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A Review on Thermal Analysis of Shell and Tube Heat Exchanger with Different Design of Baffle Plate

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Abstract- A heat exchanger may be defined as a device that transmits thermal energy between two or more fluids of varying temperatures. Several industrial processes would indeed be impossible to complete without this equipment.Refrigeration, air conditioning, and chemical plants all use heat exchangers. It's utilised for a variety of things, including transferring heat from a hot to a cold fluid. They're commonly employed in a variety of industrial settings.Researchers had worked on a variety of projects in attempt to increase performance. The velocity and temperature contour fields upon that shell side, on the other hand, are much more complicated, and their performance is influenced by baffle elements such as their arrangement the spacing scheme.

Keywords- Shell and Tube Heat Exchanger, baffle, design, thermal analysis.

I. INTRODUCTION

Heat exchangers are devices that allow heat to be transferred efficiently from one medium to another, whether the mediums are separated by a solid wall and never interact, and then they're in direct touch.

Space heating, refrigeration, air conditioning, power plants, chemical plants, petrochemical plants, petroleum refineries, and natural gas processing are also all places where they're employed. The aim of a heat exchanger is to adjust the temperature of a system or material by adding or withdrawing thermal energy. While heat exchangers available in a range of sizes, complexity levels, and kinds, they always employ a thermally conducting device, generally in the shape of a tube or plate, to separate two fluids so that everyone can transmit thermal energy to another.

Shell and Tube heat exchangers are having special importance in boilers, oil coolers, condensers, pre-heaters. They are also widely used in process applications as well as the refrigeration and air conditioning industry. The robustness and medium weighted shape of Shell and Tube heat exchangers make them well suited for high pressure operations.

The basic configuration of shell and tube heat exchangers, the thermal analysis and design of such exchangers form an included part of the mechanical, thermal, chemical engineering scholars for their curriculum and research activity.Shell and tube heat exchangers are used extensively throughout the process industry andsuch a basic understanding f their design, construction and performance is important to the practicing engineer.

The optimum thermal design of a shell and tube heat exchanger involves the consideration of many interacting design parameters which can be summarized as follows:

1. Process:
Process fluid assignments to shell side or tube side Selection of stream temperature specifications.Setting shell side and tube side pressure drop design limits. Setting shell side and tube side velocity limits.Selection of heat transfer models and fouling coefficients for shell side and tube side. Selection of heat exchanger TEMA layout and number of passes.Specification of tube parameters – size, layout, pitch and material. Setting upper and lower design limits on tube length.

Specification of shell side parameters materials, baffle cut, baffle spacing One of the important processes in engineering is the heat exchange between flowing fluids, and many types of heat exchangers are employed in various types of installations, as petrol-chemical plants, process industries, pressurized water reactor power plants, nuclear power stations, building heating, ventilating, and air-conditioning and refrigeration systems.

As far as construction design is concerned, the tubular or shell and tube type heat exchangers are widely in use.The shell-and-tube heat exchangers are still the most common type in use. They have larger heat transfer surface area-to-volume ratios than the most of common types of heat exchangers, and they are manufactured easily for a large variety of sizes and flow configurations. They can operate at high pressures, and their construction facilitates disassembly for periodic maintenance and cleaning. The shell-and-tube heat exchangers consist of a bundle of tubes enclosed within a cylindricalshell. One fluid flows through the tubes and a second fluid flows within the space between the tubes and the shell.

II. REVIEW OF PAST STUDIES

Sundaram et al (2016) examine the prediction of an outlet liquid temperature of a saturated steam heat exchanger from its liquid flow rate, 4 distinct neural networks are considered: Elman Recurrent Neural Networks (ERNN), Time Delay Neural Networks (TDNN), Cascade Feed Forward Neural Networks (CFFNN), and Feed Forward Neural Networks (FFNN). To train, validate, and evaluate the performance of each neural network model, a benchmark dataset of 4000 tuples is employed.

Shrikant (2016) the impacts of various baffle designs on the heat transfer coefficient and pressure drop in a shell and tube heat exchanger (STHX) were investigated. The use of baffles in shell and tube heat exchangers improves heat transmission while simultaneously increasing pressure drop. SOLIDWORKS Flow Simulation software is used to design shell and tube heat exchangers featuring single, double, triple segmental baffles, helical baffles, and flower baffles, as well as fluid dynamic simulations (ver.2015).Simulation studies revealed how single segmental baffles had the highest heat transfer coefficient, pressure drop, or heat transfer rate for much the same shell side mass flow rate.

Kamble et al (2014) The use of artificial neural network (ANN) modelling in different heat transfer applications, such as constant and dynamic thermal issues, heat exchangers, gas-solid fluidized beds, and so forth, was examined. Several crucial issues in thermal engineering cannot always be solved using typical analysis methods such as basic equations, conventional correlations, or trial and error to build unique designs from experimental data.

