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A Review of Literature on 'Experimental Analysis of Overall Heat Transfer Coefficient in Parallel Flow Heat Exchanger by Using Helical Ribs'

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ABSTRACT

A heat exchanger is a device use for efficient heat transfer from one medium to another. Generally the efficiency of heat exchanger is not so good. There have been continuous attempts to increase the heat transfer rate. Different active and passive methods are developed in last few years. Like twisted tapes, wire coils, helical ribs, fins, dimples, etc. The heat transfer between the inner and outer tube of heat exchanger can be improved by either increasing the heat transfer surface area using extended and corrugated surfaces without enhancing heat transfer coefficient or by increasing heat transfer coefficient using the turbulence promoters inside the tube. In this review paper make helical ribs on the tube surface by machining the surface on the lathe So that artificial roughness can be created The artificial roughness that results in an undesirable increase in the pressure drop due to the increased friction; thus the design of the tubes surface of heat exchanger should be executed with the objectives of high heat transfer rates.

Keywords : Heat Exchanger, Helical Ribs, Heat Transfer Coefficient, Reynolds Number, Nusselt Number.

I. INTRODUCTION

Heat Exchanger

A heat exchanger is a device built for efficient heat transfer from one medium to another, weather the medium are separated by a solid wall so that they never mix, or the medium are in direct contact. They are widely used in space heating, refrigeration, air conditioning, power plant, chemical plants, petrochemical plants, petroleum refineries and natural gas processing. Heat exchanger serve the purpose, controlling a system's or substance's temperature by adding or removing thermal energy. Although there are many different sizes, levels of sophistication, and types of heat exchanger, they all use a thermally conducting element usually in the form of a tube or plate to separate two fluids, such that one can transfer thermal energy to the other.

1.1 Types of heat exchanger

a. Air cooled heat exchanger
b. Water cooled heat exchanger

a. Air cooled heat exchanger:- Air cooled heat exchanger are a family of custom designed heavy duty fin tube heat exchangers which allow the direct cooling by air of various process mediums. Air cooled heat exchangers are used for many industrial Applications, such as power, chemical ORC plant, Oil and gas, steel industry and many other applications.

b. Water cooled heat exchanger: - Water cooling is a method of heat removal from components and industrial equipment. Water is used as the heat conductor. Water cooling is commonly used for cooling automobile internal combustion engines and large industrial facilities such as steam electric power plants, hydroelectric generators, petroleum refineries and plants.

1.2 Classification of Heat Exchanger

- 1.1.1 Nature of heat exchanger
- 1.1.2 Based on flow pattern or arrangement
- 1.1.3 Design and mechanical construction
- 1.1.4 Physical state of tube
- 1.1.5 Heat exchanger based on application

1.1.1 Nature of heat exchanger

a. Direct contact heat exchanger: In direct contact heat exchanger the exchanger of heat takes place by direct mixing of hot and cold fluids and transfer of heat and mass takes place simultaneously. Example: cooling tower, jet condenser, and direct contact feed water.

b. Indirect contact heat exchanger: In this type of heat exchanger, the heat transfer between two fluids could be carried out by transmission through wall which separates the two fluids. Example: Regenerator, Recuperator.

1.1.2. Based on flow pattern or arrangement

a. Parallel flow heat exchanger: - In a parallel flow heat exchanger fluids flow in the same direction. If the specific heat capacity of fluid are constant

b. Counter flow heat exchanger:-In a counter flow heat exchanger fluids flows in the opposite direction. If the specific heat capacity of fluids are constant

c. Cross flow heat exchanger:- In a cross flow heat exchanger the direction of fluids are perpendicular to each other. The required surface area across for this heat exchanger is usually calculated by using tables. It is between the required surface area for counter flow, a counter and parallel Flow, A parallel i.e.

$$A_{counter}<A_{cross}<A_{parallel}$$

1.1.3. Design and mechanical construction

a. Shell and tube heat exchanger: A shell and tube heat exchanger is a class of heat exchanger design. It is the most common type of heat exchanger in oil refineries and other large chemical processes, and is suited for higher pressure applications. As its name implies, this type of heat exchanger consists of a shell (a large pressure vessel) with a bundle of tubes inside it. One fluid runs through the tubes, and another fluid flows over the tubes (through the shell) to transfer heat between the two fluids. The set of tubes is called a tube bundle, and may be composed by several types of tubes: plain, longitudinally finned, etc.

b. Compact heat exchanger: There are special purpose heat exchanger and have a very large transfer surface area per unit volume of the exchanger. They are generally employed when convection heat transfer coefficient associated with one of the fluids is much smaller than that associated with the other fluid. Example: plate fin, flattened fin tube exchanger etc.

c. Concentric tubes: In this tunes, two concentric tubes are uses, each carrying one of the fluids. The direction of flow may be parallel or counter. The effectiveness of the heat exchanger is increased by using swirling flow.

