Recapitulation on Shell & Tube Heat Exchanger

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Abstract— Heat exchanger is one among promising thermal device in which heat transfer takes place between high temperature and low temperature fluid. Among various classifications of heat exchangers, specific major focus was shown by researchers with indirect contact type heat exchangers. Still numerous research works were under progress with such type of heat exchangers. In this study a short review on shell and tube type heat exchangers, an indirect contact type is discussed. Such reviews are based on design of heat exchangers, methods to improve effectiveness, selection of heat transfer fluid, mass flow rate, area occupied by heat exchanger etc. In addition methods to improve rate of heat transfer with optimized input parameters were also highlighted.

Key words: Heat Exchanger, Shell & Tube

I. Introduction

The applications of heat exchangers are widely adopted in many systems comprising of exchanging of heat. Their need and efficiency are most adorable for increasing the performance of the systems. The heat exchangers are adhered in many industrial applications to construct a bridge between varying temperature ranges. The heat exchangers accomplish a connection between cold and hot fluid, such that it also recover the equipment from predominant heating which leads to reduction in efficiency and life time. In heat exchanger the conduction and convection plays a vital role for establishing higher performance. Now days the design of heat exchangers are much more concentrated, such that the higher efficiency must attended with minimum surface area. In that regard the shell and tube heat exchangers paved a good satisfactory result. The main boon of shell and tube heat exchangers is the higher heat transfer is achieved with in the small volume. Since it comprises of n number of tubes within the constrained length its heat transfer rate will be higher compared to other heat exchangers. The one of the most valuable design consideration parameter of heat exchangers is to increase the heat transfer area, this was achieved in shell and tube heat exchangers. With this advantage, this type of heat exchangers are widely used in micro applications such that to overcome space constraints.

II. Literature survey

Gabriela Huminic et.al [1] has undergone a review on summarizing the enhancement of the convection heat transfer in heat exchangers using nano fluid. Experiments were conducted on application of nano fluids in various type of heat exchangers like plate heat exchangers, shell and tube heat exchangers, compact heat exchangers, double pipe heat exchangers. Most of the experimental and numerical studies showed that nano fluids exhibit an enhanced heat transfer coefficient compared to its base fluid and it increases significantly with increasing concentration of nanoparticles as well as Reynolds number.

Z.Wang et.al [2] conducted experimental investigation on microtubes with inner diameter 0.8mm are arrayed with hexahedral shell to serve as the heat transfer unit in the mini heat exchanger. The inlet temperature and mass flow rates for both shell side and tube side fluids can be adjusted and the heat transfer coefficient is calculated to evaluate the efficiency of the heat transfer and some of parameters such as diameter, temperature difference, mass flow rate etc. on the heat transfer coefficient are investigated. Experimental results indicate that heat transfer coefficient is improved by 126% & 260%.

Anand Kumar Solanki et.al [3] set forth a work on, condensation heat transfer coefficients and frictional pressure drops of R-134a in a inner tubes comprise of one smooth straight tube and one micro-fin helical coiled tube, which are made of copper with the cooling water flowing inside the shell in opposite flow direction are experimentally investigated The experimental measurements are carried out at mass fluxes of 75, 115, 156 and 191 kg m-2s-1 and saturation temperatures of 35 and 45 degree Celsius. Finally, the average heat transfer coefficient for micro-fin helical coiled tube increases, as mass flux or vapor quality of refrigerant increases. On the other hand side, the frictional pressure drop also increases with the rise of mass flux and vapor quality, but, it decreases with the increase of saturation temperature.

Jan WAJS et .al [4] presented a research on, the original compact shell-and-tube heat exchanger with circular minichannels condenser for the domestic micro heat and power plant investigated. The heat exchanger is equipped with turbulizing baffles inside the shell. The shell itself is made of a tubular sleeve having an inner diameter of 0.067 m and the length of 0.38 m. The tube bundle constitutes of 103 pipes arranged hexagonally with the active length equal to 0.31 m. The tubes inner diameter equals to 0.002 m and the wall thickness is 0.001 m. During the tests the condenser was cooled by water with ethanol as a working fluid. The obtained performance of the in-house micro-CHP system is very promising and demonstrates its potential.

B. Anil Kumar Naik et.al [5] conducted an experiment on heat transfer using three different non-Newtonian nanofluids comprising of Fe2O3, Al 2O3 and CuO nanoparticles in aqueous carboxy methyl cellulose (CMC) base fluid. The studies were carried out to determine enhancement in heat transfer compared to base fluid (aqueous CMC solution) in a shell and helical coil heat exchanger. Non-Newtonian nano fluids containing nanoparticles in the concentration range of 0.2–1.0 wt% were prepared. Nano fluid and water were used on shell side and tube side respectively. The thermal analysis was carried out to determine overall heat transfer coefficient and shell-side Nusselt number, at different conditions such as flow rate of cold water (0.5–5 lpm), shell side fluid (nanofluid) temperature (40–60 °C) and stirrer speeds (500–1500 rpm). The overall heat transfer coeffcient and Nusselt number increase with increasing flow rate of cold water (Dean Number), temperature of nanofluid and stirrer speed.

