Shell & Tube Type Water Cooled Condenser Having Spiral Tube

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Abstract--- A Shell and Tube Condenser is a class of heat exchanger designs. It is the most common type of heat exchanger in oil refineries and other large chemical processes, and is suited for higher-pressure applications. As its name implies, this type of condenser consists of a shell (a large pressure vessel) with a bundle of tubes inside it. One fluid runs through the tubes, and another fluid flows over the tubes (through the shell) to transfer heat between the two fluids. Purpose of this review paper is to assess some aspect of the design of shell & tube type condenser having spiral tubes and validate with experimentally data with the use of CAD design software & make a model if it. The set of tubes is called a tube bundle, and may be composed of several types of tubes: plain, longitudinally finned, etc.

I. INTRODUCTION

In the simple type of straight tube condenser the efficiency of the condenser is not as much as obtained, because in this type of condenser water is come in the direct contact with steam which we are going to be cooled. On the other side by using spiral tubes in the condenser the contact time between water and steam is high so it will helps to improve the efficiency of the condenser. In this project work we are going to make a model in such a way that we can improve the efficiency by using the spiral tube in the shell and type condenser.

II. REVIEW

Heat exchanger are in a improve heat transfer rate. Shell and tube heat exchangers are use in a project work model that we can improve the efficiency by using the spiral tube. Several thermal design features must be considered when designing the shell and tubes in the shell and tube heat exchangers.

Jiangfeng Guo, Lin Cheng, Mingtian Xu et al [2009] observed in a present work, a new shell-and-tube heat exchanger optimization design approach is developed, wherein the dimensionless entropy generation rate obtained by scaling the entropy generation on the ratio of the heat transfer rate to the inlet temperature of cold fluid is employed as the objective function, some geometrical parameters of the shell-and-tube heat exchanger are taken as the design variables and the genetic algorithm is applied to solve the associated optimization problem. It is shown that for the case that the heat duty is given, not only can the optimization design increase the heat exchanger effectiveness significantly, but also decrease the pumping power dramatically. In the case that the heat transfer area is fixed, the benefit from the increase of the heat exchanger effectiveness is much more than the increasing cost of the pumping power.

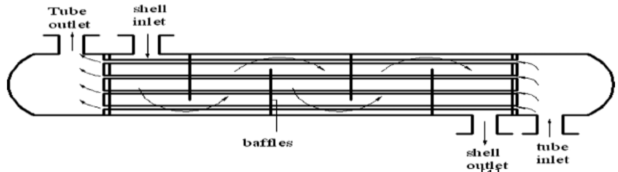

Fig. 1: Diagram of a typical STH [1]

In summary, based on the second law of thermodynamics a new heat exchanger optimization approach is developed. In this approach, the modified entropy generation number which can avoid the entropy generation paradox is taken as the objective function, the genetic algorithm is applied to solve the multi-variable optimization problems which not only yields the globe optimum solution but also demonstrates the flexibility to select the design variables and constraint conditions.

In the traditional optimization design of the STHE based on the first law of thermodynamics, the thermodynamic irreversible losses in a heat exchanger has not been accounted for. Furthermore it is found that the traditional optimization design with the total cost as the objective function suffers from decreasing the heat exchanger effectiveness. In this point the optimization approach developed in the present work is more advantageous.

V.K. Patel, R.V. Rao et al [2010] observed shell-and-tube heat exchangers (STHEs) are the most common type of heat exchangers that find widespread use in numerous industrial applications. Cost minimization of these heat exchangers is a key objective for both designer and users. Heat exchanger design involves complex processes, including selection of geometrical parameters and operating parameters. The traditional design approach for shell and- tube heat exchangers involves rating a large number of different exchanger geometries to identify those that satisfy a given heat duty and a set of geometric and operational constraints. However, this approach is time-consuming and does not assure an optimal solution. Hence the present study explores the use of a non-traditional optimization technique; called particle swarm optimization (PSO), for design optimization of shell-and-tube heat exchangers from economic view point. Minimization of total annual cost is considered as an objective function. Three design variables such as shell internal diameter, outer tube diameter and baffle spacing are considered for optimization. Two tube layouts viz. triangle and square are also considered for optimization. Four different case studies are presented to demonstrate the effectiveness and accuracy of the proposed algorithm. The results of optimization using PSO technique are compared with those obtained by using genetic algorithm (GA).