1.1.4. Physical state of tube

a. Condensers: In a condensers, the condensing fluid remains at constant temperature throughout the exchanger while the temperature of the colder fluid gradually increases from inlet to outlet. The hot fluid loses part of heat which is accepted by the cold fluid.

b. Evaporators: The boiling fluid (cold fluid) remains at constant temperature while the temperature of hot fluid gradually decrease from inlet to outlet.

1.1.5. Heat exchanger based on application.

A. Steam boiler where water is boiled to steam using fire generated by solid, liquid or gaseous fuels.
B. Condenser where the vapours are condensed into liquid by using cold fluid.
C. Radiator where the heat is radiated into the atmosphere by natural convection.
D. Evaporators where change of phase of fluid take place.
E. Cooling tower where there is a direct contact of atmosphere air with the water, which is to be cooled.
F. Regenerators are periodic heat flow device where the hot and cold fluid alternately transfer heat between them.
G. Recuperator are continuous heat flow device where the hot and cold fluid are separated by a wall as shell and tube heat exchanger.

II. LITERATURE SURVEY

A study was performed in September 2017 on "experimental investigation of surface vibration effects on increasing the stability and heat transfer coefficient of MWCNTs-water Nano fluid in a flexible double pipe heat exchanger", in this study they given Nanoparticles deposition is one of the most challenges for industrial use of Nano fluids. In the present study, the heat transfer enhancement of Multi Wall Carbon Nano Tube, MWCNT-water Nano fluid in a double pipe heat exchanger due to vibrating walls is examined for different mass fractions. This work is performed by a flexible double pipe heat exchanger made of PVDF. Heat transfer enhancement techniques essentially reduce the thermal resistance in a conventional heat exchanger by promoting higher convective heat transfer coefficient with or without surface area increases. By this research we come to know that .The heat transfer coefficient increases by increasing the flow rate, Nano fluid temperature and concentration and vibration amplitude. [1]. A paper was published in August 2017 on "Experimental investigation on the thermal performance of a double pipe heat exchanger with segmental perforated baffles", in this study they emphasize that the experimentally investigates the characteristics of convective heat transfer and pressure drop of water flow in the annulus-side of horizontal double pipe heat exchangers. Twelve heat exchangers of counter-flow configurations are constructed with/without Single Segmental Perforated Baffles (SSPBs), which are fabricated with different holes spacing, void, cut, pitch ratios and inclination angle. The experiments are performed for annulus-side Reynolds number from 1380 to 5700, and for Prandtl number from 5.82 to 7.86. By this study we come to know that the installing segmental perforated baffles inside double pipe heat exchangers increases the heat transfer rate in addition to the pressure drop in the annulus side when compared with that in un-baffled heat exchangers and the annulus average Nusselt number and friction factor increase with increasing SSPBs holes spacing ratio, void ratio and inclination angle, and with decreasing SSPBs cut ratio and pitch ratio [2]. A study was performed in June 2017 on "enhancement of cooling characteristics and optimization of a triple concentric-tube heat exchanger with inserted ribs", in this study they give that the experimental and numerical investigation of the triple concentric-tube heat exchanger with inserted ribs has been carried out. The purpose is to evaluate the performance characteristics of the triple tube heat exchanger with rib inserts. The investigation key design parameters involve water mass flow rate, flow pattern, temperature variation, rib height and rib pitch. The energy conservation has been attracted and most of researchers directed their efforts more and more attention for this topic because of the scarcity of energy. Overall thermal performance of the heat exchangers can be improved by heat transfer enhancement techniques. Heat transfer enhancement has significant meanings for energy conservation and environmental problems. By this research we come to that higher values of the Nusselt number and heat exchanger effectiveness are obtained at counter current flow pattern and increasing the rib height slightly improves the hot water-side heat transfer coefficient by 6.2%; however, it much increases the pressure drop for the hot fluid side by 79.8%. [3]. A paper was published in November 2017 on "Experimental investigation on the hydrothermal performance of a double pipe heat exchanger using helical tape insert", in this study they give experimentally examines the hydrothermal performance of horizontal Double Pipe Heat Exchangers (DPHEs) with and without continuous Helical Tape Insert (HTI) conducted on the outer surface of the internal pipe for enhancing the thermal performance of heat exchange affects directly on energy, material and cost savings. Consequently, improving the heat exchange can significantly improve the thermal efficiency in applications involving heat transfer processes as well as the economics of their design and operation. By this study we come to know that installing a continuous HTI around the outer surface of the inner pipe of DPHEs significantly increases the heat transfer rate in addition to the pressure drop in the annulus-side when compared with that in the plain annulus heat exchangers. [4]. A study was performed in November 2017 on "Numerical and experimental analysis on shell side thermo-hydraulic performance of shell and tube heat exchanger with continuous helical FRP baffles," in this study they give that the numerical and experimental investigation of heat and fluid in shell and tube heat exchanger with continuous helical baffles on shell side. Heat exchangers such as shell-and-tube, plate type and finned tube are used in various industries for different applications such as heating, cooling, condensation or evaporation process. Most of the modern day heat exchangers are provided with baffles which help in enhancing the heat transfer.

