A Short Review on Double Pipe Heat Exchanger

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Abstract

Heat exchanger is a thermal device that transfers heat from high temperature fluid to low temperature fluid. Heat exchangers-based researchers proposed various classification of heat exchangers. Among which double pipe heat exchangers (DPHE) are commercially used in many industrial applications. Various classification of DPHE includes parallel, counter and cross flow. Numerous research works have been conducted with DPHE in terms of stand-alone parallel, counter and cross flow system. In addition, research works were also conducted to improve the performance of DPHE by using inserts, plenum at both ends, turbulators, varying geometry of the flow channels etc. In this study, we presented a short review on various DPHE research works in a manner to identify the right performance deciding parameters. In addition, the art of introducing artificial intelligence in the field of heat exchangers are also highlighted.

Keywords - *heat exchanger; performance; parameter; DPHE*

I. INTRODUCTION

In recent years, heat exchangers are extensively used in many industrial and engineering applications. Heat exchangers have been categorized based on flow directions(parallel-flow, counter-flow, and cross-flow), type of construction ofthe heat exchanger (such as tubular or plate heat exchangers), or onthe basis of way of contact between the fluids (direct or indirect).The type of heat exchanger to be used is determined by theprocess and the product specifications. The performance of the heatexchanger generally depends on the various physicalcharacteristicsof the fluid and the type of material used. One of the most simple and applicable heat exchangers is double pipe heat exchanger (DPHE). Many of small-scale industries use DPHEs due to their low cost of design and maintenance. In this type of heat exchangers, hot and cold fluids flow through concentric tubes where the temperature of hot fluid reduces from inlet to outlet and the temperature of cold fluid increases from inlet to outlet.

Recently, double pipe heat exchangers are on extreme focusby numerous scholastic researchers and scientific networks due to theirsignificance and explicit application in industries. Upcoming section consists of comparative review on DPHEs performance deciding parameters. It also addresses the trending research gap in the field of DPHE.

II. LITERATURE SURVEY

MohamadOmidi et.al [1] analyzed the development procedure of double pipe heat exchanger and heat transfer enhancement methods have also been widely discussed. Moreover, various studies concerning using nanofluids in double pipe heat exchanger have been discussed in detail. In this review, the correlations of Nusselt number and pressure drop coefficient are also presented.

M. Sheikholeslami et.al [2] presented a forced convective turbulent hydrothermal analysis in a double pipe heat exchanger.Perforated turbulators are used in annulus region. It is proved by experimentation that thermal performance enhances with augment of open area ratio and temperature gradient decreaseswith augment of pitch ratio.NSGAII is utilized to optimize the design. Maximum thermal performance obtained at η=1.59 which is occurred for Re=6000, λ=0.07, PR=1.06.

TianyiGao et.al [3] predicted the transient response of an unmixed-unmixed cross flow heatexchanger by numerically solving the established thermal dynamic model.Transient response for various mass flow rates and inlet temperatures areanalyzed.Transient conditions such as step and linear ramp functions are used for the variation of flow rate and step, ramp and exponential functions are applied to the fluid inlet temperature. This study provides fundamental insights that can improve the cooling unit performance of the heat exchanger.

Shuyong Liu et.al [4] designed a non-contacted double-walled-straight-tube heat exchanger for Lead-BismuthEutectic (LBE) loop KYLIN-II. Itis identified that the flow rate and temperature distribution influence the performance of the heat exchanger. The results of numerical simulation show that non-uniform LBE flow does not affect thermal performance of the heat exchanger filled with powder in the gap between tubes.

G.A. Quadir et.al [5] investigated the performance of a triple concentric pipe heat exchanger numerically using finite element method (FEM) under steady state conditions for both insulated as well as non-insulated conditions. The temperature variations predicted by using FEM follow closely to that of the experimental results. Parametric studies are also being carried out on individual design parameter of the heat exchanger.

Uttam Roy et.al [6]evaluated the performance parameters of shell and tube heat exchanger (STHX) through simulation modeling.The performance parameters include energetic plant efficiency, energetic cycle efficiency, electric power, fouling factor and cost are analyzed with the help of feed forward back propagation network (FFBN) algorithm. In the validation process different training algorithm are used to train the network structure. The result shows that the proposed system maximizes energetic plant efficiency, energetic cycle efficiency, and electrical power by 98.11%, 97.4%, and 96.35% respectively.

SoheilSoleimanikutanaei et.al [7] studied numericallythe effects of different tube spacing and the inlet water vapor mass fraction on the overallperformance of a membrane-based heat exchangerusing a combined condensationmodel based on the capillary condensation and condensation on a solid wall. The results were obtainedin terms of the Euler number, dimensionless volumetric heat transfer density, and contours of the watermass fraction and temperature distribution inside the transport membrane condenser (TMC) heat exchanger.

K. Manjunath et.al [8] presented the reviews of scientific work and provides the state-of-the-art review of second law of thermodynamic analysis of heat exchanger. In addition, the literature survey is based on the performance parameters such as entropy generation, energy analysis, production and manufacturing irreversibility. This review highlights the importance of first and second law investigations of heat exchangers leading to energy conservation.