Heat exchangers are an integral component of all thermal systems. Their designs should be adapted well to the applications in which they are used; otherwise their performances will be deceiving and their costs excessive. Heat exchanger design can be a complex task, and advanced optimization tools are useful to identify the best heat exchanger for a specific duty.

Amin Hadidi, Ali Nazari et al [2013] introduce the cost minimization of Shell-and-tube heat exchangers is a key objective. Traditional design approaches besides being time consuming, do not guarantee the reach of an economically optimal solution. So, in this research, a new shell and tube heat exchanger optimization design approach is developed based on biogeography-based optimization (BBO) algorithm. The BBO algorithm has some good features in reaching to the global minimum in comparison to other evolutionary algorithms. In this study BBO technique has been applied to minimize the total cost of the equipment including capital investment and the sum of discounted annual energy expenditures related to pumping of shell and tube heat exchanger by varying various design variables such as tube length, tube outer diameter, pitch size, baffle spacing, etc. Based on proposed method, a full computer code was developed for optimal design of shell and tube heat exchangers and three different test cases are solved by it to demonstrate the effectiveness and accuracy of the proposed algorithm. Finally the results are compared to those obtained by literature approaches up to the present. The obtained results indicate that the BBO algorithm can be successfully applied for optimal design of shell and tube heat exchangers.

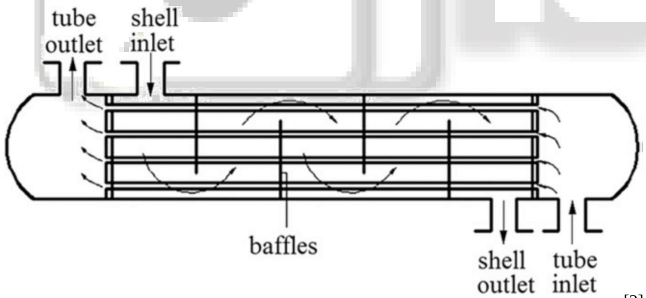

Fig 2: Diagram of a typical shell and tube heat exchanger [2]

Heat exchanger design can be a complex task, and advanced optimization tools are useful to identify the best heat exchanger for a specific duty. In this paper, a solution method of the shell and tube heat exchanger design optimization problem was proposed based on the utilization of a biogeography based optimization algorithm. Based on proposed method, a computer code was developed and three test cases were solved by it. Referring to the literature test cases, reduction of capital investment up to 14% and savings in operating costs up to 96% were obtained, with an overall decrease of total cost up to 56.1%, showing the improvement potential of the proposed method. Furthermore, the BBO algorithm allows for rapid solution of the design problem and enables to examine a number of alternative solutions of good quality, giving the designer more degrees of freedom in the final choice with respect to traditional methods. The presented BBO technique's ability is demonstrated using different literature case studies and the performance results are compared with those obtained by the previous researchers. The total cost decrease in all example case studies for similar operating conditions and run time in all case studies was less than 1 s by using BBO method. Biogeography-based optimization (BBO) method is found to be more accurate and quick according to traditional methods. The algorithm proposed here can help the manufacturer and engineers to optimize heat exchangers in engineering applications.

