A REVIEW ON ENHANCEMENT OF HEAT TRANSFER RATE BY VARIOUS PASSIVE METHODS

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Abstract: As in present world we are living, shortage of non renewable energy is a great issue that the society can be facing in near future. Thus a great deal of work is being done in optimizing the usage of the energy resources that we currently have available to ourselves. Thermal energy is a form of Energy which we depend upon to a great extent, so better utilization of it is of great importance. Thermal energy can be noticed with bodies having high temperature and that energy we extract with the help of a Heat Exchanger. Fluid heat exchangers are used to transfer heat from a high temperature fluid to a low temperature fluid usually separated by a conducting wall. The enhancement of rate of this energy transfer is one of the works that is currently gaining the interest of many researchers. A typical concentric tube heat exchanger finds its usage in the heat recovery from engine cooling circuits, refineries and paper industries. This present research work is to review and acknowledge the work that has been done in this field in past years and to identify the possible ways by which the work can be further carried on.

1. Introduction:

A heat exchanger is a device that transfers heat from a high thermal potential fluid to a low thermal potential fluid by either letting the fluids come in direct contact with each other or by separating them with a conductive material wall. Such devices have their utility in thermal power stations, paper industries, chemical industries and many more. These days energy crisis plays a key role on human life and utilizing the energy resources efficiently by improving heat transfer rate of heat exchanger has become a topic of high interest. A huge amount of research is going on the topic of enhancement of heat transfer rate techniques

The enhancement of heat transfer rate is noticed to be achieved by applying various active and passive methods by various researchers and this paper is about discussing and acknowledging their efforts in this field. The heat transfer rate can be increased by increasing either the surface area of heat exchanger or the overall heat transfer coefficient and in order to make the heat exchanger more compact, we are restricted with a given surface area and weight. The only option remains is to increase the heat transfer coefficient of the system.

2. Literature Survey:

The heat transfer process focuses on heat transfer rate, and on which a great amount of research work have been done in the form of research papers, book chapters and patents. A brief review of same has been presented in this section.

Tikendra Nath Verma et al [1]: The main aim of this work to estimate the heat transfer performance of proposed fabricated heat exchanger using corrugated and non-corrugated pipes. Pitch and depths are varied in case of corrugated pipe. Authors have achieved the maximum heat transfer coefficient and Nusselt number with helical shaped ribs of 4 mm pitch and 1.5 mm depth with the variations in Reynolds number from 5000 to 17000, mass flow rates from 0.03 to 0.13 kg/s and 0.04 to 0.14 kg/s for cold and hot fluid respectively

S.M. Shahril et al (2017) [2]: The study shows the performance analysis of a shell-and-double concentric tube heat exchanger (SDCTHEX) using commercially available CFD software ANSYS FLUENT 14.0. First, the SDCTHEX having fixed inner tube diameter is compared with classical shell-and-tube heat exchanger (STHEX) for their thermo-hydraulic performances for different mass flow rates of the hot fluid. Then, the effects of different inner tube diameters on the performance of SDCTHEX are investigated. The results show that the average percentage increase in overall heat transfer rate per overall pressure drop of SDCTHEX with inner tube diameter equal to 8/12 mm/mm, is nearly 343% higher than that of STHEX while the total friction power expenditure of SDCTHEX is reduced by around 85.5% as compared to that of STHEX. Also the overall heat transfer rate per overall pressure drop of SDCTHEX is sensitive to inner tube diameter. It is found that U=DP for the mass flow rate of 22.5 kg/s is maximum and found to be about 400% higher at inner tube diameter of 12/16 mm/mm with respect to the

STHEX. The results of simulation present that, the SDCTHEX has a higher heat transfer performance while maintaining a lower pressure drop.

Valerio Giovannoni et al (2017) [3]: The excessive heat losses from the hot parts of the Ultra-Micro Gas Turbines (UMGTs) leading to low thermal efficiency, fluid dynamic losses at micro scale need further investigation and the necessity of developing a material able to withstand combined thermal and mechanical stresses. A method to increase thermal efficiency and limiting fuel consumption is to recover heat from the combustion products to preheat the cold incoming mixture. Therefore, this study focuses on the interactions between combustion and heat exchanges at small scale. A numerical model of a three concentric tubes combustion chamber was developed and investigated with the aim of evaluating its thermal performances. A 17 species, 73 reactions skeletal mechanism able to describe methane oxidation was utilized for the purpose. A parametric study was carried out varying the mass flow rate and the thermal conductivity of the walls. Also, the effects of utilizing a flame holder in the combustion chamber were investigated. Results showed how the triple tube combustion chamber allows a good level of regeneration and the inclusion of the flame holder produces additional benefit in terms of heat transferred to the cold mixture.

