Heat Transfer Enhancement Technique in Heat Exchanger: An Overview

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Abstract: **Heat exchanger is used in different industries to heat transfer enhancement purpose. This paper studies the different heat transfer enhancement technique, to find out the some new technique for enhancement of heat transfer rate.**

Introduction

The energy conservation is one of the most vital issues in current century, and it will certainly be one of the most significant challenges in the near future. Therefore, scientists are considerably trying to address this important concern. The advances made in heating or cooling in industrial devices cause energy saving and heat transfer improvement, and increase the operational life of the equipment. Energy savings can be performed by the efficient use of energy. Energy conversion, conservation and recovery are some routes for energy saving.

To above mentioned purpose, various types of heat exchangers are utilized in many industrial areas such as power plants, nuclear reactors, petrochemical industry, refrigeration, air-conditioning, process industry, solar water heater, food engineering, and chemical reactors. Heat Exchanger is a device which is used for effective Transfer of heat energy between two fluids with maximum rate and minimum operating cost. The heat transfer in the heat exchanger in the form of latent heat (e.g. in boiler and condenser) or sensible heat (e.g. heater or cooler), it depends on the Fluid medium, space available, applied pressure, heat transfer rate and mass flow rate.

Different technologies are employed to improve the efficacy of heat exchangers. There are so many arrangements are used such as different tube shape, tube with fins , corrugated tube, insertion in tubes, baffle arrangements and Nano fluid and find out the better technique used for enhancement heat transfer rate.

This review article attempts to present the developments in use of different strategy used to enhance heat transfer rate in heat exchangers, and identify shortcomings and challenges.

At first, the review focuses on the investigations conducted on the different approach used to enhance the heat transfer rate in heat exchanger and finally find out predict a new approach to enhance heat transfer rate in double tube heat exchanger.

Review of Literature

The purpose of this section is to provide a review of the past research efforts such as journals or articles related to heat Exchanger also review of other relevant research studies are used to provide more information in order to understand more on this research. There are so many arrangements are used and studied done to get better heat transfer rate such as different tube shape, tube with fins, corrugated tube, insertion in tubes, baffle arrangements and nano - fluid are used to enhance the heat transfer rate. There arrangements are used for obtain different purpose like increases the contact surface area of hot and cold fluid by for increase heat transfer rate, baffle inclination and tube orientation for decrease pressure drop. When tube used with fins or corrugated surface then the heat transfer rate is improve but the it also increase

The pressure drop and also when we increase the baffle inclination so pressure drop decrease but it also decreases the heat transfer rate.

Heat transfer enhancement techniques may be divided in two types - active and passive techniques. In first, active techniques require external forces, e.g. electric field, acoustic or surface vibration, etc. Yang Xia [1] experimental studied of active technique in which the electro hydro dynamics (EHD) effect is used, which is the couple effect of the electric field, flow field and thermal field, to enhance the performance of the shell and tube heat exchanger. EHD effect was generated by the strong electric field applying through the fluid of heat transfer surface. In the experiment, DC high voltage electrode range of 0 – 40 kV was set in central tube side of the heat exchanger. The convective heat transfer can be enhanced by applying high electric field. The performance of EHD-enhanced is sensitive to the variation of flow rate, and in the same flow rate, there exist an optimized voltage in the EHD-enhanced process rather than the monotonic positive-correlation relationship.

In Second, passive techniques require fluid additives or special surface geometries. There are so many works on passive technique which is based on different types of tube and changes in their geometries; changes in fluid used etc. which is described below,

1**. Different tube coils:** Different types of tubes coils are used to increase the heat transfer rate, which slow the flow rate and turn increase the contact area in small distance. Curved tubes, helically coiled tubes, spirally coiled tubes, and other coiled tubes is used by the Paisarn Naphon [2] to enhance the heat transfer in heat exchanger and it is the most widely used tubes in several heat transfer applications. In this method, describe on heat transfer and flow characteristics of single-phase and two-phase flow in curved tubes and also describe the use of three main categories of curved tubes; helically coiled tubes, spirally coiled tubes, and other coiled tubes.

2. Tube in which dimple identifed : Dimples is identiffied in the tube which retard the flow and also increase the cross sectional area that reason the heat transfer rate is increases. But only draw back is the dimple may be store slug so time to time maintenance required. Mr. B. Vijayaragavan [3] used the different shapes of dimples are identified in the tubes and performances are comparison with other techniques. The studied is carried out in CFD and verified by the experimental results. This method improves the heat transfer rate by creating turbulence in the flow at a minimum pressure drop.

