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A REVIEW ON ENHANCEMENT OF HEAT TRANSFER IN A DOUBLE PIPE HEAT EXCHANGER AFFECTED WITH V-SHAPED OR U-SHAPED OR USING TWISTED-TAPES

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ABSTRACT

An experimental study will be conducted to investigate the flow friction and heat transfer performance in tube with plain twisted tape and twisted tape with Passive method hole or geometrical shape for Reynolds number for turbulent flow. The friction factor, Nusselt number and the overall thermal performance parameters of the twisted tape with various geometrical shapes will have been obtain and compare with the plain tube and plain twisted tape. The comparisons showed that, compared with the plain twisted tape, the twisted tape without elliptical hole has further improved convective heat transfer performance by about x% and whereas lowered flow friction. The twisted tape with elliptical hole shows about y% greater thermal performance than plain twisted tape.

KEYWORDS: agumentation, Coagulation, Twisted Tape, Heat transfer, double pipe of HE.

1. INTRODUCTION

Heat exchangers have several industrial and engineering applications. The design procedure of heat exchangers is quite complicated, as it needs exact analysis of heat transfer rate and pressure drop estimations apart from issues such as long-term performance and the economic aspect of the equipment. The major challenge in designing a heat exchanger is Power and Energy to make the equipment compact and achieve a high heat transfer rate using minimum pumping power. Techniques for heat transfer augmentation are relevant to several engineering applications. In recent years, the high cost of energy and material has resulted in an increased effort aimed at producing more efficient heat exchange equipment. Furthermore, sometimes there is a need for miniaturization of a heat exchanger in specific applications, such as space application, through an augmentation of heat transfer. For example, a heat exchanger for an ocean thermal energy conversion (OTEC) plant requires a heat transfer surface area of the order of 10 000 m^2 /MW. Therefore, an increase in the efficiency of the heat exchanger through an augmentation technique may result in a considerable saving in the material cost. Furthermore, as a heat exchanger becomes older, the resistance to heat transfer increases owing to fouling or scaling. These problems are more common for heat exchangers used in marine applications and in chemical industries. In some specific applications, such as heat exchangers dealing with fluids of low thermal conductivity (gases and oils) and desalination plants, there is a need to increase the heat transfer rate. The heat transfer rate can be improved by introducing a disturbance in the fluid flow (breaking the viscous and thermal boundary layers), but in the process pumping power may increase significantly and ultimately the pumping cost becomes high. Therefore, to achieve a desired heat transfer rate in an existing heat exchanger at an economic pumping power, several techniques have been proposed in recent years and are discussed in the following sections.

1.1 Heat exchanger

A heat exchanger is a system used to transfer heat between two or more fluids. Heat exchangers are used in both cooling and heating processes. The fluids may be separated by a solid wall to prevent mixing or they may be in direct contact. They are widely used in space heating, refrigeration, air conditioning, power stations, chemical plants, petrochemical plants, petroleum refineries, natural-gas processing, and sewage treatment. The classic example of a heat exchanger is found in an internal combustion engine in which a circulating fluid known as engine coolant flows through radiator coils and air flows past the coils, which cools the coolant and heats the

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incoming air. Another example is the heat sink, which is a passive heat exchanger that transfers the heat generated by an electronic or a mechanical device to a fluid medium, often air or a liquid coolant.

A device whose primary purpose is the transfer of heat energy between two fluids at different temperature is named a heat exchanger. A heat exchanger may be defined as equipment which transfers the energy from a hot fluid to a cold fluid, with maximum rate and minimum investment and running costs. There are various types of heat exchangers available in the industry, however the Shell and Tube Type heat exchanger is probably the most used and widespread type of the heat exchanger's classification. It is used most widely in various fields such as oil refineries, thermal power plants, chemical industries and many more. This high degree of acceptance is due to the comparatively large ratio of heat transfer area to volume and weight, easy cleaning methods, easily replaceable parts etc. Shell and tube type heat exchanger consists of a number of tubes through which one fluid flows. Another fluid flows through the shell which encloses the tubes and other supporting items like baffles, tube header sheets, gaskets etc. The heat exchange between the two fluids takes through the wall of the tubes.