Dhahri Imen et al (2017) [4]: A solution is presented for flow inside a heat exchanger. An analytical approach is developed and validated with a numerical simulation using ANSYS CFX code module taking account different boundary condition in the inlet. The temperature distribution of the laminar flow is presented, which is related to Reynolds number and the hydraulic diameter of the heat exchanger.

Pourya Forooghi et al (2017) [5]: Flow and heat transfer in a single tube of a flat-tube heat exchanger with passive inserts as means of heat transfer enhancement is numerically investigated. The tube geometry is taken from an industrial design with an elaborate pattern of passive inserts (bumps) distributed on the two walls of the channel. The channel is not symmetric in the span wise direction, leaving an insert-free area on one side of the channel. The quasi-DNS simulations are carried out at three Reynolds numbers, spanning the threshold where laminar-turbulent regime transition is believed to occur based on previous experiments. Results show that the non-symmetric distribution of passive inserts is disadvantageous, particularly in the event of laminar-turbulence regime transition

Denise A. Haskins et al (2016) [6]: This paper presents and discusses the results of Computational Fluid Dynamic (CFD) analyses for calculating the friction pressure losses of isothermal flows of liquid sodium, water, and helium gas, on the shell side of annular heat exchangers (HEXs) of concentric, helically coiled tubes. The analyses covering wide ranges of HEX geometrical parameters and flow Reynolds numbers, varied the number of HEX coils from 4 to 16, and examined the effect of refining the numerical mesh grids on the results. Expressing the friction factor in terms of an effective HEX porosity, a weighted average of the areal and volume porosities, collapses the friction factor results on a single curve for developing a continuous dimensionless correlation. The developed correlation, which agrees with the CFD results for 5.0 < Re < 107 to within ±6%, is given as:

f ¼ ð58=ReÞ þ ð0:315=Re0:02Þ:

For low Re flow in helically coiled tubes HEXs, the friction pressure losses increase proportional to the mass flux, G, but inversely proportional to De2. For high Re flow, these losses increase proportional to the mass flux to the 1.98 power, G1.98, and inversely proportional to the equivalent hydraulics diameter to 1.02 power, De 1.02. For low Reynolds flows (Re 6 20), the HEX pressure losses are _10% lower than in open annuli, but become higher with increased Reynolds number to as much as 97% at Re = 107.

Ravi Gugulothu et al (2016) [7]: A reduction in energy consumption is possible by enhancing the performance of heat exchanger and it is one of the most important devices related to energy and heat transfer. Heat transfer is one of the most important processes in industrial and consumer products. For decades, efforts have been done to enhance heat transfer, reduce the heat transfer time. Minimize of heat exchangers and finally increase energy and fuel efficiency. Nano fluid is a new engineering fluid which could improve the performance of heat exchanger. Nano fluids have greater potential for heat transfer enhancement and highly suited to application in practical heat transfer processes. Heat exchanger has potential applications such as heat recovery from engine cooling circuit, oil cooling; de-super heating in refrigeration and air conditioning, dairy and chemical industry, pharmaceutical industry and refinery. In many industrial applications the conventional heat transfer fluids are refrigerants, water, engine oil, acetone and ethylene glycol etc. An important in energy efficiency is possible from the perspective of the heat transfer fluids. Enhancement in heat transfer is always in demand and it depends on the cooling rates, so the need for more efficient heat transfer systems increases, researchers have introduced various heat transfer enhancement techniques.

Vijaya Kumar Reddy K et al (2016) [8]: A helical coil tube heat exchanger is generally applied in industrial applications due to its compact structure, larger heat transfer area and higher heat transfer capability etc. In the present study a tube in tube helically coiled heat exchanger has been modeled for fluid flow and heat transfer characteristics for different fluid flow rates in the inner as well as outer tube. A CFD analysis has been conducted for a TTHC heat exchanger. The geometry was developed in PRO-E 5.0 with meshing performed in ICEM-CFD and was exported to Fluent 14.0.

Zaid S. Kareem et al (2015) [9]: The article presents an extensive review of numerical and experimental studies on heat transfer enhancement, which covers the laminar and turbulent flow regions in the corrugations, especially in corrugated tubes. This paper dealt with 95.74% of papers published in corrugated tubes for different applications to offer one article representing a database stop for the designers and authors whom concerning and dealing with heat transfer enhancement in corrugated tubes.

Sombat Tamna et al (2016) [10]: 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. 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 how the increasing trend with the rise of Re and BR. The V-ribbed twisted tape with BR 0.19 yields the highest heat transfer and friction factor. However, the maximum thermal enhancement factors about 1.4 for the V-ribbed twisted tape at BR 0.09 but is around 1.09 for the twisted tape with no rib.

