Review on Different Passive Methods on Heat Exchanger

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Abstract - *Heat Exchanger is device that is used to transfer the thermal energy(Enthalpy) between two or more fluids, between a solid surface and a fluid, or between solid particulates and a fluid at different temperatures and in thermal contact. Heat Exchanger is a device which is used to transfer the heat from one medium to another with or without mixing the media. Heat Exchanger are used for cooling and heating processes. Common example of heat exchanger are shell and tube heat exchanger, automobile radiators, condensers, evaporators, air preheater and cooling towers. Heat Exchanger are classified according to number of passes, Flow arrangement etc. There are various types of heat exchanger e.g. Shell and tube heat exchanger, Parallel flow heat exchanger, Counter flow heat exchanger etc. There are various techniques are used to make heat exchanger compact which is called heat exchanger augmentation techniques and they are broadly classified as active, passive and compound techniques. Active methods require external power to input process and passive methods do not require any additional energy or power to improve thermohydrulic. Passive methods are widely used in both experimental and numerical applications when investigating heat transfer enhancement and frictional losses to save energy and costs. Performance of the system. Twisted tape (Insert), Grooves and Nano fluid comes under passive techniques and this are used to increase overall performance of heat exchanger. The present review comprises investigations on the enhancement of heat transfer using different twisted tape. Various effects of different twisted tape.*

Key Words: Heat transfer augmentation techniques, Different passive method, Thermal performance factor, nusselt number, friction factor.

1. INTRODUCTION

Heat Exchanger are device designed to transfer the heat between two or more fluid i.e. liquids, vapors, or gases of different temperature. They are widely used in refrigeration, air conditioning, power plant, chemical plant etc. This device is widely used in industry both for cooling and heating large scale industrial processes. The type and size of heat exchanger used can be tailored to suit a process depending on the type of fluid, its phase, temperature, density, viscosity, pressure, chemical composition and various thermodynamic properties. In many industry processes there is waste of energy or a heat stream that is being exhausted, heat exchanger can be used to recover this heat and put it to use by heating different stream in the process. This practice saves a lot of money in industry. In waste water treatment, heat exchanger plays vital role in maintain optimal temperatures within anaerobic digesters to promote the growth of microbes that removes pollutant. The common heat exchanger used are double pipe and plate frame heat exchanger. Heat exchanger classified according to different criteria e.g. according to flow arrangement. Number of passes etc. According to flow arrangement they are classified as parallel flow heat exchanger, counter flow heat exchanger, shell and tube heat exchanger, double pipe heat exchanger etc. Compact heat exchanger is characterized by a high level of heat transfer enhancement due to their geometrical features and particularly the shape of their heat transfer surface that maximize the heat transfer rate by the generation of local turbulence at the expense of increased pressure drop. On other hand heat transfer enhancement techniques applied to tubular heat exchangers seek to promote local turbulence by mechanical means. Heat transfer augmentation techniques improve heat transfer coefficient and bring about reduction in heat transfer area. Heat transfer augmentation techniques are used to make the equipment compact, to achieve high heat transfer rate using minimum pumping power, minimize cost of energy and material, increase efficiency of process and system, reduce volume and weight and for given temperature difference improved heat transfer. Heat transfer enhancement is process of increasing effectiveness of heat exchanger. This can be achieved when power given to system increased or when the pressure losses generated by the device reduced. Heat transfer augmentation techniques are classified into three categories active, passive and compound. Active techniques require external power input for the enhancement of heat transfer e.g. mechanical aids, surface vibration, fluid vibration, injection etc. Passive techniques do not require external power input. There are various techniques are used like twisted tape inserts, groove, Nano fluid etc.

1.1 Passive Technique

Passive technique is one of the heat transfer augmentation technique. Passive technique is referring to the thermodynamics of conduction, convection and radiation to complete the heat transfer process. These technologies are most commonly used. These techniques generally use surface or geometrical modification to the flow by using inserts or additional devices. They promote higher heat transfer coefficient by disturbing or alternating the existing flow behavior (expect for extended surface) which also leads to increase the pressure drop. Passive techniques have the advantage over active technique as they do not require any direct input of external power. Twisted tape, wire coils, extended surfaces, 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 different passive techniques.

Coiled Tubes

Coiled tubes are appropriate for more compact heat exchanger. These methods produce secondary flows which support higher heat transfer coefficient. Salimpour [1] performed an experimental investigation in order to study the heat transfer characteristics of temperature dependent property engine oil inside shell and coiled tube heat exchangers. They found that the coil side heat transfer coefficients of coiled tubes with larger pitches are less than those of the ones with smaller pitches; and the effect of pitch on Nusselt number is more discernible in high temperature. Aly [2] has been carried out a numerical study to investigate the heat transfer and pressure drop characteristics of water based Al2O3 Nano fluid flowing inside coiled tube in tube heat exchangers. He showed that the friction factor increases with increase of curvature ratio and there is no pressure drop penalty with increasing volume concentration up to 2%.

