INVESTIGATING THE SHELL AND TUBE TYPE HEAT EXCHANGER USED IN DIFFERENT INDUSTRY AND ALSO INVESTIGATE THE PROCESS PARAMETERS

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1. INTRODUCTION

A heat exchanger is a device used to transfer heat between a solid object and a fluid, or between two or more fluids or gases. It is device in which heat is transferred from one fluid to another fluid .the hot fluid gets cooled, and the cold fluid is heated. 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 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.

2. LITERATURE REVIEW

In order to increase the heat transfer rate of heat exchanger it is necessary to analyze different parameters of heat exchanger. Many of the researchers have already analyzed the effect of different parameter and optimize different parameter. Some of the works in this area are

Jayavel et. al [1], Numerical study on confined flow over circular tube isolated from the bundle of circular tubes in a compact and widely spaced heat exchangers, to explore the influence of flow shedding frequency under forced convection heat transfer. The flow and heat transfer characteristics such as pressure, frictional and total drag coefficients, skin friction coefficient, Strouhal number, volume goodness factor, convective heat transfer coefficient, Nusselt number and effectiveness are estimated for different dimensionless transverse pitch ratios and Reynolds numbers. The highly confined flow past a circular tube makes the flow steady, highly attached and postponed the flow separation, flow shedding and also advances the laminar to turbulent transition. The increases in flow attachments and transitions have been confirmed by observing the frictional drag and skin friction coefficients and also through various contours respectively. Three different flow shedding nature has been observed when Reynolds number increases at different blockage ratios. It is confirmed that the heat transfer enhancement in compact and widely spaced heat exchanger at blockage ratios less than or equal to 3 does not depend on flow shedding frequency. Also, at low Reynolds number region, the heat transfer enhancement is due to highly attached flow. But the gradual increase in Reynolds number advances laminar to turbulent transition and responsible in heat dissipation.

CHOUDHURY et. al. [2], A transient analysis has been carried out on a hybrid solar water heater which comprises a rock bed air heater with optimum design parameters in conjunction with an air-to-water transverse fin shelland- tube heat exchanger (mixed air and unmixed water type) in which cold water from the storage tank receives heat from the hot air coming out of the air heater which flows in the shell at right angles to the water flowing in the tubes. The system's performance has been evaluated for typical winter weather conditions in Delhi for different combinations of flow rates of air and water for different volumes of the water storage tank. No hot water is assumed to be withdrawn front the tank to serve the load. A comparative analysis of the system's performance with and without a rock bed in the air heater reveals about I I C higher temperature of storage tank in the former at 50 kg/h m 2 air flow rate. With both the air heater types, although the system performance was observed to increase with the rates of air and water flow, no significant improvement in system performance was achieved at .~t,, >/ Z~/,,.

Juan et.al. [3], This paper presents a disjunctive mathematical model for the optimal design of air cooled heat exchangers.The modelinvolves seven discrete decisions which are related to the selection of the type of the finned tube, number of tube rows, number of tube per row, number of passes, fins per unit length, mean fin thickness and the type of the flow regime. Each discrete decision is modeled using disjunctions, boolean variables and logical propositions. The main continuous decisions are: fan diameter, bundle width, tube length, pressure drops and velocities in both sides of the ACHE, heat transfer area, fan power consumption. Then, the resulting generalized disjunctive programming model is reformulated as a mixed integer non-linear programming, implemented in GAMS (general algebraic modeling system) and solved using a branch-and-bound method. The proposed model was successfully verified by comparing the obtained output results with different designs taken from the literature. Then, the model is solved to obtain the optimal designs corresponding to the following optimization criteria:

a) minimization the total annual cost which includes investment (heat transfer area) and operating cost (fan power consumption),
b) minimization the heat transfer area
c) minimization the fan power consumption.