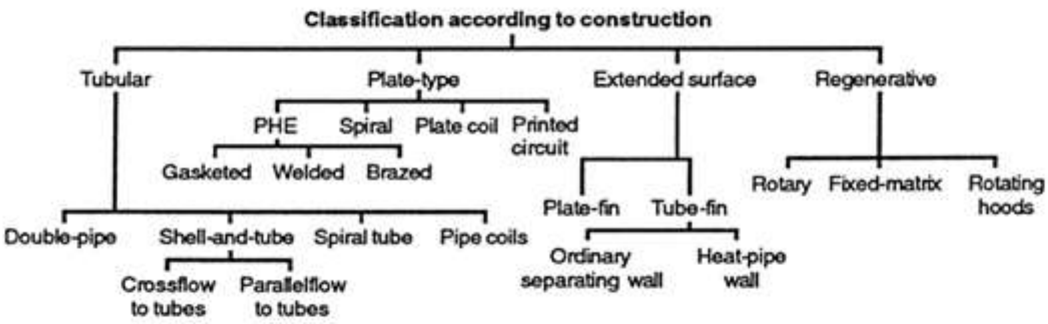

Figure 1: Classification of heat exchanger

1.2 The double-pipe heat exchanger

The double-pipe heat exchanger is one of the simplest types of heat exchangers. It is called a double-pipe exchanger because one fluid flows inside a pipe and the other fluid flows between that pipe and another pipe that surrounds the first. This is a concentric tube construction. Flow in a double-pipe heat exchanger can be co-current or counter-current. There are two flow configurations: co-current is when the flow of the two streams is in the same direction, counter current is when the flow of the streams is in opposite directions. 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. When heat is beginning to be transferred, this changes the temperature of the fluids. Until these temperatures reach a steady state their behavior is dependent on time. In this double-pipe heat exchanger a hot process fluid flowing through the inner pipe transfers its heat to cooling water flowing in the outer pipe. The system is in steady state until conditions change, such as flow rate or inlet temperature. These changes in conditions cause the temperature distribution to change with time until a new steady state is reached. The new steady state will be observed once the inlet and outlet temperatures for the process and coolant fluid become stable. In reality, the temperatures will never be completely stable, but with large enough changes in inlet temperatures or flow rates a relative steady state can be experimentally observed.

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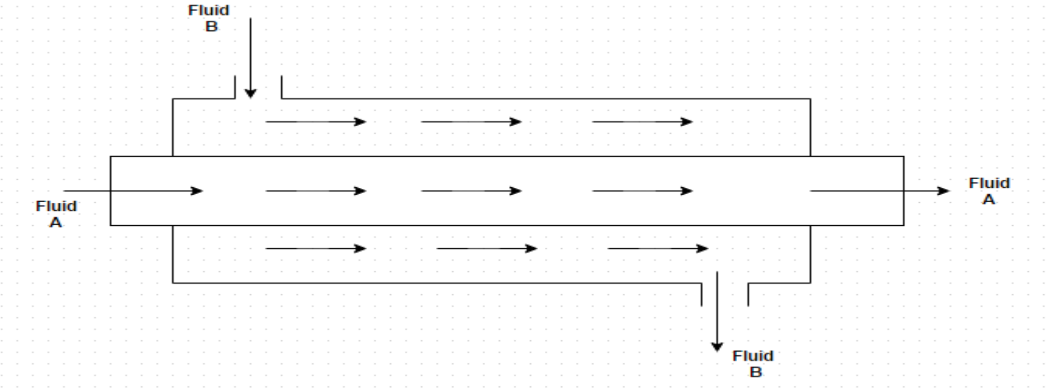