Zaid S. Kareem et al (2015) [11]: A Computational Fluid Dynamics was employed for water flowing at low Reynolds number in spiral corrugated tubes. This article aimed for the determination of the thermal performance of unique smooth corrugation profile. The Performance Evaluation Criteria were calculated for corrugated tubes, and the simulation results of both Nusselt number and friction factor were compared with those of standard plain and corrugated tubes for validation purposes. Results showed the best thermal performance range of 1.8–2.3 for the tube which has the severity of 45.455 .10 to 3 for Reynolds number range of 100–700. The heat transfer enhancement range was 21.684%–60.5402% with friction factor increase of 19.2–36.4%. This indicated that this creative corrugation can improve the heat transfer significantly with appreciably increasing friction factor.

Xuemei Su et al (2015) [12]: experimentally investigated that at two mass flow of 147.2 $kgm^{-2}s^{-1}$and 191.5kgm^{-2} s^{-1} and fluxes ranges from 9023Wm^{-2} to 39051$Wm^{-2}$of saturated LN2 corrugated stainless steel horizontal tube are investigated, due to area augmentation the heat transfer is enhanced as and increase with increase heat flux and mass flow flux the local heat transfer coefficient increases and strong dependence on heat flux.

Ki Jung Ryu et al(2015) [13]: Analysed the performance of heat exchanger, by report on heat transfer and fluid flow correlation use corrugated louvered fins .With respect to the ratio of the fin pitch to the louver pitch (Fp/L/pc)col burn factor j and Friction factor f is investigated. The j and f correlations independent of Ll/Fl in the range 0.8 <Ll/Fl< 0.9, because the changes in the pressure-drop and heat-transfer characteristics were small (±5%).We also established the flow efficiency g correlation, which is applicable for 0.3 <Lp sin La/Fp< 0.7 in 100 < Re < 3000 within an error of ±15%.

Hamed Sadighi Dizaji et al (2015) [14]: experimentally investigated that the outcomes of heat flow, thermodynamically and geometrically characteristics on exergy loss in shell and coiled tubes heat exchangers. Pressure drop and heat transfer characteristics in shell and coiled tube heat exchangers have been widely studied. Exergy loss increases with the increase of shell or coil side flow rate. Dimensionless exergy loss can increase or decrease with the increase of flow rates. It depends on Cmin. Both of the exergy loss and dimensionless exergy loss increase with the increase of coil side inlet temperature and decrease of shell side inlet temperature.

Morteza Khoshvaght-Aliabadi et al (2015) [15]: Indirect channels like the serpentine tubes are widely utilized in many engineering applications such as chemical and petrochemical industries, air conditioning and refrigeration systems, and modern energy conversion. Nano fluids are advanced and potential coolants, which can provide appropriate thermal performance in heat exchange devices. In this paper, fluid flow and heat transfer characteristics of Cu–water nano fluid inside five serpentine tubes with variable straight section lengths are experimentally investigated. The concentrations of 0%, 0.1%, and 0.4% wt. of stabilized Cu–water Nano fluid are examined with variation of flow rates in the range of 1–5 l/min. The Cu–

water nano fluids are produced by a one-step method, namely electro-exploded wire (EEW) technique, and the thermo-physical properties of the nano fluids required for the analysis are systematically measured to obtain accurate results.

Vamsi Mokkapati et al (2014) [16]: The purpose of this work is to investigate gas to liquid heat transfer performance of concentric tube heat exchanger with twisted tape inserted corrugated tube and to evaluate its impact on engine performance and economics through heat recovery from the exhaust of a heavy duty diesel generator (120 ekWrated load).A study to improve the effectiveness of a diesel exhaust heat recovery System (concentric tube heat exchanger) of Ruby, Alaska has been Conducted. The improved system is the original heat exchanger inserted with a twisted tape. The goal of the present work is to maximize the heat recovery rate by optimizing the design of twisted tape insert. The physical size of the heat exchanger, twist ratio and exhaust back pressure change are the constraints. In this study, the outer tube is a plain tube and the inner tube is an annularly corrugated tube with and without twisted tape inserts. The following paragraphs summarize the findings obtained from this study.

Ji Chan Park et al (2014) [17]: It analyzed, Steel catalyst coated metallic foam and heat exchanger type reactor was developed with the consideration of the severe heat and mass transfer limitations in the Fischer–Tropsch synthesis reaction. The system showed highly desirable results not only in terms of its lowCH_4 and CO_2 selectivity's, but also its high productivity, because of its enhanced heat and mass transfer properties in the reaction. The CO conversion decreased, but the C5+ selectivity increased, with increasing synthesis gas flow rate, because the former was strongly affected by the reaction contact time and the latter was deeply related to the superficial velocity of the synthesis gas in the reactor. Furthermore, this system effectively prevented the formation of CH_4, even at high temperature, and reduced the diffusion restrictions of the hydrocarbons produced in the catalyst pores with the temperature.