Extended Surfaces (Fin, Louvered Strip, Winglet)

Fins are surface that extend from an object to increase the rate of heat transfer to or from the environment by increasing convection. The amount of conduction, convection, or radiation of an object determines he amount of heat transfer increasing temperature gradient between the object and the environment, increasing the convection heat transfer coefficient, or increasing the surface area of the object increase the heat transfer. The aim of introducing these methods is to crate swirl turbulence and secondary flow. Fins are quite often found in industry, especially in heat exchanger industry as in finned tubes of double-pipe, shell-and-tube and compact heat exchangers. As an example, fins are used in air cooled finned tube heat exchangers like car radiators and heat rejection devices. Also, they are used in refrigeration systems and in condensing central heating exchangers. Moreover, fins are also utilized in cooling of large heat flux electronic devices as well as in cooling of gas turbine blades. Fins are also used in thermal storage heat exchanger systems including phase change materials. To the best knowledge of the authors, fins as passive elements for enhancing heat transfer rates are classified according to the following criteria.

(1) Geometrical design of the fin.

(2) Fins arrangements.

(3) Number of fluidic reservoirs interacting with the fin.

(4) Location of the fin base with respect to the solid boundary.

(5) Composition of the fin.

Mohammed and sabzpooshani [3] studied single pass solar air heater with fins and baffles attached over the absorber plate. They showed that attaching fins and baffles leads to noticeable increase comparison with the simple air heater. With increasing the mass flow rate, the rate of enhancement of outlet temperature reduce sharply. Eiamsa-ard et al. [4] investigated the louvered strip inserted on concentric tube heat exchanger. They confirmed that the use of louvered strip leads to a higher heat transfer rate over the plain tube The use of the louvered strip with backward arrangement leads to better overall enhancement ratio than that with forward arrangement around 9-24%. The effect of using louvered strip insert placed in a circular double pipe heat exchanger on the thermal and flow fields utilizing various types of Nano fluid was studied by Mohammed et al. [5]. They found the Nusselt number is augmented by around 4 times for the louvered strip insert than that of the smooth tube the forward louvered strip arrangement can promote the heat transfer by approximately 350-400% at the highest slant angle 300 and pitch of 30 mm while the backward arrangement could improve the heat transfer by approximately 367-411%.

Swirl Flow Device

Swirl flow devices causes swirl flow or secondary flow in the fluid. A variety of devices can be employed to cause this effect which includes tube inserts, altered tube flow arrangements, and duct geometry modifications. Among the swirl flow device, twisted tape inserts had been very popular owing to their better thermal hydraulic performance in single phase, boiling and condensation forced convection, as well as design and application issues. This device produces secondary recirculation on the axial flow for single phase or two phase flows heat exchanger.

2. Twisted tape

The Twisted tape inserts introduced by Sir Whitham et al. There are many kinds of twisted tape inserts used for heat transfer enhancement factor. Inserts play important role as turbulence promoters in the heat exchangers. Twisted tapes are the metallic strips twisted with some appropriate techniques at preferred shape and dimension, inserted in the flow. The twisted tape inserts are widely used in heat exchanger for heat transfer augmentation because twisted tape inserts increase heat transfer rates with less friction factor penalty on pumping power. There are number techniques used in heat exchanger for creating turbulence in flow. Inserts also gives compactness to heat exchanger. The type of twisted tapes are as follows:

1. Typical Twisted Tape
2. Helical Twisted Tape
3. Tapered Twisted Tape
4. Wire Coil Insert
5. Anti-Clockwise and Clockwise Twisted Tape

2.1 Typical Twisted tape

These tapes have length equal to the length of exchanger tube. An experimental investigation for a solar water heater with twisted tape inserts having twist pitch to tube was studied by Kumar and Prasad [6]. They found that twisted tape generate turbulences superimposed with swirliness inside the flow tube and consequently result in enhancement heat transfer. Decreasing the values of twist ratio leads to increasing values of heat transfer rate and pressure drop. Esmaeilzadeh et al. [7] investigated heat transfer and friction factor characteristics of Al2O3-water Nano fluid through circular tube with twisted tape inserts with various thickness at constant heat flux. They showed that the use of twisted tapes increase friction factor due to larger contact surface and reduction of fluid free flow area which causes high speed swirl flow. Finally, the convective heat transfer enhancement outweighs the effect of friction factor increase, leading enhanced thermal performance.