Figure 2: Double-pipe heat exchanger

1.3 Introduction of augmentation techniques

Heat transfer augmentation techniques (passive, active or a combination of passive and active methods) are commonly used in areas such as process industries, heating and cooling in evaporators, thermal power plants, air-conditioning equipment, refrigerators, radiators for space vehicles, automobiles, etc. Passive techniques, where inserts are used in the flow passage to augment the heat transfer rate, are advantageous compared with active techniques, because the insert manufacturing process is simple and these techniques can be easily employed in an existing heat exchanger. In design of compact heat exchangers, passive techniques of heat transfer augmentation can play an important role if a proper passive insert configuration can be selected according to the heat exchanger working condition (both flow and heat transfer conditions). In the past decade, several studies on the passive techniques of heat transfer augmentation have been reported. The present paper is a review on progress with the passive augmentation techniques in the recent past and will be useful to designers implementing passive augmentation techniques in heat exchange. Twisted tapes, wire coils, ribs, fins, dimples, etc., are the most commonly used passive heat transfer augmentation tools. In the present paper, emphasis is given to works dealing with twisted tapes and wire coils because, according to recent studies, these are known to be economic heat transfer augmentation tools. The former insert is found to be suitable in a laminar flow regime and the latter is suitable for turbulent flow. The thermo hydraulic behavior of an insert mainly depends on the flow conditions (laminar or turbulent) apart from the insert configurations. The present review is organized in five different sections: twisted tape in laminar flow; twisted tape in turbulent flow; wire coil in laminar flow; wire coil in turbulent flow; other inserts such as ribs, fins, dimples, etc

1.4 Classification of augmentation techniques:

Generally, heat transfer augmentation techniques are classified in three broad categories:
(a) Active method,
(b) Passive method,
(c) Compound method.

The active and passive methods are described with examples in the following subsections. A compound method is a hybrid method in which both active and passive methods are used in combination. The compound method involves complex design and hence has limited applications.

1.4.1 Active method

This method involves some external power input for the enhancement of heat transfer and has not shown much potential owing to complexity in design. Furthermore, external power is not easy to provide in several applications. Some examples of active methods are induced pulsation by cams and reciprocating plungers, the use of a magnetic field to disturb the seeded light particles in a flowing stream, etc.

1.4.2 Passive method

This method does not need any external power input and the additional power needed to enhance the heat transfer is taken from the available power in the system, which ultimately leads to a fluid pressure drop. The heat exchanger industry has been striving for improved thermal contact (enhanced heat transfer coefficient) and

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reduced pumping power in order to improve the thermo hydraulic efficiency of heat exchangers. A good heat exchanger design should have an efficient thermodynamic performance, i.e. minimum generation of entropy or minimum destruction of available work (exergy) in a system incorporating a heat exchanger. It is almost impossible to stop exergy loss completely, but it can be minimized through an efficient design.

1.5 Important definitions

In this section a few important terms commonly used in heat transfer augmentation work are defined. Thermo hydraulic performance For a particular Reynolds number, the thermo-hydraulic performance of an insert is said to be good if the heat transfer coefficient increases significantly with a minimum increase in friction factor. Thermo-hydraulic performance estimation is generally used to compare the performance of different inserts such as twisted tape, wire coil, etc., under a particular fluid flow condition.

1.5.1 Overall enhancement ratio

The overall enhancement ratio is defined as the ratio of the heat transfer enhancement ratio to the friction factor ratio. This parameter is also used to compare different passive techniques and enables a comparison of two different methods for the same pressure drop. The overall enhancement ratio is defined as $(Nu/Nu_0)/(f/f_0)^{1/3}$

Where Nu, f, Nu_0 and f_0 are the Nusselt numbers and friction factors for a duct configuration with and without inserts respectively. The friction factor is a measure of head loss or pumping power.

1.5.2 Nusselt number

The Nusselt number is a measure of the convective heat transfer occurring at the surface and is defined as hd/k, where h is the convective heat transfer coefficient, d is the diameter of the tube and k is the thermal conductivity.

1.5.3 Prandtl number

The Prandtl number is defined as the ratio of the molecular diffusivity of momentum to the molecular diffusivity of heat, $n = \nu / \alpha$

1.5.4 Pitch

Pitch is defined as the distance between two points that are on the same plane, measured parallel to the axis of a twisted tape.