K. Mohammadi, M.R. Malayeri et al [2013] introduce the uniform distribution of flow in tube bundle of shell and tube heat exchanger is an arbitrary assumption in conventional heat exchanger design. Nevertheless, in practice, flow maldistribution may be an inevitable occurrence which may have severe impacts on thermal and mechanical performance of heat exchangers i.e. fouling. The present models for flow maldistribution in the tube-side deal only with the maximum possible velocity deviation. Other flow maldistribution models propose and recommend the use of a probability distribution, e.g. Gaussian distribution. None of these, nevertheless, estimate quantitatively the number of tubes that suffer from flow maldistribution. This study presents a mathematical model for predicting gross flow maldistribution in the tube-side of a single-pass shell and tube heat exchanger. It can quantitatively estimate the magnitude of flow maldistribution and the number of tubes which have been affected. The validation of the resultant model has been confirmed when compared with similar study using computational fluid dynamics (CFD).

A mathematical model has been proposed for the estimation of gross flow maldistribution in single-pass shell and tube exchangers when the flow is in turbulent regime. The resultant findings show that: a potential means of reducing flow maldistribution is to increase DPT and/or to decrease uinlet. The present work shows also the maximum possible flow deviation for the attempted exchanger is about 25%.

In turbulent flows, the flow maldistribution is a function of tube number. As tube number increases, the uniformity distribution of flow, or the tube number Nj_ej65%, increases too. For tube number greater than 1000, more than 65% of tubes have an absolute velocity deviation less than 5%, however, for tube numbers less than 180 all the tubes will have an absolute velocity greater than 5%.

Uday C. Kapale, Satish Chand et al [2005] a theoretical model for shell-side pressure drop has been developed. The model incorporates the effect of pressure drop in inlet and outlet nozzles along with the losses in the segments created by baffles. The results of the model for Reynolds numbers lying between 103 and 105 match more closely with the experimental results available in the literature compared to analytical models developed by other researchers for different configurations of heat exchangers.

The present model is developed based on estimated actual flow pattern of the liquid in the shell. The model is simple and based on geometrical and operating parameters of the heat exchanger and covers the Reynolds numbers ranging from103 to 105. The present model results can be used by designers confidently.

Yusuf Ali Kara, Ozbilen Guraras et al [2004] observed in a computer-based design, many thousands of alternative exchanger configurations may be examined. Computer codes for design are organized to vary systematically the exchanger parameters such as, shell diameter, baffle spacing, number of tube-side pass to identify configurations that satisfy the specified heat transfer and pressure drops. A computer-based design model was made for preliminary design of shell-and tube heat exchangers with single-phase fluid flow both on shell and tube side. The program covers segment ally baffled U-tube, and fixed tube sheet heat exchangers one-pass and two-pass for tube-side flow. The program determines the overall dimensions of the shell, the tube bundle, and optimum heat transfer surface area required to meet the specified heat transfer duty by calculating minimum or allowable shell-side pressure drop.

The design of a new heat exchanger (HE) is referred to as the sizing problem. In a broad sense, it means the determination of exchanger construction type, flow arrangement, tube and shell material, and physical size of an exchanger to meet the specified heat transfer and pressure drop.

This sizing problem is also referred to as the design problem. Inputs to the sizing problem are: flow rates, inlet temperatures and one outlet temperature at least, and heat transfer rate. The number of tubes that can be placed within a shell depends on tube layout, tube outer diameter, pitch size, number of passes, and shell diameter. These design parameters have been standardized and given as tabulated form that usually called ‘‘tube counts’’. Many tube count tables are available in open literature. In this work we use tube counts given by Saunders. He presented a tube counts table for fixed tube sheet, U-tube and split backing ring floating type exchangers, having the 24-shell diameter from 203 to 3048 mm and 13 tube configurations. In these tubes count tables both full counts, which gives the maximum number of tubes that can be accommodated under the conditions specified, and reduced count, due to an internally fitted impingement baffles are given for every case. The program selects an optimum exchanger among total number of 240 exchangers. The program is restricted to single-segmental baffle having 25% baffle cut that is most frequently used, triangular-pitch layout that results in greatest tube density. The exchanger type covers only fixed tube sheet with one-pass and two-pass, and U-tube for E-type shell. This program can be extended to different exchanger configurations, such as square pitch, 4or 6 tube-pass, etc. by inserting data from tube counts. Working fluids other than water can also be introduced easily.