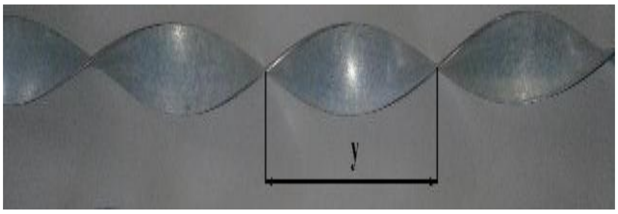

Fig -1: Typical Twisted tape

2.2 Helical Twisted tape

Eiamsa-ard et al, [8] studied the heat transfer enhancement attributed to helically twisted tapes. They observed that heat transfer rate and friction factor increases as the tape twist ratio and helical pitch ratio decreases, while the thermal performance shows opposite trend. Experimental investigations of heat transfer, friction factor and thermal performance of solar water heater system fitted with helical and Left-Right twist has been performed by Jai sankar et al. [9]. They showed that the helical twisted tape induces swirl flow inside the riser tubes unidirectional over the length. But, in Left-Right system the swirl flow is bidirectional which increases the heat transfer and pressure drop when compared to helical system. Bhuiya et al. [10] investigated experimentally the enhancement of heat transfer of a tube fitted with double helical tape inserts with different helix angles. It was clearly noted that the Nusselt number, friction factors, and thermal enhancement efficiency were increased by decreasing of helix angles under the same operating conditions. As it is shown in Figure 16, the maximum thermal enhancement efficiency (⍰) of 215% was found with use of the double helical tape insert with helix angle 9∘ at high Reynolds number [11].

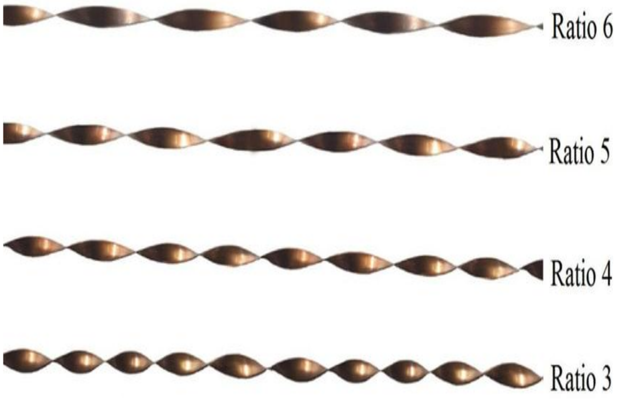

Fig -2: Helical Twisted tape

2.3. Tapered Twisted tape

Piriyarungrod et al. [12] studied the effects of inserted tapered twisted tapes, their taper angle and twist ratio on heat transfer rate, pressure drop, and thermal performance factor characteristics. They reported that thermal performance factor tended to increase with increasing taper angle and decreasing tape twist ratio. The effects of inserted tapered twisted tapes, their taper angle and twist ratio on heat transfer rate, pressure drop and thermal performance factor characteristics have been reported. The experiments were carried out by using the tapered twisted tapes with 4 different taper angles which θ= 0.0° (typical twisted tape), 0.3°, 0.6° and 0.9°. At each taper angle, the tapered twisted tapes were twisted at three different twist ratios (y/W) of 3.5, 4.0 and 4.5. All tapes were tested under turbulent flow regime for Reynolds numbers between 6000 and 20,000. A twist ratio is defined as the ratio of twist length (y) to twisted tape width at the large end (W). The plain tube was also tested for comparison. Heat transfer enhancement and friction loss increased with decreasing taper angle and twist ratio. Thermal performance factor tended to increase with increasing taper angle and decreasing tape twist ratio. For the present range, the tube with the tape with taper angle (θ) of 0.9° and twist ratio (y/W) of 3.5 yielded the maximum thermal performance factor of 1.05 at Reynolds number (Re) of 6000.