1.5.5 Twist ratio, y

The twist ratio is defined as the ratio of pitch to inside diameter of the tube y = H/di, where H is the twist pitch length and d is the inside diameter of the tube

1.6 Twisted tape in laminar flow

A summary of important investigations of twisted tape in a laminar flow is presented. Twisted tape increases the heat transfer coefficient at a cost of rise in pressure drop. Several researchers have studied various configurations of twisted tape, such as full-length twisted tape, short-length twisted tape, full-length twisted tape with varying pitch and regularly spaced twisted tape. This section discusses which configuration of twisted tape is suitable for laminar flow. Whitham studied heat transfer enhancement by means of a twisted tape insert way back at the end of the nineteenth century. Date and Singham [3numerically investigated heat transfer enhancement in laminar, viscous liquid flows in a tube with a uniform heat flux boundary condition. They idealized the flow conditions by assuming zero tape thickness, but the twist and fin effects of the twisted tape were included in their analysis. Saha reported experimental data on a twisted tape generated laminar swirl flow friction factor and Nusselt number for a large Prandtl number (205 , Pr , 518) and observed that, on the basis of a constant pumping power, short-length twisted tape is a good choice because in this case swirl generated by the twisted tape decays slowly downstream which increases the heat transfer coefficient with minimum pressure drop, as compared with a full-length twisted tape. Regularly spaced twisted tape decreases the friction factor and reduces the heat transfer coefficient because the spacing of the twisted tape disturbs the swirl flow. Hong and Bergles reported heat transfer enhancement in laminar, viscous liquid flows in a tube with uniform heat flux boundary conditions, but their correlation has limited applicability as it is valid for a high Prandtl number (approximately 730). The circumferential temperature profile for swirl flow is related to tape orientation. Tariq found that in a laminar flow the introduction of turbulent promoters, such as an internally threaded tube, is not efficient compared with a twisted tape insert on the basis of the overall efficiency. Depending upon the flow rate and tape geometry, the enhancement in heat transfer is due to the tube partitioning and flow blockage, the large flow path and secondary fluid circulation. Manglik and Bergles considered all these effects and developed laminar flow correlations for the friction factor and Nusselt number, including the swirl parameter, which defines the interaction between viscous, convective inertia and centrifugal forces. These correlations pertain to the constant wall temperature case for fully developed flow, based on both previous data and their own experimental data.

1.7 Twisted tape in turbulent flow

In turbulent flow, the dominant thermal resistance is limited to a thin viscous sublayer. The following section discusses the performance of twisted tape inserts in turbulent flow. A tube inserted with a twisted tape performs better than a plain tube, and a twisted tape with a tight twist ratio provides an improved heat transfer rate at a cost of increase in pressure drop for low Prandtl number fluids. This is because the thickness of the thermal boundary layer is small for a low Prandtl number fluid and a tighter twist ratio disturbs the entire thermal boundary layer, thereby increasing the heat transfer with increase in the pressure drop, as discussed by Royds . Smithberg and Landis gave an analytical model of the tape-generated swirl mechanism. Because of swirl, the ratio of maximum velocity to mean velocity is smaller in a tube with a twisted tape compared with that in a straight flow (i.e. without a twisted tape). This creates a centrifugal force and aids convective heat transfer . Twisted tape is also effective in high Prandtl number fluids because for such fluids it provides high heat transfer with less pressure drop compared with other inserts. Lopina and Bergles observed that the difference between isothermal and heated flow friction factors for the swirl flow of liquids is substantially less than the corresponding difference for a plain tube. In turbulent flow, insertion of a twisted tape increases the heat transfer, but the pressure drop also increases significantly. Short-length twisted tape (25–45 per cent of the tube length) performs better than full-length twisted tape. Date reviewed available friction factor and Nusselt number correlations for flow in a tube containing a twisted tape and pointed out that existing correlations deviate from measurements by 30 per cent. Studies of Klepper and Kidd Jr suggest that short-length twisted tape is more useful in a gas-cooled nuclear reactor compared with full-length tape.

2. LITERATURE REVIEW

The heat transfer processed is which focused on heat transfer rate and on which a great amount of research work have been done in the form of research paper, books chapter and patents .a brief review has presented on this sections.