Dillip Kumar Mohanty et al (2014) [18]: Analysis of heat exchanger fouling using previous data of a shell and tube heat exchanger has been found to be a very useful methodology to predict and consequently improve the overall performance of a process plant involved with such systems. The developed fouling prediction model provides a priori picture about the fouling

Cong Chen et al(2013) [19]:had analyzed for enhanced heat transfer of mixed molten hitec salt in corrugated tubes with three different sets of structural parameters. Experimentally find out that smooth tube and transversally corrugated tube, the drag coefficient for transversally corrugated tubes, is larger than the smooth tube. Correlations between drag coefficient and Re number were obtained for transversally corrugated tubes with different parameters and for smooth tubes. The drag coefficient for transversally corrugated tubes is larger than that for smooth tubes, and the drag coefficient for tubes of smaller pitch is larger than that for tubes of larger pitch.

Shriram S. et al (2013) [20]: It observed that the $Al_2O_3$is a promising candidate for the enhancement of overall convective heat transfer coefficient of water. The heat transfer characteristics of nano fluids improve with Reynolds number significantly as compared to base fluids. For same range of Reynolds number, addition of nano particles to the base fluid enhances the heat transfer performance and results in higher heat transfer coefficient than that of the base fluid. The heat exchanger is fabricated from Steel concentric inner tube with a length of 1000 mm.

Zan Wu et al (2013) [21]: For both laminar flow and turbulent flow, no anomalous heat transfer enhancement was found. The heat transfer enhancement of the nano fluids compared to water is from 0.37% to 3.43% according to the constant flow velocity basis. Figure of merit based on the constant Reynolds number can be misleading and should not be used for heat transfer enhancement comparison. Additional possible effects of nano particles, e.g., on the convective heat transfer characteristics of the nano fluids are insignificant compared to the dominant thermo physical properties of the nano fluids. The heat transfer enhancement of the five nano fluids over tap water ranges from 0.37% to 3.43% for the constant flow velocity basis for both laminar and turbulent flows. Figure of merit based on the constant Reynolds number can be misleading and should not be used to evaluate heat transfer enhancement because the net result.

XuXiu-qing et al (2013) [22]: The corrosion rate reached the maximum of 0.195 mm/a when the medium temperature was 60 ◦C. The corrosion course of refinery heat exchanger tubes at different corrosion medium temperatures are divided two parts: one is the formation of corrosion products below 50 ◦C, the other is the formation and dissolution of corrosion products film. The corrosion products are mainly composed of $CaCO_3$, SiO_2 and Fe_3O_4. And the under scale corrosion and the electrochemical corrosion are the main forms of corrosion for 10# carbon steel.

Carsten Schroer et al (2012) [23]: Specimens cut from two different sample materials of T91 ferritic /martensitic steel were exposed for up to8000 h to flowing oxygen-containing lead–bismuth eutectic (LBE) at 450 _C, 2 m/s flow velocity and oxygen concentration averaging 1.1 _ 10_6 mass%. Under these conditions, T91 forms an essentially bi-layer corrosion scale consisting of magnetite and iron–chromium spinel, whose thickness as a function of exposure time was measured in the light-optical microscope. The accompanying metal recession was assessed in dependently by a metallographic method as well. The quantitative data was analysed using different kinetic laws, in consideration of the results of electron-microscopic investigations and energy-dispersive X-ray micro-analyses of the scale.

S. Peth kool et al (2011) [24]: had investigated experimentally heat transfer enhancement and friction factor with nine helically corrugated tube with three different pitch –to-diameter ratios (p/DH=0.18,0.22, and 0.27)and three rib-height to diameter ratios(e/DH=0.02,0.04 and 0.06). It is found that the friction factor and thermal performance factor increase with increasing the Pitch ratio (P/DH) and the rib-height ratio (e/DH). Behaviors of the exchanger over the next period of operation were noticed. It observed that maximum error is found to be 1.25% during training phase and 0.064% during the testing phase.

3. Conclusion:

Afetr going through the above mentioned works done by the honorable researchers it can be noticed that the enhancement of heat transfer rate can be done by introducing turbulence in the flow of any or both the fluids. The passive methods used by the above researchers are the corrugations produced over the outer surface of inner tube in order to create turbulence in the flow of fluid flowing through the annulus, or by inserting twisted inserts inside the inner tube to create turbulence in the flow of fluid inside in inner tube. Out of the above mentioned works we can see that S.M. Shahril et. Al (2017) has achieved the best results in the enhancement, as the results show that the average percentage increase in overall heat transfer rate per overall pressure drop of SDCTHEX with inner tube diameter equal to 8/12 mm/mm, is nearly 343% higher than that of STHEX while the total friction power expenditure of SDCTHEX is reduced by around 85.5% as compared to that of STHEX.

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