RESEARCH ARTICLE OPEN ACCESS

Exergy analysis of inlet water temperature of condenser

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Abstract

The most of the power plant designed by energetic performance criteria based on first law of thermodynamics. According to First law of thermodynamics energy analysis cannot be justified the losses of energy.The method of exergy analysis is well suited to describe true magnitude of waste and loss to be determined. Such information can be used in the design of new energy efficient system and increasing the efficiency of existing systems.In the present study exergy analysis of the shell and tube condenser is carried out. As the condenser is one of the major components of the power plant, so it is necessary to operate the condenser efficiently under the various operating condition to increase the overall efficiency of the power plant. In the present study inlet temperature of the condenser is optimized using the exergy method. The main aim of paper is to be find out causes of energy destruction that can be helpful to redesign the system and to increase the efficiency

I. Introduction:

In the present scenario of energy capacity and consumption determines the level of development of nation. This cause interest in the scientists and researcher to take a close look on energy conservation devices and to develop for better utilization of available sources.

The importance of developing thermal systems that effectively use energy resources such as oil, natural gas, and coal is apparent. Effective use is determined with both the first and second laws of thermodynamics. Energy entering a thermal system with fuel, electricity, flowing streams of matter, and so on is accounted for in the products and by-products. Energy cannot be destroyed (a first law concept).

The method of exergy analysis is well suited for furthering the goal of more effective energy resource use, for it enables the location, cause, and true magnitude of waste and loss to be determined. Such information can be used in the design of new energy efficient system and increasing the efficiency of existing systems.

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 condenser is 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.

Condensation is initiated and sustained when the temperature of a surface is maintained below the dew-point temperature of the surrounding vapor.Shell and tube condensers are composed of with circular pipes which are installed in cylindrical shells. It is a well known heat exchanger which is a key component in refrigeration and heat pump systems, thermal system plants, petrochemical plants and refrigeration/air-conditioning systems .Shell and tube heat exchanger, as shown in Fig. 1, is widely used in many industrial power generation plants as well as chemical, petrochemical, and petroleum industries. They are used to transfer heat between two or more fluids, between a solid surface and a fluid, or between solid particulates and a fluid, at different temperatures and in thermal contact. In heat exchangers, there are usually no external heat and work interactions.

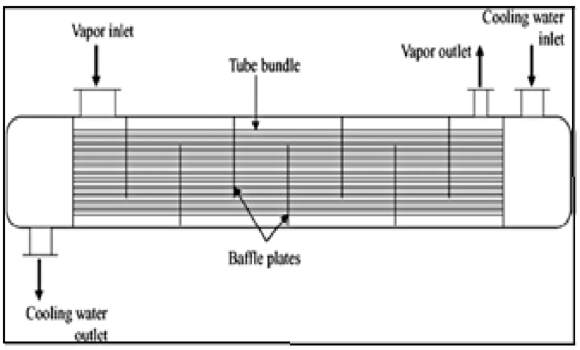

Fig. 1 Plant view of the shell and tube condenser.

Shell side condensation is relevant to many important applications, both in power and process industries. In the present work, the exergy destruction and exergy efficiency for condensation of a vapor in a shell and tube condenser are modeled. Then, the optimization problem is formulated to obtain the optimal upstream coolant temperature, which results in the minimum (maximum) exergy destruction (efficiency) for a given heat transfer area of heat exchanger

II. Literature review:

Y. Haseli, I. Dincer, G. F. Naterer carried out the analysis of the shell and tube condenser with respect to exergy. They focused on evaluation of the optimum cooling water temperature during condensation of saturated water vapour within a shell and tube condenser, through minimization of exergy destruction. They derived and expressed the exergy destruction as a function of temperature of cooling water and solved it using the sequential quadratic programming (SQP) method. The exergy destruction and exergy efficiency of condensation of vapor in a shell and tube condenser are formulated. It is shown that they can be expressed as functions of several operating parameters, such as the inlet and outlet cooling water and condensation temperatures. The optimization problem has been formulated for a given configuration of condenser. The method of sequential quadratic programming (SQP) is utilized in this study to solve the optimization problem.

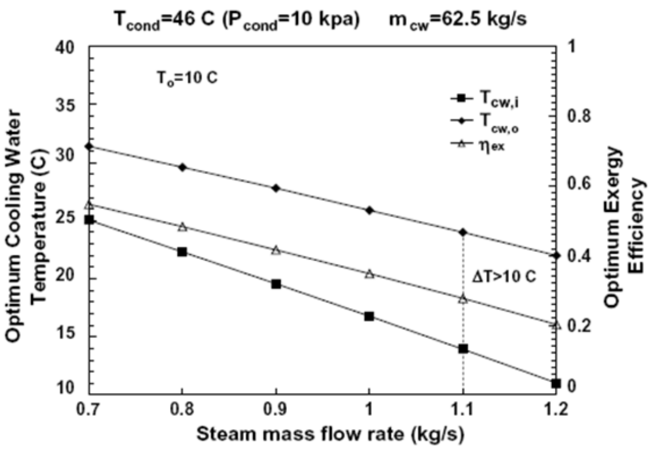

Fig-1 Variation of optimum cooling temperature and optimum exergy efficiency at different upstream steam mass flow rate

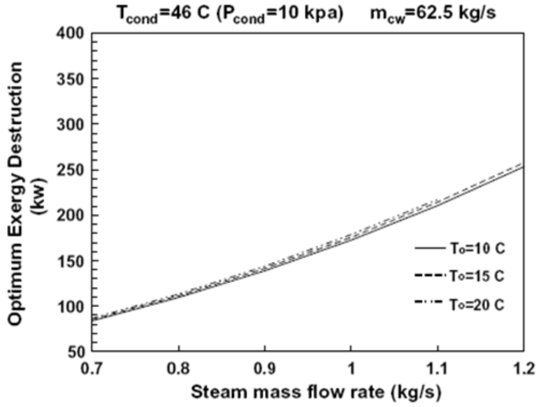

Fig-2 Variation of minimum Exergy destruction at different upstream steam mass flow rate.