Baffles is preventing corrosion and acts as guide ways for the flow across bundles of tube to obtain higher heat transfer rate. By this study we come to know that the Numerical & experimental results it is confirmed that the performance of tubular heat exchanger can be improved by helical baffles instead of conventional segmental baffles and the fabrication cost of producing helical baffles is simple, easy and cost effective with the help of wooden pattern. [5]. A study was performed in April 2017 on “Summary and evaluation on the heat transfer enhancement techniques of gas laminar and turbulent pipe flow”, in this study they give that the A systematic survey and evaluation on the thermal-hydraulic performance of gas inside internally finned, twisted tape or swirl generator inserted, corrugated, and dimpled, totally 436 pipes is conducted in this work. The encouragement and requirement to fabricate ultra-compact heat exchangers have driven the development of many types of surfaces to enhance the heat transfer. Because heat transfer enhancement of gases usually needs large surface area and the intensification from tube side is limited by space, the enhancement techniques typically locate in outside of tubes. By this study we come to know that the number of investigations on the tubes fitted with twisted tapes, coil loops, and swirl generators are the largest. The pressure drop of twisted tape inserts increased appreciably at the turbulent flow compared with liquids. In the performance evaluation plot, most of data fall into the Regions of 2 and 3. The efficiency are lower compared with other three enhancement techniques in this survey. [6]. A paper was published in November 2017 on “Laminar thermal and fluid flow characteristics in tubes with sinusoidal ribs”, in this study they give that effect of novel sinusoidal ribs transversely mounted in a tubular heat exchanger on convective heat transfer and flow pressure loss characteristics. The numerical study was performed under a constant heat flux condition for laminar water flow with Reynolds number (Re) ranged from 400 to 1800. The employment of sinusoidal ribs in the tube was aim to induce longitudinal vortex streams to give more intense flow mixing and to interrupt thermal boundary layer at the tube wall. The sinusoidal rib tubes were investigated at four rib height to diameter ratios (H/D = 0.026, 0.042, 0.058 and 0.074), three rib amplitude to diameter ratios (A/D = 0.211, 0.316 and 0.421), four rib width to diameter ratios (W/D = 0.158, 0.263, 0.368 and 0.474), three rib pitch to diameter ratios (P/D = 1.053, 1.316 and 1.579) and six circumferential rib numbers (N = 1, 2, 3, 4, 5 and 6 . Laminar flow is encountered in many industrial applications. Due to its low velocity, non-interfering in fluid mass, and flow calming in flow structures, the tube/duct/channel heat transfer in this circumstance always give poor performance. By this research we come to know that the heat transfer rate in the tube can be improved by adopting sinusoidal ribs mounted on the tube wall, resulting from the enhanced flow mixing and increased temperature gradient facilitated by the multiple longitudinal vortices in the flow domain. Due to the boosted flow disturbance coming from flow separation and surface drag, the pressure drop in the SRTs is also augmented compared with their counterpart of the plain tube. [7]. A paper was published in January 2016 on “Enhancement of forced convection in wide cylindrical annular channel using rotating inner pipe with interrupted helical fins”, in this study they give the results of heat transfer and pressure drop in concentric annular wide channel with inner plain or finned pipe under stationary and rotating conditions in Taylor–Couette–Poiseuille flow. The experiments are conducted for one plain pipe and three finned pipes with helical fin spacing of 75, 110 and 150 mm at rotating speeds of 0, 200, 250, 300, 350 and 400 rpm. Many mechanical systems comprise a concentric cylindrical annulus where either the inner or outer cylinder is stationary or rotating including annular heat exchangers, rotating pipe heat exchangers, gas-cooled nuclear reactors, packed beds, gas turbines, jet engines, electric motors, mechanical and chemical mixers and drilling operations in the oil and gas industry. Thus, the study of forced convection heat transfer in annular passages is of interest for many process and aeronautical industries. By the study of this research paper we come to know that the The annular channel with interrupted helical fin spacing of 75 mm that rotates to pumping power of about 26 that is 7.6 times the ratio attained by plain stationary pipe at Re = 1.5×10^5. This is because the combined effects of both fins and rotation enhance Nu by about 7.5 times than Nu for plain stationary annular channel. On the other hand, both plain and finned pipes attain relatively low and comparable ratio of heat exchange to pumping power under stationary conditions. This ratio increases with Ta (rotational speed) and decreases as axial Re increases. [8]. A study was performed in February 2016 on "Numerical investigations of the thermal-hydraulic performance in a rib-grooved heat exchanger tube based on entropy generation analysis", in this study they give that the numerical simulation has been conducted to examine the turbulent flow characteristics and heat transfer performance in a rib-grooved heat exchanger tube. Ribs and grooves characterized by a discrete and inclined distribution are alternately arranged on the inner wall surface of the test section. The main purpose of this study is to determine thermal-hydraulically superior rib-groove geometry for heat transfer enhancement. Flow structures and local heat transfer characteristics are presented and analysed at first.