2.1. Divyesh Prafulla Ubale et al.(2017)

Heat transfer enhancement plays an important role in many industries. Their applications include heat exchanger, air conditioning, heating and cooling in evaporators, chemical reactors and refrigeration systems. There are different techniques to enhance heat transfer such as active, passive or a combination of both. Several techniques are used to increase heat transfer and decrease cost and size of equipment. During design of compact heat exchangers, proper selection of passive insert is done according to heat exchanger working conditions. This paper contains a review of the use of passive enhancement techniques in the past and will help the designers to implement these techniques in heat exchange. Most commonly used passive heat transfer enhancement techniques considers use of Twisted tapes, wire coils, rough surfaces, ribs, fins, etc. This paper focuses on the use of twisted tapes in heat transfer enhancement.

2.2 A. Hasanpour, M. Farhadi , K. Sedighi et al.(2015)

In this paper, heat transfer and friction factor are experimentally studied in a double pipe heat exchanger which has an inner corrugated tube filled with various categories of twisted tapes from conventional to modified types which include perforated, V-cut and U-cut types. The twist ratios are 3, 5 and 7, the hole diameter ratio are 0.11 12 and 0.33, the width and depth ratio of the cuts vary from 0.3 to 0.6 and the Reynolds number is changed from 5000 to 15,000 of turbulent regime. All of these factors lead to the performance of more than 350 experiments. The results of the main parameters on heat transfer and pressure drop show that the Nusselt number and friction

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factor for all cases of twisted tape corrugated tube are more than the empty corrugated tube. Also the Nusselt number and friction factor for corrugated tube equipped with modified twisted tapes are higher than typical tapes except those of perforated types which lead to lower Nusselt number and friction factor.

2.3 Ravi Gugulothu, K Vijaya Kumar Reddy ,Naga Sarada Somanchi Etukuri, Lalith Adithya et al.(2017)

Heat transfer enhancement techniques are very important to save energy and using of optimal energy sources. It is the process of improving the performance of a heat transfer system. In the past decades, heat transfer enhancement technology has been developed and widely applied to heat exchanger applications such as automobiles, chemical industry and process industry. Much effort in the past decades has been aimed to provide economical methods for improving the performance of heat exchanger. Active, passive and compound techniques are used for the enhancement of heat transfer. Nowadays, there have been a large number of attempts to reduce size and cost of heat exchangers, in reducing size and cost of a heat exchanger are basically the heat transfer coefficient and pressure drop.

The performance of heat exchangers is essential for reducing size of the system and to make the system more compact and the performance depends on the rate of heat transfer. The high rate of heat transfer is desirable because, it reduces the fuel consumption. A wide range of experimental, theoretical and numerical studies has been performed on the effect of different parameters like Reynolds number, Nusselt number, Concentration of nanofluids and size of nano particle. The main objective of this research paper is to study the heat transfer enhancement using passive techniques as these are economical and no external additions are required.

2.4 Rafał Andrzejczyk Tomasz Muszynski Przemyslaw Kozak et al. (2019)

In this paper, the possibility of heat transfer enhancement in the U-bend exchanger was presented. Experimental research has been carried out for four individual heat exchanger constructions i.e. plain tube in tube, turbulized tube in tube, plain U-bend and U-bend with turbulator. Also, heat transfer experiments for various boundary conditions were performed to obtain reference values. In case of U-bend exchanger with and without turbulator, tests were conducted based on the water-water system. The study covered a wide measuring range, i.e. Re = 800–9000 - on the jacket side, P_{el} = 500–1400 W (for reference) cold water temperature of 9°C and hot water of 50°C. The exchangers were made from a copper pipe with an external diameter of 10 mm and 18 mm and wall thickness of 1 mm. The helicoidal vortex generator was made from brass wire with a diameter of 2.4 mm, coil diameter 13 mm and pitch 11 mm. For these geometries, the values of pressure drop and rate of heat transfer were determined. The comparison of heat transfer efficiency was performed based on *NTU-ε* method. For the same thermal-flow parameters, wire inserts provide up to 280% heat transfer enhancement and 85% higher heat transfer rate.