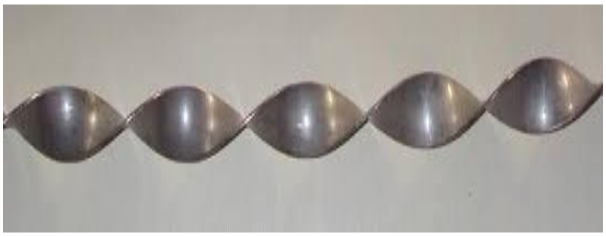

Fig -3: Tapered Twisted tape

2.4 Wire Coil Insert

Transverse or helical ribs, for example, coiled wire inserts, are an attractive method to create the surface roughness. The coiled wire inserts intensify the disturbances of laminar boundary layer and promote redevelopment of the thermal and hydrodynamic boundary layers in the tube flow effectively. More ever helical coiled wire can be used to generate secondary flow which helps to enhance the heat transfer rate with increment of vorticity in the tubular flow. They have also some advantage in relation to other passive methods such as easy manufacturing and installation; lower manufacturing cost; better fluid mixing and disturbance of laminar boundary layer. According to the study the heat transfer coefficient for the tube in heat exchanger using coil wire inserts gives higher coefficient compared to the plain tube. The fact that the maximum heat transfer enhancement can be achieved for tube with the thickest wire was discovered by an investigation on the effect of coiled wire thickness on heat transfer enhancement during forced convection-condensation of R-22. And Nusselt number increases with increasing of wire thickness. Nusselt number increases as decrease of pitch ratio.Gunes et al. [13] studied the wire coiled insert on heat transfer enhancement in heat exchanger. In the experiment the result shows that pressure drop increases with decreasing distance between the coiled wire and the tube wall.

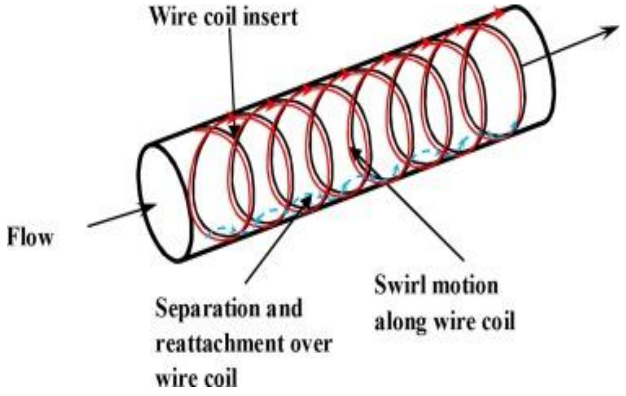

Fig -4: Wire Coil Insert.

2.5 Anti-Clockwise and Clockwise Twisted Tape

Smith Eiamsa-ard and Pongjet Promvonge [14] studied the turbulent heat transfer and flow friction characteristics in a circular tube equipped with two types of twisted tapes: (1) typical twisted tapes and (2) alternate clock-wise and counterclockwise twisted tapes (C–CC twisted tapes). Nine different C–CC twisted tapes are tested in the current work; they included the tapes with three twist ratios,y/w= 3.0, 4.0 and 5.0, each with three twist angles=30o,60oand 90o. The experiments have been performed over a Reynolds number range of 3000–27,000 under uniform heat flux conditions, using water as working fluid. The obtained results reveal that the C–CC twisted-tapes provide higher heat transfer rate, friction factor and heat transfer enhancement index than the typical twisted-tapes at similar operating conditions. The results also show that the heat transfer rate of the C–CC tapes increases with the decrease of twist ratio and the increase of twist angle values. Depending on Reynolds number, twist ratio and twist angle values, the mean Nusselt numbers in the tube fitted with the C–CC twisted tapes are higher than those with the typical ones and the plain tube around 12.8–41.9% and 27.3–90.5%, respectively. The maximum heat transfer enhancement indexes of the C–CC twisted tapes with=90ofory/w= 3.0, 4.0 and 5.0, are 1.4, 1.34 and1.3, respectively. In addition, correlations of the Nusselt number and the friction factor for using the C– CC Twisted tapes are also determined. Both predicted Nusselt number and friction factor are within ±15% and±15% deviation compared to the experimental data.

