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Research Paper

CRITICAL ASSESSMENT OF LITERATURE IN THE FIELD OF ENHANCED HEAT TRANSFER TECHNIQUES

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The purpose of this paper is to comparatively analyse heat transfer and pressure drop characteristics of Double pipe heat exchanger with augumentation techniques like turbulator, nano particle suspension, fins on inner rotating tube, triple concentric pipe and enhanced tubes concept. This paper features a broad discussion and comparative study on various techniques for improving heat transfer coefficient for double pipe heat exchanger. The motivation for heat transfer enhancement is discussed, and the principles behind heat exchangers are summarized. For well over a century, efforts have been made to produce more efficient heat exchangers by employing various methods of heat transfer enhancement. The study of enhanced heat transfer has gained serious momentum during recent years, however, due to increased demands byindustry for heat exchange equipment that is less expensive to build and operate than standard heat exchange devices. Savings in materials and energy use also provide strong motivation for the development of improved methods of enhancement. In the present review we are focusing upon passive techniques which causes heat transfer enhancement.

Keywords: Double pipe heat exchanger, Twisted tape, Nano fluids, Helical fins, Heat transfer coefficient, Heat transfer enhancement, Pressure drop, Reynolds number, Nusselt number

MOTIVATION

For well over a century the study of enhanced heat transfer has gained serious momentum during recent years, however, due to increased demands by industry for heat exchange equipment that is less expensive to build and operate than standard heat exchange devices. Especially light weight and compact heat exchangers is prime importance for designing various systems. Heat exchanger design involves the consideration of mechanical pumping power expended to overcome fluid

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friction in addition to the consideration of heat transfer rate. The frictional power limitations force the designers to keep the velocities moderately low. Also as the Reynolds number is progressively increased, the unsteadiness is onset at a much earlier location, leading to increased heat transfer rates. It can be observed that effective heat transfer achieved by implementing geometrical changes alonf flow passages. The objective behind these methods is to efficiently interrupt the boundary layer that forms on the exchange surface and replace it with fluid from the core, thereby creating a fresh boundary layer that has increased nearwall temperature gradients. This leads not only to higher rates of heat transfer, but to greater frictional losses as well. Therefore, the primary goal for any enhancement scheme is to increase heat transfer as much as possible while minimizing pressure drop.

INTRODUCTION

Heat exchangers are a device that exchange the heat between two fluids of different temperatures that are separated by a solid wall. The temperature gradient, or the differences in temperature facilitate this transfer of heat. Transfer of heat happens by three principle means: radiation, conduction and convection. In the use of heat exchangers radiation does take place. However, in comparison to conduction and convection, radiation does not play a major role. Conduction occurs as the heat from the higher temperature fluid passes through the solid wall. To maximize the heat transfer, the wall should be thin and made of a very conductive material. The biggest contribution to heat transfer in a heat exchanger is made through convection. The simplest form of the heat exchanger consist of two concentric pipes of different diameters known as double pipe heat exchanger. In this type of heat exchanger, one fluid flows through the small pipe and another fluid flows through the space between both the pipes. As conditions in the pipes change: inlet temperatures, flow rates, fluid properties, fluid composition, etc., the amount of heat transferred also changes. This transient behavior leads to change in process temperatures, which will lead to a point where the temperature distribution becomes steady as in Incropera[1*].

The high performance heat exchangers can be obtained by utilization of heat transfer enhancement techniques. Heat transfer enhancement is the process of improving the performance of the heat transfer system, by means of increasing heat transfer coefficient. Heat transfer enhancement creates one or more combinations of following conditions that are favorable for the increase in heat transfer rate with an undesirable increase in friction: (a) interruption of boundary layer development and rising degree of turbulence, (b) increase in heat transfer area, (c) generating of swirling or secondary flows. As the heat exchanger gets older, the resistance to heat transfer rate increases due to fouling or scaling. Also in some industries there is need to increase heat transfer rate in the existing heat exchangers. Therefore to achieve desired heat transfer in an existing heat exchanger, several methods have been investigated in the recent years. Passive techniques do not require any direct

[1*] Incropera F.P., D.P. DeWitt, Fundamentals of Heat and Mass Transfer, John Wiley & Sons, Inc., pp. 460, 582-612. (1996).

input of external power; rather they use it from the system itself which ultimately leads to an increase in pressure drop. They generally use surface or geometrical modifications to the flow channel by incorporating inserts or additional devices. They promote higher heat transfer coefficients by disturbing or altering the existing flow behaviour. Heat transfer equipment is defined by the function it fulfills in a process.