2.5 SombatTamnaYingyongKaewkohkiatSompol SkullongPongjet Promvong et al. (2017)

An experimental work on heat transfer enhancement in a round tube by insertion of double twisted tapes in common with 30°V-shaped ribs has been conducted. Air as the test fluid flowed through the test tube having a constant wall heat-flux with Reynolds number (Re) from 5300 to 24,000. The combined vortex generators (called-ribbed twisted tape") were obtained by incorporating V-shaped ribs into the edges of double co-twisted tapes having a similar twist ratio of 4. The effect of pertinent V-rib parameter such as four relative rib heights, (called "blockage ratio",BR¼b/D¼0.07, 0.09, 0.14 and0.19) and a relative rib pitch, (PR¼P/D¼1.9) at an attack angle of rib,α¼30°on thermal characteristics was investigated. The experimental results reveal that the heat transfer and pressure drop in terms of the respective Nusselt number and friction factor for the V-ribbed twisted tapes show the increasing trend with the rise of Re and BR. The V-ribbed twisted tape withBR¼0.19 yields the highest heat transfer and friction factor. However the maximum thermal enhancement factor is about 1.4 for the V-ribbed twisted tape atBR¼0.09 but is around 1.09 for the twisted tape.

2.6 Xu Liang, Xi Lei, Zhao Zhen, Gao Jianmin, Li Yunlong et al. (2018)

Conjugate heat transfer of air and steam in a rectangular channel with 90° ribs along two opposite walls was investigated experimentally and numerically. The stainless steel test section was 80 mm × 40 mm × 2.5 mm and the ribs were 80 mm × 2.5 mm × 2.5 mm with 25 mm between ribs. The tests investigated the effects of coolant mass flow rate (the corresponding Reynolds numbers in the range of 10,000-50,000) on the conjugate heat

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transfer enhancement with the ribs. Two conjugate heat transfer calculation methods with different models were developed. For the first model (CHT-Q model) solid domain was viewed as a uniform internal heat source with the adiabatic exterior surfaces, while for the second model (CHT-T model) the outwall temperature was specified by the fitting polynomials of measured data with the zero internal heat. Comparisons between the experimental and numerical results showed that the SST k–ω turbulence model was more suitable for the conjugate heat transfer in such channels. Regardless of numerical error, an approximation of heat loss was specified by the successive trial calculations of the CHT-Q model, while a relatively accurate heat loss was evaluated by the post-processing of the CHT-T calculation. Local heat transfer coefficient can be determined accurately by the quantified heat loss of test system. The critical impact of conjugate heat transfer was demonstrated. Furthermore, the steam coolant compared to air exhibited a higher heat transfer performance by 12–25% for both the ribbed and smooth walls at the same Reynolds number.

2.7 Pongjet Promvongea, Pattarapan Tongyotea, Sompol Skullong et al. (2019)
An experimental work has been conducted to explore the influence of the combined V-rib and chamfered-V-groove vortex generator (VG) on flow and heat transfer behaviors in a heat exchanger channel having a constant heat-flux on the top wall. Firstly, the V-shaped ribs were mounted on the plain top-wall with a view to creating multiple vortex flows inside. The investigated geometrical parameters were three relative rib pitches (RP = P/H = 1.0, 1.5 and 2.0) and relative rib heights (called "blockage ratio", RB = e/H = 0.3, 0.4 and 0.5) at a single attack angle (α = 45°). Secondly, the ribs were again placed on the chamfered-V-grooved top-wall having three relative groove-pitches (RP = 1.0, 1.5 and 2.0) like the rib case but at a fixed groove width and depth. Air as the test fluid flowed through the heat exchanger channel for Reynolds number (Re) ranging from 5300 to 23,000. Influences of the newly designed heat exchanger surface on the Nusselt number (Nu) and friction factor (f) have been examined and compared with the flat surface data at similar test conditions. The experimental result reveals that the combined rib-groove with small RP and large RB yields the heat transfer and friction loss higher than the one with large RP and small RB. Nevertheless, thermal enhancement factor (TEF) obtained at a constant pumping power shows that the combined rib-groove case with PR = 1.5 and RB = 0.4 provides the highest value around 1.907. To explore the influence of the rib thickness on thermal performance, the rib thickness size was reduced to be a very thin rib, called the "baffle". The study points that at PR = 1.5, the baffle-groove with RB = 0.3, 0.4 and 0.5 provide, respectively, TEF around 2.12, 2.14 and 2.11, indicating that the baffle-groove performs better than the rib-groove around 13%.