3. Tube with Extended surface: To increase the heat transfer rate they are used the tube with extended surface that reason they are used the different types of tube like
i. Corrugated tube
ii. Micro fins tube
iii.Single groove tube
iv. Multi Groove tube
This tubes increases the contact surface of the fluid that reason heat transfer rate is increases. Some of the experimental cases discuss below, experimental Study of heat exchanger in different types of copper tube like, smooth, corrugated and with micro-fins by R. Hosseini et al. [4] for an oil cooler which used in a power transformer for calculating heat transfer coefficient and pressure drop and result compared with theoretical data collected and also provides the correlations between pressure drop and Nusselt number for the three tube types. This compares result show that micro-fins tube provide the better performance than others. To improve the performance of the micro fins, Mr. L. J. Brognaux et al. [5] experimental studied done in the single-grooved and crossed grooved micro-fin tubes used for tube side condensation and evaporation. This study was conducted for turbulence flow and the result found that cross-grooved tube provides higher performance. Y.S. Chen et. al. [6] used a concentric tube heat exchanger with transversely grooved tube in which molten salt use as the hot fluid flowing through the inner tube and compare the with smooth tube and they find that this tube provide the better heat transfer.

4. Tapes insertion in Tubes: In this method tapes insertion is used inside the tube to increase the heat transfer rate by retard the motion of flow of fluid. Smith Eiamsaard et. al. [7] is helical tapes insertion is used inside the tube to generating swirl flow that helps to increase the heat transfer rate. They are used the two types of swirling flow devices use for experimental purpose: (1) the full-length helical tape with or without a cantered-rod, and (2) the regularly-spaced helical tape, are inserted in the inner tube of a concentric tube heat exchanger. This experimental result compares with plain tube and found that the use of helical tapes leads to a higher heat transfer rate over the plain tube. The full-length helical tape with rod provides 10% higher heat transfer rate than that without rod but it increased the pressure drop. This work is extented by the Smith Eiamsaardet. al. [8], in which they are study of insertion of a helical screw-tape with or without core-rod in a concentric double tube heat exchanger. The stainless steel helical screw-tape has the with the 4 mm clearance to the tube wall is used with a loose-fit. This experimental setup hot fluid was entered in different range of Reynolds no. and find out the effect of the loose-fit helical tape with or without core-rod, is inserted in the inner tube of the heat exchanger and they found that for the loose-fit, helical tape without core-rod, the friction factor is around 50% less than that for the one with core-rod while the Nusselt number is about 50% higher. Furthermore, the enhancement efficiency of the helical screw-tapes varies between 1.00 and 1.17, 1.98 and 2.14, for the tapes with and without core-rod, respectively.

Another method in which plain tube with twisted wire brush inserts in double pipe heat exchanger is used by Deepali Gaikwad et.al. [9]. This provides the better heat transfer compare to plain tube and Smith Eiamsaard [10] used the regularly spaced twisted tape elements in double tube heat exchanger for experimental investigation. Stainless steel strips of 1 mm thickness were used to made twisted tapes the length of 1500 mm. Twisted tube was inserted in two different case which was (1) full-length typical twisted tape at different twisted ratios (y =6.0 and 8.0), and (2) twisted tape with various free space ratios (S=1.0, 2.0, and 3.0). The result compares with exchanger without twisted tape and found that the heat transfer coefficient increased with twist ratio.

5. Swirl Vanes used : In this method the swirl vanes is used in the flow path of the fluid which create the swirl flow that incrase the friction that reason heat transfer rate is also increases. Mahmoud GalalYehia [11] studied focus on the effect of friction characteristics of the heat exchanger model when using different number of swirl vanes at different locations along the pipe length to enhance the heat transfer rate. When increase the no of swirl vanes so heat transfer rate is also increases.