Benhammou et. al. [4], In this paper, a new design of passive cooling system which consists in an Earth-to-Air Heat Exchanger (EAHE) assisted by a wind tower is presented. This system is intended for the summer cooling in hot and arid regions of Algeria. A transient analytical model was developed in order to investigate the influence of design parameters on the performance of the EAHE. The model of the EAHE is validated against both theoretical and experimental data carried out by other authors. Since it is well-known that the performance of the EAHE systems is more influenced by the air flow velocity, another model was presented to predict the air velocity inside the buried pipe. Moreover, a burying depth of 2 m was adopted and the period under consideration is July where the ambient temperature exceeds 45 _C. This study was also extended to examine the behaviour of system during the whole year.

In addition, a sensitivity survey was curried out to investigate the influence of tower and pipe dimensions on the air flow velocity and the performances of the EAHE. Results showed that the wind tower dimensions (height, cross section) have not an important impact compared to the pipe dimensions (length, diameter).

Ramos et.al. [5], This paper applies CFD modelling and numerical calculations to predict the thermal performance of a cross flow heat pipe based heat exchanger. The heat exchanger under study transfers heat from air to water and it is equipped with six water-charged wickless heat pipes, with a single-pass flow pattern on the air side (evaporator) and two flow passes on the water side (condenser). For the purpose of CFD modelling, the heat pipes were considered as solid devices of a known thermal conductivity which was estimated by experiments conducted on the exact same heat pipe configuration under an entire testing range. The CFD results were compared with the experimental and the numerical results and it was found that the modelling predictions are within 10% of the experimental results.

Kuchhadiya et. al. [6], The Present work is carried out to investigate the thermal behavior of cross flow plate fin heat exchanger having offset strip fin. An experimental set up has been built in the laboratory to test the Plate fin Heat exchanger. Sets of experiments had conducted to determine the thermal performance of the given heat exchanger. Mass flow rate of cold fluid, mass flow rate of hot fluid, hot fluid inlet temperature, cold fluid inlet temperature, hot fluid and cold fluid inlet pressure are considered as input parameters.

Prasad et.al.[7], In the present work, the design and analysis of a multi-block heat exchanger has been carried out by applying the concept of constructional theory proposed by Bejan. The heat exchanger works on the principle of developing laminar flow in each block carefully designed to avoid fully developed heat transfer coefficient. The additional thermal interaction is provided by the special design allowing heat transfer in ports as well as collecting and distributing channels. Numerical simulations were carried out for different values of heat capacity rate ratios on finned and unfinned constructal heat exchangers and four cross flow heat exchangers (two finned and two unfinned).

Mahmoud et.al. [8], A bayonet tube heat exchanger is typically a pair of concentric tubes, the outer of which has a closed end that creates a clearance pass between the inner and annulus tube. This paper evaluates the impact of key parameters and operating conditions on the performance of a bayonet tube by utilizing computational fluid dynamic approach and Taguchi statistical method. A validated two-dimensional model, that considers conservation of mass, momentum and energy, was employed together with an L25 orthogonal array (OA) of Taguchi matrix of five factors and five level designs to determine the optimum combination of parameters as well as their interactions.

Manish et.al. [9], Transient temperature response of cross-flow heat exchangers having finite wall capacitance with both fluids unmixed is investigated numerically for perturbations provided in both temperature and flow. Results are presented for step and ramp change in flow rate of hot and cold fluids, and step, ramp, exponential and sinusoidal variation in hot fluid inlet temperature.

Kumar et.al. [10], In the present study a tube-in-tube helically coiled (TTHC) heat exchanger has been numerically modeled for fluid flow and heat transfer characteristics for different fluid flow rates in the inner as well as outer tube. The three-dimensional governing equations for mass, momentum and heat transfer have been solved using a control volume finite difference method (CVFDM). The renormalization group (RNG) k–ε model is used to model the turbulent flow and heat transfer in the TTHC heat exchanger. The fluid considered in the inner tube is compressed air at higher pressure and cooling water in the outer tube at ambient conditions.