3. PROBLEM DEFINATION

The performance of heat exchanger can be improved to perform a certain heat transfer duty by heat transfer enhancement techniques. The heat transfer enhancement able the size of the heat exchanger to be considerably decreased.

Most of the investigations on heat transfer coefficient are for constant wall temperature or constant heat flux. The situation of constant wall temperature is idealizes in heat exchangers with phase change such as condensers. The boundary condition of constant heat flux finds applications in electrically heated tubes and nuclear fuel elements. However the case of fluid –fluid heat exchanger has not been studies well. In current work the fluid to fluid heat exchanger is taken into consideration and analyzed flow. Forced convection and tube side heat transfer coefficient are taken into consideration for analysis of heat exchanger.

Due to lack of experimental data available double pipe heat exchanger regarding effect of pitch of twisted tape insert in inner tube of double pipe heat exchanger. Experments were carried out in the lab itself to determine effectiveness, overall heat transfer coefficient, LMTD, NTU, capacity ratio and heat transfer rate for double pipe heat exchanger using with or without inserts.

4. HYPOTHESIS

4.1 Conical-Tape, V Shaped Tape, Rectangular rib
It is well known that energy transport is considerably improved if the flow is stirred and mixed well. This has been the underlying principle in the development of enhancement techniques that generate swirl flows. Among the techniques that promote secondary flows, twisted-tape inserts are perhaps the most convenient and effective.

They are relatively easy to fabricate and fit in the tubes of shell-and-tube or tube-fin type heat exchangers. A typical usage in the multi-tube bundle of a shell-and Tube heat exchanger. The geometrical features of a conical tape, as depicted in Fig, are described by its 180º cone pitch H, the diameter. In most usage, the helical twisting nature of the tape, besides providing the fluid a longer flow path or a greater residence time, imposes a helical force on the bulk flow that promotes the generation of secondary circulation. The consequent well-mixed helical swirl flow significantly enhances the convective heat transfer.

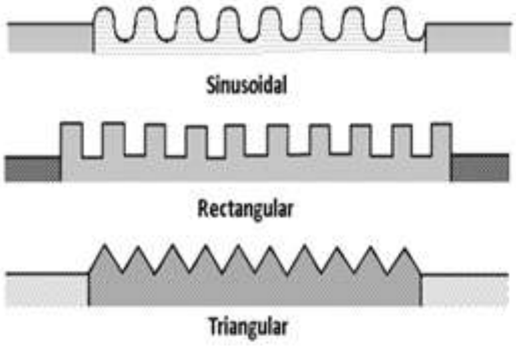

Figure 3: rib geometry on surfaces

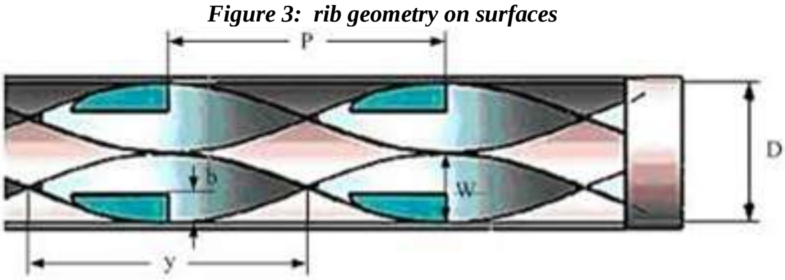

Figure 4: (b) v shaped tape
Fig 4.1 (c) pitch of v shaped tape

5. OBJECTIVES

Heat transfer enhancement plays an important role in many industries. Their applications include heat exchanger, air conditioning, heating and cooling in evaporators, chemical reactors and refrigeration systems. There are different techniques to enhance heat transfer such as active, passive or a combination of both. Several techniques are used to increase heat transfer and decrease cost and size of equipment. During design of compact heat exchangers, proper selection of passive insert is done according to heat exchanger working conditions. This contains a review of the use of passive enhancement techniques in the past and will help the designers to implement these techniques in heat exchange. Most commonly used passive heat transfer enhancement techniques considers use of Twisted tapes, wire coils, rough surfaces, ribs, fins, etc. This paper focuses on the use of twisted tapes in heat transfer enhancement.