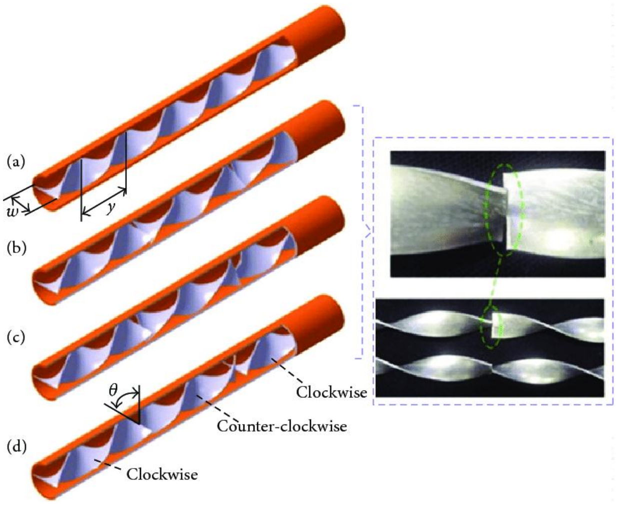

Fig -5: Anti-Clockwise and Clockwise Twisted Tape

3. Nano fluids

A Nano fluid is a fluid containing nanometre-sized particles, called nanoparticles. These fluids are engineered colloidal suspensions of nanoparticles in a base fluid. The nanoparticles used in Nano fluids are typically made of metals, oxides, carbides, or carbon nanotubes. Common base fluids include water, ethylene glycol and oil. Nano fluids have novel properties that make them potentially useful in many applications in heat transfer, including microelectronics, fuel cells, pharmaceutical processes, and hybrid-powered engines, engine cooling/vehicle thermal management, domestic refrigerator, chiller, heat exchanger, in grinding, machining and in boiler flue gas temperature reduction. They exhibit enhanced thermal conductivity and the convective heat transfer coefficient compared to the base fluid. Knowledge of the rheological behaviour of Nano fluids is found to be critical in deciding their suitability for convective heat transfer applications. Nano fluids also have special acoustical properties and in ultrasonic fields display additional shear-wave reconversion of an incident compressional wave; the effect becomes more pronounced as concentration increases. Nano fluids are fluids that contain suspensions of nanoparticles of high thermally conductive materials like carbon, metals, and metal oxides into heat transfer fluids to improve the overall thermal conductivity. These nanoparticles are usually of order 100nm or less. Nanoparticles could be either spherical or cylindrical like carbon multi walled nanotubes [102]. The advantages of properly engineered nano fluids according to Ding et al. [10] include the following:

(a) higher thermal conductivities than that predicted by currently available macroscopic models.

(b) excellent stability.

(c) little penalty due to an increase in pressure drop.

(d) little penalty due to an increase in pipe wall abrasion experienced by suspensions of millimetre or micrometre particles.

The suspensions of nanoparticles in nanofluids are found to increase the effective thermal conductivity of the fluid under macroscopically static conditions. Numerous studies have been carried on this aspect. On the other hand, there are few number of studies have been conducted on other aspects like phase change behaviour of nanofluids. Moreover, there are few researches that demonstrate the enhancement in the convection heat transfer coefficient caused by nanofluids. The enhancements in thermal conductivity of nanofluids are due to the fact that particles surface area to volume ratio increases as the diameter decreases. This effect tends to increase the overall exposed heat transfer surface area for a given concentration of particles as their diameters decreases. Further the presence of nanoparticles suspensions in fluids tend to increase the mixing effects within the fluid which produce additional increase in the fluid's thermal conductivity due to thermal dispersion effects as discussed by Xuan and Li [15]. Nanofluids possess a large effective thermal conductivity for very low nanoparticles concentrations. For instance, the effective thermal conductivity of ethylene glycol is increased by up to 40% percent higher than that of the base fluid when a 0.3 volumetric percent of copper nanoparticles of mean diameter less than 10nm are suspended in it. This enhancement is expected to be more as the flow speed increases resulting in an increase in the thermal dispersion effect. Lee et al. measured the effective thermal conductivity of Al2O3 and CuO suspended nanoparticles in water and ethylene glycol. They found out that the effective thermal conductivity was enhanced by more than 20% when a 4% volume of CuO/ethylene glycol mixture was used. Ding et al. indicated that Xuan and Li showed that the convection heat transfer coefficient was increased by ~60% for an aqueous-based nanofluid of 2% Cu nanoparticles by volume, but the nanofluid only had an effective thermal conductivity approximately 12.5% higher than that of the base liquid. Also, they indicated that Wen and Ding observed a~47% increase in the convective heat transfer coefficient of aqueous c-alumina nanofluids at x/D ~60 for 1.6vol.% nanoparticle loading and Re=1600, which was much greater than that due to the enhancement of thermal conduction (<~10%). Amazingly, Ding et al. showed that nanofluids containing 0.5wt.% of carbon nanotubes(CNT)produced enhancement in convection heat transfer which may be over 350% of that of the base liquid at Re = 800, and the maximum enhancement occurs at an axial distance of approximately 110 times the tube diameter. This increase is much greater than that due to the enhancement of thermal conduction (<~40%). The observed large enhancement of the convective heat transfer

4. CONCLUSION

This review paper emphasizes on different Passive techniques. It may be concluded that using all passive techniques are used to increase the heat transfer. we got different result of thermal performance factor, nusselt number, friction factor. We got thermal performance factor more than unity for maximum geometry of twisted tape inserts of air as a working fluid & got thermal performance factor more than unity for each geometry of twisted tape inserts of water as a working fluid.

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