SuxinQian et.al [9] discussed the fundamental principles, features and major differences of regeneration methods for various typical cooling technologies. In this study, the regeneration methods are grouped into three categories: recuperative type for steady state operated systems, regenerative type for systems under cyclicoperation, and heat recovery type for systems with solid-state functional materials. For each of the three regeneration methods, their physicalprinciples, a summary of their state-of-the-art development status, and assessments of their advantages,limitations and unique features are presented.

A. Bejan et.al[10] analyzed the flow architecture toward greater performance in a counter flow heat exchanger by attachingplenum with the core at both ends. In this configuration, the thermal resistance reaches its lowest value. This conclusion holds for fully developed laminar flow and turbulent flow through the core.

Kevin J. Albrecht et.al [11] presented a steady-state reduced-order model of a shell-and-platemoving packed-bed heat exchanger and is used to investigate the design considerations and performance limitations. It is an efficient modeling methodology for simulating moving packed-bed heat exchangers for the application of particle-to-sCO2 heat transfer in next-generation concentrating solar power (CSP) plants. Overall heat transfer coefficients for the particle-to-sCO2 heat exchanger atCSP operating temperature (500-800 °C) can approach 400 $Wm^{-2}K^{-1}$ using particle channel dimensions of 4 mm with particle diameters of 200 µm.

Han Xiaoxinget.al [12] investigated on novel concentric tube heat pipe heat exchanger. It was designed and expected to be utilized in integrated waste heat recovery equipment with higher heat transfer efficiency at lower temperature heat sources. The results showed that when the length of evaporator was 260 mm,the inclination angle was 60˚, the flow of cooling water was 0.5 m^3/h, the cooling water temperature was 30˚ C, the novel heat exchanger delivered a better heat transfer performance with maximum heat transfer quantity that is about 1600 W, and the average thermal resistance is 0.042˚C/W

Z. Said et.al [13] investigated on efficiency enhancement of the heat exchangers by maintaining the overall cost and energy consumption. Shell-and-tube heat exchanger operating withCuO/water nanofluid are investigated. Experimental outcomeshighlight the improvement of heat transfer due to nanofluids. As a result, overall heat transfer coefficient increased by 7%,convective heat transfer increased by 11.39% and a reduction in the area of 6.81% was achieved.

N. Piroozam et.al [14] investigated the thermal performance and fluid characteristics of counter flow heat exchangers (CFHEs). In this simulation, the influence of parameters is studied and CFHEs are solved unilaterally using various numerical methods. It has been concluded that all methods will improve the performanceof the CFHEs.

T.N. Verma et.al [15] estimated the heat transfer performance of heat exchanger using corrugated and non-corrugated pipes. In case of corrugated pipe, the pitch and depths are varied. The maximum heat transfer coefficient is achieved with helical shaped ribs of 4 mm pitch and 1.5mm 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. Length and diameter of pipes are 25.4 mm and 2000 mm. Artificial neural network is modeled for predicting the heat transfer coefficient.

R. Whalley et.al [16] analyzed the heat exchanger dynamically. The governing process is presented by energy balance model yielding the system and partial differential equations. Multivariable,multidimensional, Laplace transformed, distributed parameter formulation of heat exchanger representations isprovided.Suitable feedback control techniques are identified for the heat exchangers.

P.Wais[17] investigated on thermal efficiency of single row cross flowheat exchanger and compared to the fin/tube weight. The main parameters to be considered are finthickness, length and orientation of winglet. Numerical analyses are carried out to examine finned tube heatexchanger with and without winglets at the fin surface.

J.M. Gorman et.al [18] experimented on the thermal and fluid flow design of a double-pipe heatexchanger in which the wall of the inner pipe is helically corrugated. Comparison is made between smooth-walled double-pipe heat exchanger and corrugated double-pipe heat exchanger. Reynolds numbers for the investigated cases ranged from 420 to 2000.

Abdalla Gomaa et.al [19]presented the experimental and numerical investigation of triple concentric-tube heat exchanger with reference to the double tube heat exchanger. The fluid being used is water. Numerical CFD model is developed using a finite volume discretization method and is validated. Correlations of Nusselt number, friction factor and heat exchanger effectiveness with the dimensionless design parameters are also presented.

K.M.Shirvam et.al[20] employed Darcy-Brinkman-Forchheimerand K-Ɛ turbulent models to achieve heat transfer and exchanger effectiveness. The boundary parameters, Reynolds number, Darcy number and porous substrate thickness are studied. It is established that the mean Nusselt number increases by increasing Reynolds number and dwindling of the Darcy number and poroussubstratethickness.The maximum mean Nusselt number can be obtained for Re= 5000, Da = 10^{-5} and δ =1/3.To maximize only the effectiveness of heat exchanger then it attains at Re= 5000, Da=10^{-5} andδ =1.

III. CONCLUSION

Heat exchangers that are capable of transferring effective heat with reduced area occupied are still in demand.

Heat exchanger-based researchers are still trying to figure out an optimal design of heat exchanger that converts the given input into an effective output.

Many researchers increased the rate of heat transfer by introducing inserts, by changing the configuration of the core tube of heat exchanger and also by using nanofluids.

In recent years, many research works are carried out extensively in the core materials of heat exchangers and in flow patterns.

There is a trending research gap in artificial intelligence-basedDPHE's performance predicting algorithm [21] & [22]. It enables us to develop an optimal design of heat exchanger that provides maximum possible heat transfer.

Thus, by considering above suggestions, it is possible to develop an optimal design.

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