6. Phase change materials, Micro Encapsulated PCM (MEPCM): as we know that Phase change materials (PCMs) are “latent” heat storage materials. Normally, the thermal energy transfer occurs when a material changes from their phase i.e. solid to liquid or liquid to solid. Both Organic and inorganic group's materials are two most common groups of PCMs. Organic materials are which is described as paraffin and non-paraffin. Most of organic PCM are non-corrosive and chemically stable or no sub-cooling and have a high latent heat per unit weight and low vapour pressure and disadvantages in low thermal conductivities, high changes in volume on phase change and flammability. In inorganic materials have a high latent heat per unit volume and high thermal conductivities, and are non-flammable and low in cost in comparison to organic materials. However, they are corrosive to most metals and suffer from decomposition and sub-cooling, which can affect their phase change properties. Therefore, to overcome these problems, a new technique of utilizing microencapsulated phase change material (MEPCM) in thermal energy storage system has been developed. The main merits of MEPCM over PCM are as follows:
(1) Increasing heat transfer area;
(2) Reducing PCMs reactivity towards the outside environment and controlling the changes in the storage material volume as phase change occurs. Samira Mehravar et al. [12] used the microencapsulated PCM (MEPCM) slurry used as cold fluid, and used

the Latent heat thermal Energy storage technique for demonstration of advantages of supplying higher energy storage density in a smaller temperature difference between retrieval and storage. They investigated effect of using Microencapsulated Phase change material (MEPCM) slurry on temperature of hot and cold fluid. Phase change material (PCM) has an ability to change its phase in certain temperature limit. Properties of MEPCM and water considered temperature dependent. They used the MEPCM slurry for different volume fractions and result found that using 25% volume fractions of MEPCM increase the fluid temperature. When compare rate of temperature change with water its increases up to 23.5% in hot fluid and decreases up to 9% in cold fluid.

7. Heat Transfer Fluid (HTF): Heat transfer fluid is manufactured from highly refined petroleum, synthetically formulated hydrocarbons. It is able to provide the high temperature at very low system pressure. It is mostly used for solar plants. F. Fornarelli et al. [13] numerical examined a latent heat storage system for Concentrated Solar Plants (CSP) with the help of CFD simulation. This study was conducted to identify the convective flows produced within the melted phase by temperature gradients and gravity. In this study the simulations is done with the help of experimental devices for applications to high temperature concentrated solar power plants. The vertical cylindrical tank which is filled by a Phase Change Material (PCM) and Heat Transfer Fluid (HTF) flow from the top to the bottom inside the steel tube is used to design an experimental device of Shell and tube heat exchanger. Unsteady Navier-Stokes equations are used to analysis the conjugate heat transfer process for the HTF and PCM and conduction for the tube and also used Boussinesq approximation to considering buoyancy effects in the PCM tank. The results show that the enhanced heat flux, due to natural convective flow, reduce of about 30% the time needed to change the heat storage. This study provides the detailed description of the convective motion in the melted phase and the heat flux distribution between the HTF and PCM

8. Nano Fluid: In the increase the heat transfer rate, nano fluid is used in which particles of nanometre-size (normally less than 100 nm) are used instead of micrometre-size for dispersing in base liquids is called nano fluid. Their are so many types of nano fluid is used. In which some of the follows:

- Al_2O_3 + water
- CuO + water
- TiO + water
- CH_3CH_2OH + water

It enhanced the heat transfer rate because it provides the higher possible thermal properties (high thermal conductivity , viscous) and stable. J. Albadr et al. [14] studied Al_2O_3+water nanofluid in different concentration and find out the conductive heat transfer coefficient is higher than base liquid at same mass flow rate at same inlet temp and heat transfer coefficient of nano fluid is also increases in increase the concentration of Al_2O_3 in base liquid.

Conclusions: These arrangements enhance the heat transfer but also pressure drop as well as increase the cost of heat exchanger also decreases the mass flow rate. And some increase the maintenance cost due to scale and slug formation. In this To Avoid this losses and to improving the heat transfer rate, different types of tube geometry is used which increase the heat transfer rate by increasing surface area of the tube without pressure drop.

The current contribution attempted to present a comprehensive review of assessments carried out to enhance of heat transfer on different arrangements used in Double tube heat exchangers.

1. In the researchers are mainly work on the passive technique, in which they increases the area to improve the heat transfer rate by the use of dimples, fins in the tubes and also insertion is used between tubes, but this also increase the cost of heat exchanger and also effect the flow rate and increases maintenance cost due to scale and slug formation. Scale and slug is also effect the efficiency of heat exchanger.

2. To reduce the cost and increase the heat transfer rate they also used the nano- fluids and PCM, which increase the heat transfer rate but it has some limitation is the cost of nano- fluids and properties of Nano - fluids.

To avoid this losses and to improving the heat transfer rate, different types of tube geometry is used which increase the heat transfer rate by increasing surface area of the tube without pressure drop. So we should increase the contact surface area without increase the flow resistance area so we are used the different types of tube shapes like elliptical, hexagonal and compare with circular tube.

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