Kim et.al. [11], The transient performance of an air-cooled condensing heat exchanger in a long-term passive cooling system was evaluated under a decay heat load modeled by the ANS-73 curve. An experiment was conducted in a 1/2500-volume scaled-down model of the emergency cool down tank (ECT) of the system integrated modular advanced reactor (SMART). It was confirmed that the scaled design requirement of cooling capacity of the air-cooled condensing heat exchanger was well satisfied under the decay heat load.

Jayakumara et. al. [12], Helically coiled heat exchangers, where one of the working fluids is flowing through helical coil, are used in various process industries due to better heat transfer characteristics and the resulting compact layout. Out of these, process requirements make some of the heat exchangers to operate in air–water two-phase region. Even though the characteristics of their operation with single-phase working fluids are well documented, it is not so for the case of two-phase flows. There do exist few experimental results on hydrodynamics of air–water flow through helical pipes. However numerical investigation, which can give much insight into the physics of the problem, is lacking and this is the subject matter of this paper.

Malleswara et.al. [13], The steady &ow of non-Newtonian polymer solutions on their own and together with air transverse to a bundle of circular rods, has been studied experimentally. In particular, the frictional pressure drop has been measured as a function of non-Newtonian power-law constants, &ow rates, voidage of bundles and the input fraction of air over wide ranges of conditions as: power-law &ow behavior index, 0.5 to 1; voidage values of 0.78 and 0.87–0.88; air velocity (super6cial), 0.09 to 0.28 m/s and liquid velocity (super6cial) 0.018 to 0.5 m/s. While the single phase &ow results for power-law liquids are in excellent agreement with an existing equation, the twophase pressure drop results are also in accordance with the form of the well-known Lockhart-Martinelli correlation. Based on these Results, it is suggested that a value of 5–10 for the Reynolds number based on rod diameter marks the limit of the laminar &ow in such systems.

Vijayarangan et.al. [14], Measurements of two-phase flow pressure drop have been made during a phase-change heat transfer process with refrigerant (R-134a) as a working fluid for a wide range of pressures right up to the critical pressure. The experiments were conducted in a uniformly heated vertical tube of 12.7 mm internal diameter and 3 m length over a heat flux range of 35–80 kW/m2, mass flux range of 1200–2000 kg/m2 s, exit quality range of 0.19–0.81 and for reduced pressures ranging from 0.24 to 1 with a fixed inlet subcooling of 3 _C. The measurements were compared with the predictions from the homogeneous flow model.

Mondalet.al. [15], the present work deals with an experimental investigation of the thermal performance of a natural draft wet-type cooling tower with counter flow arrangement. The authors perform a thorough analysis of the simultaneous heat and mass transfer phenomenon between air and water. The investigation mainly concentrates on the effect of crosswind on the thermal performance of the tower. Performance index parameters such as the temperature drop (Tdrop), effectiveness (e), and the tower characteristic ratio (KaV/L) are presented in the paper. Variation of the performance parameters in terms of inlet water temperature, water flow rate, and wind velocity is studied in a crosswind-influenced environment.

JHA et.al. [16], The performance parameters of a hybrid air-to-water solar heater has been presented in this paper for a cold climatic region in India. A conventional solar air heater in conjunction with an air-to water heat exchanger of finned-shell-and-tube type in which hot air from the collector transfers its heat to the cold water circulated from the storage tank during sunshine hours has been considered for the investigation. The steady state heat transfer analysis of the system shows that higher mass flow rate of air and/or lower mass flow rate of water result in higher storage tank temperature.

Quintero et.al. [17], Multilayered, counter flow, parallel-plate heat exchangers are studied theoretically and numerically. The analysis, carried out for constant property fluids, assumes a fully developed laminar flow with moderately large Peclet numbers in the flow channels, so that longitudinal conduction can be neglected in the fluids in first approximation. By way of contrast, both axial and transverse conduction effects are fully accounted for in the heat conducting plates, making the analysis relevant to the design of mini- and micro-heat exchangers. The exact solution for the temperature field is obtained in terms of eigen function expansions involving infinite sets of both positive and negative eigenvalues. Based on previous results, the eigen functions are expressed in terms of Whittaker functions, leading to an analytical eigen condition that provides the eigenvalues numerically. Making use of a newly defined orthogonality condition, the expansion coefficients are determined through an infinite system of linear equations that must be truncated to a sufficiently large number of terms to obtain a numerical solution of the problem.