Zahid H. Ayub et al [2005] studied about paper presents a simple but accurate method to calculate shell side heat transfer coefficient in a single segmental shell and tube heat exchanger. The method is based on a chart which is a product of actual data taken over a span of several years. The calculation procedure is presented with a case study. The results are compared with known methods and commercial/proprietary computer codes prevalent in the industry. The results from this method compare well with HTRI computer program. This method can prove to be a helpful tool for design engineers in the field. Shell side heat transfer analysis has been the subject of discussion since the late forties. It has undergone through various phases with addition of intricate complexity. With the advent of the power of computer, the complex calculation procedures have been adequately addressed. However, it is important to produce a simple but an accurate procedure that can be used by practicing engineers in the field with greater reliability. In 1949 Donohue presented a simple shell side heat transfer approach without considering leakage and by-pass effects. A similar procedure was also presented by Kern. Due to lack of Availability of statistical data, Donohue and Kern had proposed using de-rating factors for by-pass effects. Obviously, this approach was not considered accurate enough since in some cases it resulted in unrealistic sizes. This observation was affirmed by Palen and Taborek comparing results from Donohue and Kern to experimental data developed by an industry sponsored organization, Heat code written by someone else. The designer cans Transfer Research Institute (HTRI). It is important to provide essential but reliable tools to practicing and design engineers. A simple design tool that an engineer can use gives greater insight into the subject matter rather than feeding data into a computer observe the effect of change in a variable due to a change in another variable. For example if a baffle cut is changed with other parameters fixed, the effect on the size or the rating could be clearly observed. This paper is intended to address this issue. A new method is proposed to calculate single-phase shell side heat transfer coefficient for a typical single segmental shell and tube heat exchanger.

In this paper a calculation method based on a chart is presented. Numerous correlations are condensed in a chart form to make it more users friendly. In a typical shell and tube heat exchanger, two fluids exchange heat while being separated from each other. One fluid is on the shell side and another on the tube side. To understand the mechanical and construction details there is an unlimited supply of information in the form of books, articles, papers and more recently, the internet. Therefore, this aspect of the exchanger will not be addressed in this paper.

A new chart method is presented to calculate single-phase shell side heat transfer coefficient in a typical TEMA style single segmental shell and tube heat exchanger. A case study of rating water-to-water exchanger is shown to indicate the result from this method with the more established procedures and software available in the market. The results show that this new method is reliable and comparable to the most widely known HTRI software. However, it is easy to incorporate it as a simple but accurate design tool that can be beneficial for the design engineers in the field.

Jose M. Ponce-Ortega, Medardo Serna-Gonzalez, Arturo Jimenez-Gutierrez et al [2009] observed the transfer of heat between process fluids is an essential part of most chemical processes. To carry out such heat transfer process, shell-and-tube heat exchangers are widely used because they are robust and can work in a wide range of pressures, flows and temperatures. The traditional design approach for shell-and-tube heat exchangers involves rating a large number of different exchanger geometries to identify those that satisfy a given heat duty and a set of geometric and operational constraints. This approach is time-consuming, and does not guarantee an optimal solution.

The optimization procedure involves the selection of the major geometric parameters such as the number of tubes passes, standard internal and external tube diameters, tube layout and pitch, type of head, fluid allocation, number of sealing strips, inlet and outlet baffle spacing, and shell-side and tube-side pressure drops.

The objective is to minimize the total annual cost for the exchanger, including the capital costs for the exchanger and two pumps (shell-side and tube-side), and the operating cost of such pumps. The methodology considers explicitly major geometric and operational constraints. Genetic algorithms are used to guide the search towards an optimal solution. A shell-and-tube heat exchanger needs to be designed for each set of values of the search variables; the design method by Serna and Jimenez was used for that purpose.