Twisted tape leads to increase in heat transfer coefficient but it also gives rise to pressure drop. Several researchers have studied different configuration of twisted tape inserts and did experimentation. Several configurations of twisted tape inserts are full-length twisted tape, short-length twisted tape, full-length twisted tape with varying pitch and regularly spaced twisted tape. The following section discusses work carried out by different researchers: Behabadi did experimental investigation on the heat transfer coefficients and pressure drop during condensation of HFC-134a in a horizontal tube fitted with different twisted tape inserts. The cooling water flows in the annulus and the refrigerant flows in the inner copper tube. The experiments were carried out for a plain tube and four tubes with twisted tapes inserts consisting of 6, 9, 12 and 15 twist ratios. From the experiments it is observed that the twisted tape with twist ratio of 6 results in the highest enhancement in the heat transfer coefficient and the maximum pressure drop compared to the plain tube on a nominal area basis. The enhancement obtained in heat transfer and the pressure drop is increased by 40 and 240% when compared with the plain tube. Also it is seen that the twisted tape with the twist ratio of 9

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has the minimum pressure drop and it has the best performance in enhancing the heat transfer. Empirical correlations are developed to predict smooth tube and swirl flow pressure drop.

6. METHDOLOGY

Basic components of double pipe tube type heat exchanger

Some of the basic components of a double pipe heat exchangers are as given below:

6.1 Tubes

The tubes are the basic component of the shell and tube heat exchanger, providing the heat transfer surface between one fluid flowing inside the tube and the other fluid flowing across the outside of the tubes. It is therefore recommended that the tubes material should be highly thermal conductive otherwise proper heat transfer will not occur. The tubes may be seamless or welded and most commonly made of copper or steel alloys.

6.2 Tube sheets

The tubes are held in place by being inserted into holes in the tube sheets and there either expanded into grooves cut into the holes or welded to the tube sheet. The tube sheet is usually a single round plate of metal that has been suitably drilled and grooved to take the tubes however where the mixing between two fluids must be avoided, a double tube sheet may be provided. The space between the tube sheets is open to the atmosphere so any leakage of either fluid should be quickly detected. The tube sheet must withstand to corrosion. The tube sheets are made from low carbon steel with a thin layer of corrosion resisting alloy metallurgically bounded to one side.

6.3 Shell

The shell is simply the container for the shell side fluid, and the nozzles are the inlet and exit ports. The shell normally has a circular cross section and is commonly made by rolling the metal plate of appropriate dimensions in to cylinder and welding the longitudinal joint. In large heat exchanger, the shell is made out of low carbon steel wherever possible for the reason of economy, though other alloys can be and are used when corrosion or to

high temperature strength demand must be made. International Journal of Innovative and Emerging Research in Engineering Volume 2, Issue 1, 2015 62

6.4 Impingement plates

When the fluid under high pressure enters the shell there are high chances that if the fluid will directly impinge over the tubes then their breakage or deformation may occur. To avoid the same the impingement plates are installed to waste the kinetic energy of fluid upto some extent so that the fluid may impact the tubes with lower velocity.

6.5 Channel covers

The channel covers are round plates that bolt to the channel flanges and can be removed for the tube inspection without disturbing the tube side piping. In smaller heat exchangers, bonnets with flanged nozzles or threaded connections for the tube side piping are often used instead of channel and channel covers.

6.6 Baffles

Baffles serve two functions; Most importantly, they support the tubes in the proper position during assembly and operation and prevent vibration of the tubes caused by flow induced eddies, and secondly, they guide the shell side flow back and forth across the tube field, increasing the velocity and heat transfer coefficient.

Fig 6.6: Schematic diagram of component double pipe type heat exchanger

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