Gómez et.al. [18], The present paper presents a theoretical analysis of a cross flow heat exchanger with a new flow arrangement comprehending several tube rows. The thermal performance of the proposed flow arrangement is compared with the thermal performance of a typical counter cross flow arrangement that is used in chemical, refrigeration, automotive and air conditioning industries. The thermal performance comparison has been performed in terms of the following parameters: heat exchanger effectiveness and efficiency, dimensionless entropy generation, entransy dissipation number, and dimensionless local temperature differences.

Starace et.al. [19], Despite their limitations, the cross flow compact heat exchangers are generally modeled by the e-NTU and LMTD methods and this mainly leads to the absence of effective consideration on the heat transfer geometry at the micro scale. At the same time, numerical analysis applied to compact cross flow heat exchangers, having different and complex finned surfaces respectively at the hot and cold sides, involves high computational costs. A powerful alternative design procedure is here proposed that takes advantage of both numerical and analytical approaches. Hot and cold sides are numerically modeled and predictor functions for heat transfer and fluid dynamic performance are obtained with regression technique, for both sides.

Leoni et.al. [20] **,**This work presents an analysis of the shell side flow in a shell and tube heat exchanger using Computational Fluid Dynamics (CFD). The heat exchanger has been designed with the software HTRI Xchanger Suite®,while CFD simulations have been performed with the computational package ANSYS Fluent 15.0. Both k-ε and SST turbulence models have been assessed and the SST model has shown to provide more accurate results for temperature prediction. Instead of using an uniform temperature on the tubes' walls, a linear temperature profile (provided by HTRI Xchanger Suite®) was used as boundary condition for the CFD simulations. Two single-segmental-baffle geometries have been considered: with and without baffle clearances. Simulations results with the SST turbulence model regarding mean velocity, temperature and pressure profiles in the shell side have been analysed and compared with those provided by HTRI Xchanger Suite®.

Min et.al. [21], Four methods are used to evaluate the performance of a membrane-type total heat exchanger, they are the numerical method with consideration of moisture adsorption heat, the numerical method with no consideration of that heat, the effectiveness-NTU method with consideration of that heat, and the effectiveness-NTU method with no consideration of that heat. Calculations are conducted for typical exchanger parameters and operating conditions. The results generated by these four methods are presented and compared. It is found that, although the effectiveness-NTU method is easy to use, it is incapable of yielding accurate results on moisture and enthalpy effectiveness.

Xing et.al. [22], The influences of the changes in geometrical factors, including the space bar thickness, the tube pitch in the first layer, the tube external diameter, the number of layers and the centre core diameter on flow and heat transfer performances in multi-stream spiral-wound heat exchangers are numerical investigated. The shell-side and tube-side Nusselt number and pressure drop per unit length increase with the increase of number of layers, centre core diameter, and tube external diameter, but decrease with the increase of space bar thickness and tube pitch in the first layer. Quantitatively estimation of the affecting performances of these five geometrical parameters is implemented by using the Taguchi method, and the result shows that the contribution rate of them are more than 5%. Thus, the multivariate correlations with the main geometrical parameters considered are developed for shell-side Nusselt number and friction coefficient.

3. Conclusion

After going through the literature survey it is found that the performance of heat exchanger depends on different parameters. From the literature survey it is finding that following parameters affect the performance of heat exchanger

- Number of tubes.
- Type of flow pattern
- Thermal conductivity of tube material
- Flow behavior pattern.
- Turbulence during the flow of working fluid.
- Time of contact in between two medium or fluid
- Mass flow rate of fluid and many other parameters

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