Because of the disturbance of ribs and grooves, multiple longitudinal swirl flows are induced, which immensely affect the local heat transfer performance. Then, effects of geometric parameters, including the rib-groove pitch ratio (P*), the number of circumferential ribs and grooves (N), and the rib-groove inclination angle (α) on the heat transfer and flow performance are examined. Heat transfer enhancement techniques are usually needed in designing heat exchangers with high performance and low resistance. By this study we come to know that multiple longitudinal swirl flows are generated in the rib grooved tube due to the disturbances of ribs and grooves. This type of flow pattern leads to a relatively long flow path in the tube, and fluid between the wall and core flow regions is intensively mixed, which has a significant impact on the performance of heat transfer in the rib-grooved tube. [9]. A research paper was published in June 2015 on "Experimental study on heat transfer to the supercritical water upward flow in a vertical tube with internal helical ribs", in this study they give that the results of experimental research performed at the Hi-TaP-XJTU test loop on heat transfer to the supercritical water (SCW) upward flow in a vertical tube with internal helical ribs. The experiments include a large range of regime parameters: P = 22.5–28 MPa, G = 400–1000 kg/(m2 s), q = 300–700 kW/m2. These present data were compared with those known for smooth tubes and other types of ribbed tubes both under the heat transfer deterioration (HTD) and without it. Supercritical water (SCW) has been used in various industry applications, such as the supercritical pressure water-cooled reactors (SCWR) and ultra-supercritical power plant boilers, etc. The thermal efficiency of thermal power plants and nuclear power plants will be significantly improved when the live steam parameters (pressure and temperature) are increased to supercritical parameters level. By the study of this research paper we come to know that the heat transfer to SCW flow in the test ribbed tube is enhanced as compared with the smooth tube both under the heat transfer deterioration (HTD) and without it. The average heat transfer coefficient (HTC) in the cases without HTD is about 1.41–1.85 times and the critical heat flux of HTD is about 1.8 times higher than those in the smooth tube. Further comparison should be conducted for HTCs between the ribbed tube and the smooth tube in the cases with HTD. [10]. A study was performed in December 2015 0n topic “Effects of rib arrangements on the flow pattern and heat transfer in an internally ribbed heat exchanger tube,” in this study they give that the numerical simulation was carried out to investigate the effects of rib arrangements on the flow pattern and heat transfer in an internally ribbed heat exchanger tube. Details of the flow structures in the tube with parallel type ribs (P-type ribs) and V shape type ribs (V-type ribs) were presented and analyzed, respectively. The results reveal that rib arrangements have perceptible effects upon the flow pattern and heat transfer in the ribbed tube. The average Nusselt number and friction factor in the V-type ribbed tubes were about 57-76% and 86-94% higher than those in the P-type ribbed tube, respectively. Developing high-efficiency and low-resistance heat exchange equipment such as heat exchangers and effective way to save energy and material. To realize the object, heat transfer enhancement techniques are usually necessary. Among various techniques available, the artificial roughness in the form of ribs has been extensively studied and widely used throughout the engineering industry because of its high thermal hydraulic performance over the past few decades. By this study we come to know that Rib arrangements have perceptible effects upon the flow patterns in the ribbed tube.