The results are obtained and presented for a typical industrial condenser. Condensation of saturated steam is considered with cooling water as the coolant, through two examples that depend on the condensation temperature, which may be found frequently in actual design of a condenser. Additionally, optimization results reveal new characteristics for the cooling water, with respect to the minimization of exergy destruction of the condensation process

Yavuz Ozcelik carried out the exergetic optimization of shell and tube heat exchanger. In his study, a genetic based algorithm was developed, programmed and applied to find optimum configuration of heat exchanger by minimizing the sum of the annual capital cost and exergetic cost of shell and tube heat exchanger. Shell and tube heat exchangers are crucial components of energy systems and in this study, a computer program that can estimate the optimum values of the discrete and continuous variables of the exergetic optimization of the STHE's problem was proposed. The acceptable deviations from the global optimum values of the objective functions in the test problems showed that the genetic based algorithm can be used to estimate continuous variables and exact optimum values of integer variables of MINLP problems.
Although there is no study to determine the optimum design configuration based on exergetic optimization, As a result, optimum heat exchangers could be successfully determined and parametric studies can be made successfully for continuous design parameters depending on discrete design parameters given by the user.

Jose M. Ponce-Ortega, Medardo Serna-Gonzalez, Arturo Jimenez-Gutierrez used genetic algorithms method for optimization of shell and tube heat exchanger. They used Bell- Delaware method for the description of the shell side flow and optimize the major geometrical parameters such as number of tube-passes, standard internal and external tube diameters, tube layout and pitch, type of head, fluids allocation, number of sealing strips, inlet and outlet baffle spacing, and shell side and tube-side pressure drops.

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 his work.

V.K. Patel, R.V. Rao carried out the optimization of shell and tube heat exchanger using the new technique called particle swarm optimization. Minimization of total cost is considered as the objective function. Three design variables such as shell internal diameter, outer tube diameter and baffle spacing are considered for optimization. Two tube layouts, 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 are compared with those obtained by using genetic algorithm.

Thermoeconomic optimization of a shell and tube condenser was carried out by Hassan Hajabdollahi, Pouria Ahmadi, Ibrahim Dince. They use two new optimization methods, genetic algorithm and particle swarm (PS) method. These methods are used to find out optimal total cost including investment and operation cost of the condenser. Initial cost includes condenser surface area and operational cost includes pump output power to overcome the pressure loss.

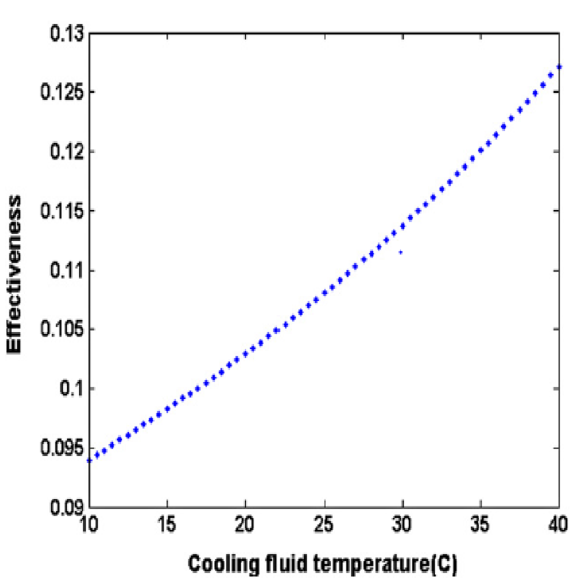

Fig-The variation of the effectiveness versus cooling fluid temperature at the optimum point.The objective function was introduced as a total cost of the condenser. Moreover, five design parameters were considered for the optimization program. To have a real analysis, the simulation code was compared with literature and the results showed the reasonable difference between the data. In addition, to have a good insight into the study, the sensitivity analysis was conducted at the optimal point. The results showed that increase in the tube number leads to decrease in the objective function first then it leads to a considerable increment in the objective function. Also, results show that any increases in the number of tube pass led to increase in the total cost of the condenser. Moreover, it was concluded that although GA has less speed in comparison with PSC algorithm, it has better results as well as less CPU running time. The sensitivity analysis of the tube pitch ratio reveled that variation of this parameter had no effect of the variation of objective function because the pressure drop was in the tube side.

III. CONCLUSION :

After understanding all this above literatures, we can conclude that In the present study, optimization of the shell and tube condenser has been performed using exergy analysis method. The objective function was introduced optimum inlet water temperature. Moreover, five design parameters were considered for the optimization program. Exergy analysis is depends on 2^{nd} law of thermodynamics, allows us to locate and quantify the irreversibilites in the production process and to identify which part of the system and what reasons they affect the overall efficiency. The exergy analysis combines the 1^{st} and 2^{nd} law of thermodynamic and from a prospective of quantity and quality to revel the law of conservation. It was concluded that to improve exergy efficiency, we should look for a way to reduce irreversibility in condencer, because this component had a high contribution to exergy destruction. This kind of improvement in power plant gives Higher efficiency and economic power generation.

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