Shuang Cao et. Al [6] designed a set up to conduct a study with the copper tube which has an inner diameter of

14.70 mm with a 1600 mm heat transfer length. Mass fluxes and vapour mass qualities covered ranges of 198.8-504.7 kg per sq.m and 0.291-0.976. Condensation heat transfer coefficients are increased with increases of mass fluxes and vapour mass qualities. For better thermal performance it is operated at inclined flow. The yield minimum values at the horizontal position with the inclination angles from – 30^o to 30^o.

Amin Moosavi et. Al [7] undergone a couple of academic investigations which have focused on air bubble injection inside the shell-and-coiled-tube heat exchangers in order to increase the performance and effectiveness of these heat exchangers. Air flow rate was changed between 1LPM and 5LPM. Coil side water flow rate was kept at 1LPM (inlet temperature of 40 ^{0}C) and shell side water flow rate was varied between 1LPM and 5 LPM (inlet temperature of 15^{0}C. Air injection into the shell side of the heat exchanger increased the overall heat transfer coefficient 6-187% depending on air flow rate. If the amount of shell side water flow rate is increased more and the amount of overall heat transfer coefficient is increased.

Claudio Zilio et. Al [8] experimentally compares the heat transfer performance of four different shell and tube gas coolers implemented in a 5 kW, R744 water/water heat pump controlled by a back pressure valve as expansion device. The tubes bundle consists of 10 tubes in a 30° arrangement for all the gas coolers with different tube geometries: smooth, corrugated, internally grooved, and corrugated and internally grooved, respectively. The results were carried out at fixed gas cooler inlet water temperature of around 25 °C and by imposing two inlet gas cooling pressures: 8 MPa and 10 MPa, by varying the water flow rate was varied from 340 to 786 l h-1.. The results obtained from the simulation of the gas cooling process highlight the effective heat transfer capabilities of the enhanced surfaces showing their qualities and limitations, allowing for an advanced optimization of this kind of gas coolers.

AbazarVahdat Azad et.al [9] established a study to investigate application of alumina nanofluid to enhance the efficiency of heat exchangers while reducing energy consumption and overall cost. In the case studied in this paper, over 185% increases in tube side heat transfer coefficient allows reduction of heat exchanger length and flow velocity and thereby reduction of pressure drops up to 94%. Consequently, the overall cost of the heat exchanger reduced more than 55%.

Jaafar Albadr et.al [10] conducted a detailed study which reports the forced convective heat transfer and flow characteristics of a nanofluid consisting of water and different volume concentrations of Al_2O_3 nanofluid (0.3-2) % flowing in a horizontal shell and tube heat exchanger counter flow and turbulent flow conditions are investigated. The Al_2O_3 nanoparticles of about 30 nm diameter are used in the present study. Friction factor increases with the increase in particle volume concentration. This is because of the increase in the viscosity of the nanofluid.

Huaishuang Shao et.al [11] encrypted a research on numerical model based on a scaled experimental facility is developed to analyse the shell side thermal hydraulic performances. The velocity of two phase is about 0.1-0.3 m/s and varies slightly inside the tube bundle. The average HTC heating tubes in the middle column decreases greatly along the two phase mixture flow direction.

Mohsen Mirzaei et.al [12] investigated that the thermal efficiency and cost are two most important parameters in the design of the heat exchangers. The results of the optimization show that the increase in the thermal efficiency is more than 28%, which proves that the constructal theory can be used as an efficient method for designing the shell-and-tube heat exchanger. B.Farajollahi et.al [13] carried out experiment on heat transfer characteristics of Al_2O_3 / water and TiO_2 /water nanofluids are measured in a shell and tube heat exchanger under turbulent flow condition. Both nanofluids possess better heat transfer behaviour at the lower and higher concentrations

Sunil Shinde et.al [14] presented a detailed study which deals with the numerical and experimental investigation of heat and fluid flow in shell and tube heat exchanger with continuous helical baffles on shell side. Results revealed that the larger helix angles(30°, 38°and50°) adds to lower heat transfer and lower pressure drop and smaller helix angles (10°, 19°and 21°) resulted in higher heat transfer as well as higher pressure drop. The experiments were carried out on shell and tube heat exchanger for helical baffles with 25° helix angle and results were compared with segmental baffles. For material comparison between FRP and stainless steel, the deviation of heat transfer coefficient is 8–10%. From the Numerical & experimental results it is confirmed that the performance of tubular heat exchanger can be improved by helical baffles instead of conventional segmental baffles. Maximum effectiveness is observed for helix angle of 21°.

III. Conclusions

1) Shell and tube heat exchangers capable of transferring effective heat with reduced area occupied are still in demand.
2) An optimal design of shell and tube heat exchanger converting input in to effective output is under recent study by many researchers.
3) Micro channel type shell and tube heat exchanger with effective and competitive heat transfer rate in comparison with normal channel heat exchangers is trending research gap.
4) Changes in core tube configuration, using nano fluids, using inserts inside core tube may also increase heat transfer rate of heat exchangers.
5) Right selection of innovative materials (i.e for both shell and tube arrangements), innovative flow pattern through tubes, innovative baffle designs, research on innovative inserts which produces less pressure drop were also been focused by researchers of recent days.

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