 2021, reported enhanced forced heat transfer in tube heat exchangers using serrated ring turbulators, studying heat transfer, friction factor, and thermohydraulic performance index for changing Re, PR, and serrated-diagonal ring angles. Tubes with smaller diagonal angles with a serrated ring produced better heat transfer. The friction factors decrease with higher values of Re due to the acceleration of the liquid when it enters the heating test section. Ring piles with smaller diagonal angles resulted in higher friction factors.

Zhiqiang Sun et al. 2021, reported experimental and numerical study of turbulent heat transfer in a circular duct with curved winged vortex generators, Studying the characteristics of turbulent fluid flow inside a duct with vortex generators of various diameters and PR. In the same dynamic aircraft, wider wings greatly aid in fluid mixing resulting in more mass and power transfer. With decreasing PR, the regions of high turbulence kinetic energy gradually move to the smooth flow region and the TKE in both the smooth flow region and the regions near the walls become stronger, which means better mass and energy transport. **Ahmed Ramadhan Al-Obaidi et al. 2021,** reported a study of flow characteristics, pressure drop, and thermal conductivity in a horizontal pipe with and without twisted tapes. A study was conducted to compare the flow characteristics with three cross-sectional area twisted tapes and without the application of twisted tape. The installation of the twisted tape caused flow and swinging and cross mixing in the pipe. The pressure drop through the pipe with the insert was greater than the pipe without the insert. The temperature drop was more pronounced in the wide section tape.

4 CONCLUSIONS

The objective is to study flow characteristics such as temperature drop and pressure drop from inlet to outlet of one, two, and three helical intensifiers in the inner surface of a heat pipe, using ANSYS Software.

- Temperature Drop Variations
  1. Variation across the cross-sectional area.
  2. Variation across the varying volume flow rate.
  3. Variations with the constant wall heat fluxes.
- Pressure Drop Variations
  1. Variation across the cross-sectional area.
  2. Variation across the varying volume flow rate.
  3. Variations with the constant wall heat fluxes.

REFERENCES

1. Ahmed Ramadhan Al-Obaidi, Issa Chaer; 2021, Study of the flow characteristics, pressure drop and augmentation of heat performance in a horizontal pipe with and without twisted tape inserts
2. Ermakov, A.M., M.V. Gureev and R.R. Salakhov, 2011. Design development of radiators made of plastic injection for the production using molding machines. Tatarstan Energetics, 1: 33-36.
3. Gortyshov Yu.F., Misbakhov R.Sh., V. M. Gureev, I. F. Gumerov, A.P. Shaikin Influence of fuel hydrogen additives on the characteristics of a gaz-piston engine under changes of an ignition advance angle, Russian Aeronautics, (Iz.vuz) 2009, Vol.52, No. 4 pp 488–490.
4. I.A. Popov and A.V. Schelchkov, 2009. Thermal-hydraulic efficiency of the promising methods for heat transfer enhancement in channels of heat exchange equipment. Center for Innovative Technology, pp: 531.
5. I.A. Popov, 2006. The scientific basis of calculations of highly efficient compact heat-transfer apparatuses with judicious heat-transfer intensifiers. Source of the Document Thermal Engineering (English translation of Teploenergetika), 53(4): 249-261.
6. I.A. Popov, R.D. Amirkhanov, et al., 1998. 11th International Heat Transfer Conference, pp: 83-88.
7. M. Pimsarn, P. Samruaisin, P. Eiamsa-ard, N. Koolnapadol, P. Promthaisong, S. Eiamsa-ard; 2021, Enhanced forced convection heat transfer of a heat exchanger tube utilizing serrated-ring turbulators.

8. Masoud Outokesh, Seyed Soheil Mousavi, Ajarostaghi, Ali Bozorgzadeh, Kurosh Sedighi, 2020, Numerical evaluation of the effect of utilizing twisted tape with a curved profile as a turbulator on heat transfer enhancement in a pipe.
9. Rinat Misbakhov, Nikolai Ivanovich Moskalenko, Victor Mihaylovich Gureev, Andrey Mihaylovich Ermakov; 2015, Heat transfer intensifiers efficiency research by numerical methods. Life Sci J 2015;12(1s):9-14] (ISSN:1097-8135) http://www.lifesciencesite.com.
10. Zhiqiang Sun, Qiang Chen, Nianben Zheng; 2021, Experimental and numerical studies of intensified turbulent heat transfer in the round pipe with curved wing vortex generators.