Longitudinal swirl flow with multiple vortices is induced in the V-type ribbed tube while longitudinal swirl flow with single vortex is generated in the P-type ribbed tube. [11]. A study was performed in June 2014 on “Heat transfer augmentation in a helical-ribbed tube with double twisted tape inserts”, in this study they give that the Turbulent convective heat transfer characteristics in a helical-ribbed tube fitted with twin twisted tapes have been investigated. The experiment was carried out in a double tube heat exchanger using the helical-ribbed tube having a single rib-height to tube-diameter ratio, e/DH=0.06 and rib-pitch to diameter ratio, P/DH=0.27 as the tested Section. The insertion of the double twisted tapes with twist ratio, Y, in the range of 2.17 to 9.39 is to create vortex flows inside the tube. The inserted ribbed tube is arranged in similar directions of the helical swirl of the twisted tape and the helical rib motion of the tube. Heat transfer enhancement techniques have been extensively developed to improve the thermal performance of heat exchanger systems with a view to reducing the size and cost of the systems. By this study we come to know that for the inserted ribbed tube, the Nu tends to increase with the rise in Re while the f and TEF give the opposite trends and the TEF obtained from the inserted ribbed tube is found to be much higher than unity and compound enhancement devices of the ribbed tube and the twin twisted tapes show a considerable improvement of heat transfer rate and thermal performance relative to the smooth tube and the helical-ribbed tube acting alone, depending on twist ratios. [12]. A study was performed in June 2014 on "Thermodynamic investigation and optimization of laminar forced convection in a rotating helical tube heat exchanger", in this study they give that the entropy generation investigation is carried out under given dimensionless parameters, i.e. heat exchanger duty, heat flux, with respect to heat transfer and frictional pressure drop in a rotating helical tube heat exchanger with laminar convective flow. The entropy generation from heat transfer across a finite temperature difference $-\psi$ decreases with increasing Dean Number which represents the impact of centrifugal force induced secondary flow in enhancing heat transfer. Flow and heat transfer in rotating helical channel has drawn many attentions not only because of the additional momentum and energy transportation by cross-sectional convection due to coexistence of centrifugal force and Coriolis force but also has many industrial applications, especially for heating or cooling in rotating machinery By this research we come to know that the thermodynamic analysis of laminar convective flow in rotating helical tube heat exchanger has been carried out in this article. An asymptotic model concerning the combined effect of centrifugal and Coriolis force on enhancing heat transfer and flow friction is adopted to the investigation of entropy generation rate.[13].

III. CONCLUSION

The heat transfer coefficient increases by increasing the flow rate, Nano fluid temperature and concentration and vibration amplitude. The installing a continuous HTI around the outer surface of the inner pipe of DPHEs significantly increases the heat transfer rate in addition to the pressure drop in the annulus-side when compared with that in the plain annulus heat exchangers. Due to the boosted flow disturbance coming from flow separation and surface drag, the pressure drop in the SRTs is also augmented compared with their counterpart of the plain tube. Longitudinal swirl flow with multiple vortices is induced in the V-type ribbed tube while longitudinal swirl flow with single vortex is generated in the P-type ribbed tube.

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