LITERATURE SURVEY REPORTS

Snehal S Pachegaonkar make use of insertion of twisted tape as one of the effective methods to increase heat transfer coefficient with relatively small pressure drop losses. For experimentation, three types of twisted tape inserts made from M S strips of thickness 1.4 mm were used with 45^0 and 60^0 twist angles. The present work deals with finding the friction factor and the heat transfer coefficient for the various types of twisted tapes with twist ratios (y/w = 6.7, 10.7) and comparing those results with that of plane pipe and finally finding the heat transfer enhancement in comparison to a smooth tube on constant flow rate basis as well as constant pumping power basis. Hot water at room temperature was allowed to flow through the outer pipe while cold water flowed through the annulus side in the parallel and counter current direction. From the results obtained it is concluded that the best performance with twisted tape inserted into annulus of double pipe heat exchanger is obtained at twist angle 45^0 due to more swirl and turbulence induced by tape insert that for counter flow. The highest increase in pressure drop resulted for 45^0 twisted tape compared to 60^0 twisted tape. From the experimental results it is concluded that the double pipe heat exchanger with 450 twisted tape insert produced optimum performance. From the enhancement factor and pressure drop factor results, it can be determined that a higher increase in enhancement factor was achieved related to increase in pressure drop factor.

Antony luki demonstrated that more heat transfer and an earlier transition to high heat transfer can be accomplished through the use of dimpled tubes. Tubes have been evaluated and can be designed to produce more heat transfer than smooth tubes. The enhanced structure for both the ellipsoidal and spherical dimple could disturb, swirl, break the boundary layer developing, and enhance the mixing of the hot and cold fluid and then improve the heat transfer of the tubes. Kim *et.al.* (2012) reported numerical study on characteristics of flow and heat transfer in a cooling passage with protrusion-in-dimple surface. Four different protrusion heights were considered and protrusion height to channel height (h/H) of 0.05, 0.10, 0.15, and 0.20. This experiment under performed by turbulent flow. Water as test fluid. CFD analysis and experimental method and 40% negligible pressure drop, 24% increase heat transfer, increase friction factor up to 5–6% and volume goodness factor slightly increases by approximately 4%.

Shewale Omkar experimented and convective heat transfer coefficients were obtained for the stationary as well as rotating inner tube for the counter flow mode using water as cold fluid in the tube side and glycerol as hot fluid in the shell side. The flow rate of cold fluid was kept constant and that of hot fluid was varied. The Nusselt number was calculated for the each speed of the rotation and compared with standard values obtained from Dittus-Boelter equation. The helical fins increases heat transfer area and rotation of the inner tube increases the mixing of fluid particles which is necessary for the convection mode of heat transfer. The Nusselt number increased up to 64% at 100 rpm compared to stationary inner tube with helical fins.

Pardhi suggested the effect of inserting twisted tapes in the tubes of double pipe heat exchanger. Twisted tape is a metallic tape twisted about its longitudinal axis and inserted in a tube. The twist ratio is defined as the ratio of half pitch of the tape to the tube inside diameter. Usually tape is easy to make and fit. The strips were snuggly fitted inside the tube. These interrupt the fluid flow so that a thick boundary layer cannot form.Series of tests conducted for double pipe heat exchanger with and without turbulator by inputs of changing mass flow rate. Thermal performance of heat exchanger is ratio of heat transfer coefficient to pressure drop. Zuritz developed a set of analytical equations for fluid temperatures at any axial location along the heat exchanger for parallel and counter flow configurations and conducted simulation of triple concentric pipe heat exchanger. The equations account for heat losses to the surroundings and are useful for design purposes Simulations show that the creation of an annular region within the inner pipe increases the overall heat transfer efficiency and reduces the heat exchanger length requirement by almost 25%.

Tejas M Ghiwala, The present study involves the sizing of triple concentric pipes heat exchanger where in two cold water streams flow through the central tube and outer annular space at same mass flow rates and same inlet temperatures in co-current direction while hot water flows through inner annular space in counter-current direction. Overall heat transfer coefficient and length of the equivalent double pipe heat exchanger are compared with that of the triple pipe heat exchanger. The theoretical analysis shows that introducing an intermediate pipe to the double pipe heat exchanger reduces effective length of heat exchanger, which results in savings in material and space. The triple concentric pipes heat exchanger provides large heat transfer area per unit heat exchanger length and better heat transfer efficiencies compared to double pipe heat exchanger.