To generate an efficient optimization method, genetic algorithms are used. Genetic algorithms search for an optimum solution based on the mechanics of natural selection and genetic. An algorithm for the optimal design of shell-and-tube heat exchangers based on genetic algorithms has been presented. The model uses the Bell–Delaware correlations for a proper calculation of heat transfer coefficients and pressure drops in the shell-side. The use of GA together with the Bell–Delaware method allows several design factors, typically specified from experience and later subject to a rating test, to be calculated as part of the optimum solution. Also, the objective function can accommodate any type of information available for the cost of equipment; highly non-linear functions that arise from a detailed cost model for a heat exchanger can be handled without the convergence problems typically encountered in mathematical programming techniques based on gradient methods. Also, because of their nature, genetic algorithms provide better expectations to detect global optimum solutions than gradient methods, in addition to being more robust for the solution of non-convex problems. The solution to examples taken from the literature show how previously reported designs can be improved through the use of the approach presented in this work.

H. Shokouhmand, M.R. Salimpour, M.A. Akhavan-Behabadi et al [2008] an experimental investigation was performed to study the shell and helically coiled tube heat exchangers. Three heat exchangers with different coil pitches and curvature ratios were tested for both parallel-flow and counter-flow configurations.All the required parameters like inlet and outlet temperatures of tube-side and shell-side fluids, flow rate of fluids, etc. Were measured using appropriate instruments. Overall heat transfer coefficients of the heat exchangers were calculated using Wilson plots. Heat transfer coefficients of shell and tube sides were evaluated invoking the calculated overall heat transfer coefficients. The inner Nusselt numbers were compared to the values existed in open literature. Though the boundary conditions were different, a reasonable agreement was observed.

The design of an efficient heat exchanger has always been significant to equipment designers. The different methods to enhance heat transfer rate are being investigated for quite a long time. Webb the various kinds of heat transfer enhancement techniques and has classified them into two main categories viz. active techniques which require external power for heat transfer augmentation, and passive techniques which need no such external power for enhancement. One of the passive methods is the use of helically coiled tubes as heat exchangers.

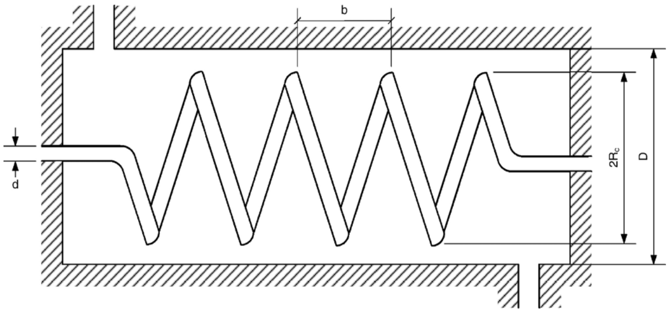

Fig. 3: Schematic view of a typical shell and coiled tube heat exchanger [3]

From the results of the present study, it was found out that the shell-side heat transfer coefficients of the coils with larger pitches are more than the ones with smaller pitches. Besides, it was seen that the shell-side Nusselt numbers of counter-flow configuration were slightly more than the ones of parallel-flow configuration. Finally, it was observed that the overall heat transfer coefficients of counter-flow configuration are 0–40% more than those of parallel-flow configuration.

III. CONCLUDING REMARKS

From literature review shell-and-tube type heat exchanger (STHE) is the most common type of heat exchanger which is use in most of industrial applications. Heat exchanger design involves complex processes, including selection of geometrical parameters and operating parameters. in present literature review heat transfer coefficient, pressure drop and efficiency can improve by using NTU method, by making mathematical model of heat exchanger, by chart and algorithm, by optimize design of condenser means by changing different parameter like shell diameter, baffle spacing, number of tube-side pass.

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