Senthilraja, Experimentally investigated heat transfer coefficient of CuO/Water nanofluid (by dispersing a CuO nano particle in deionized water) in this paper. This experimental result showed that the convective heat transfer coefficient increases with an increase in time also the Nusslet number increases with increasing the liquid flow rate. The conventional heat transfer fluids like water, ethylene glycol, propylene glycol, widely used to remove the heat from the mechanical systems have poor heat transfer properties. Nano fluids are relatively new class of fluid containing suspension of nanometer sized particles in the base fluids like water, ethylene glycol, propylene glycol, oil, etc. Choi *et al.* found that Nano fluids possess enhanced thermal conductivity compared to base fluids.

RESULTS AND DISCUSSION

From conceptual study of research papers following conclusions can be drawn:

1. Experimental investigation of enhancement efficiency, heat transfer characteristics of circular tube fitted with twisted tape inserts of different twist ratios has been investigated. It is observed that the swirl flow helps decrease the boundary layer thickness of the hot water flow and increase residence time of water in the outer tube. The secondary fluid motion is generated by the tape twist, and improves the convection heat transfer. The heat exchanger with annular twist tape of angle 45^0 resulted in highest increase in Nusselt number over Plain double pipe heat exchanger and heat exchanger with annular twisted tape of angle 60^0. As a penalty this heat exchanger also had the highest increase in pressure drop. However, enhancement obtained is higher than the increase in pressure drop. Thus it is concluded that heat exchanger with twisted tape of twist angle 450 inserted into annulus produced optimum performance.

2. Augmented surfaces like dimpled tube is used to increase the heat transfer coefficient with a consequent increase in the friction factor. Here investigation. From theoretical calculation the overall heat transfer coefficient is increased and also effectiveness of the dimpled tube with concentric tube heat exchanger is increased 8% compare to plain tube concentric tube heat exchanger. From theoretical results shows that dimpled tube heat exchanger gives better performance. So we suggest the dimpled tube is used in concentric tube heat exchanger in various applications will give high heat transfer.

3. The Nusselt number obtained with the helical fins on the outer surface of the inner tube is higher than that obtained for the plain inner tube. The Nusselt number with only helical fins are 4 times more than that of plain tube heat exchanger. The speed of rotation of the inner tube is varied from the 0 rpm to 100 rpm in the steps of 50 rpm. The Nusselt numbers obtained for each speed of rotation are is compared and analysed. The graph showed that as the speed of rotation increases the Nusselt number goes on increasing for the same Reynolds number. The Nusselt numbers at the speed 50 rpm and 100 rpm are 36% and 64% more than that of stationary inner tube. The Nusselt number at 100 rpm is 21% higher than 50 rpm.

4. It has been observed that thermal performance for smooth tube is better than twisted tape by 1.3 times at low flow rate to 1.54 times at higher flow rate. This is because at higher flow rate pressure drop increases fastly in twisted tape. Thermal performance decreases with use of turbulators because increase in pressure drop is more than increase in heat transfer coefficient. But this increase in pressure drop does not influence pumping cost by significant amount as pumping cost is proportional to the square root of pressure drop. When only heat transfer capacity of heat exchanger is criteria regardless of pressure drop or pumping power the twisted tape is more superior as compared with smooth tube (1.6 to 1.8 times). Twisted tape of lower twist ratio (p/d = 3.5) gives higher heat transfer coefficient (by 1.39 times) than higher twist ratio of p/d = 7.

5. The overall heat transfer coefficients and length of triple concentric pipe heat

exchanger were found out using input parameters, i.e., geometrical characteristics of three pipes, mass flow rates and thermo physical properties of three fluids. The length of triple pipe heat exchanger was computed for 8°C temperature drop of hot water. The length of triple concentric pipe heat exchanger was found to be1.098 m. There are two overall heat transfer coefficients in triple pipe heat exchanger: one based on outside area of central pipe and second based on inside area of intermediate pipe. The flow regimes in triple pipe heat exchanger were observed to be: transition in the central pipe and inner annular space and laminar in outer annular space.

The value calculated for equivalent DTHE combines the effect of the overall heat transfer coefficients and if we compare the overall heat transfer coefficients of triple pipe heat exchanger with that of double pipe heat exchanger, it can be observed that the performance of triple pipe heat exchanger is better compared to double pipe heat exchanger. Thus it can be seen that, length of equivalent DPHE is more than length of TPHE. Thus, we concluded that triple concentric pipe heat exchanger provides better heat transfer efficiencies and large heat transfer area per unit exchanger length. Triple concentric pipe heat exchanger requires less space compared to double pipe heat exchanger.

6. The nanofluid prepared by dispersing CuO (27 nm) particles in deionized water showed that the convective heat transfer coefficient and Nusselt number of nanofluids were remarkably increase compared to base fluid (water) and is directly proportional to the particle volume concentration.

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