The use of the ANN tool using various methodologies and structures reveals that the findings provided using ANN and experimental data are in good agreement.The aim of this paper is to highlight current improvements in ANN and how it has been successfully used to a number of key heat transfer challenges. According to the literature, the feed-forward network with back propagation approach has been effectively utilised in various heat transfer investigations.

Kwang-Tzu Yang (2008) The goal of this work is to showcase recent advances in ANN and how it has been effectively applied to a variety of major heat transfer problems. The feed-forward network incorporating back propagation technique has already been successfully used in many heat transfer experiments, per the literature.

Singh et al. (2011) The performance of three training functions (TRAINBR, TRAINCGB, and TRAINCGF) utilised for training NN to forecast the value of the specific heat capacity of both the working fluid, LiBr-H2O, employed in a vapour absorption refrigeration system were evaluated. The percentage relative error, coefficient of multiple determination, RMSE, and sum of a square owing to error were employed as comparison metrics.

The input parameters include vapour quality and temperature, with specific heat capacity as being one of the output parameters.The training is maintained until the least mean square error (MSE) at a specific number of epochs was found. The TRAINBR function outperformed the other two training functions based on findings of performance parameters.

Gerardo Diaz et al (2001) Apply the artificial neural network (ANN) approach to the modelling of a heat exchanger's time-dependent behaviour and use it to manage the temperature of air travelling through it. Inside an open loop test facility, the tests are carried out. To begin, an approach for training and predicting the dynamic behaviour of thermal systems including heat exchangers was provided. Then, using two artificial neural networks, somebody to mimic the heat exchanger the other as a controller, an internal model strategy for controlling the over-tube air temperature is devised.

To avoid a steady-state offset, an integral control is performed in tandem with the neural network controller's filter. The findings correspond to PI and PID controllers that are commonly used. The neural network controller has less oscillating behaviour, allowing the system to attain steady-state operating conditions in areas where the PI and PID controllers are not quite as effective.

Ahilan C et al (2011) artificial neural networks are used to construct a prediction model for shell and tube heat exchangers (ANN). The trials are carried by using a full factorial design of experiments to construct a model utilising input parameters including such hot fluid intake temperature or cold and hot fluid flow rates. The total heat transfer coefficient of such a heat exchanger, which itself is utilised for performance evaluation, is the output parameter.

ANN model was educated and trained to use a feed forward back propagation neural network. Through comparing the ANN findings to the experimental data, the constructed model is validated and evaluated. It demonstrates that perhaps the model and the results are in good agreement.

Hisham Hassan Jasim (2013) Heat transfer study of shell-and-tube heat exchangers, which are frequently used in power plants and refineries, was performed using an Artificial Neural Network. To train & test networks, the Back Propagation (BP) technique was employed, which separated the data into three samples (training, validation, and testing data) to provide more approach data from genuine cases. Inlet water temperature, inlet air temperature, or air mass flow rate are all inputs to the neural network. In ANN, two outputs were collected (exit water temperature to cooling tower & exit air temperature to second phase of air compressor).

To train the classifier, the reference heat exchanger model provided 150 sets of data on different days. Regression between the planned goal and the predicted outcome For training, validation, testing, as well as all samples, the ANN output shows that the values are fairly equal to one (R=1). A total of 50 sets of data were gathered to test the network and compare the intended and predicted exit temperatures (water and air temperatures).

Govind Maheshwari (2018) artificial neural networks were used to assess the performance of a parallel flow heat exchanger (ANNs). Experiments were carried out utilising a complete factorial design of experiments to construct a model employing characteristics such as temperatures, capacity ratio, and optimal NTU constant value. A feed forward back propagation neural network is used to construct and train an ANN model regarding efficiency, entropy generation number, and total heat transfer coefficient multiplied by the area of a theoretical/clean heat exchanger.

Through comparing the findings to the experimental results, the generated model is verified and evaluated. This model is used to evaluate the heat exchanger's performance in the real/foulled system. It helps the system enhance its performance through maximising asset usage, conserving energy, and lowering production costs.

Nader Jamali SoufiAmlashi (2013) Applied an artificial neural network model to the nonlinear identification of a liquid saturated steam heat exchanger (LSSHE). Heat exchangers are nonlinear and non-minimum phase processes with changeable operating conditions. The rate of change of fluid flow into to the system is also employed as such an input variable, while experimental data collected from fluid outlet temperature measurement inside a laboratory environment has been used as an output variable. The outcomes of neural network & traditional nonlinear model identification are compared.Due to the obvious independence of the model assignment, the simulation results demonstrate that perhaps the neural network model is reliable and quicker than standard nonlinear models using time series data.

III. CONCLUSION

Shell and tube exchangers have been widely employed in a variety of engineering applications for decades, including chemical engineering processes, power generation, petroleum refining, refrigeration, air-conditioning, and the food sector [1]. Especially compared to other types of heat exchangers, shell and tube heat exchangers are very easy to produce but have a wide range of applications [2]. Shell-and-tube heat exchangers have been shown to account for more than 30% of all heat exchangers in operation [3, 4].

Baffles serve an important part in the construction of Shell and Tube Heat Exchangers (STHX). They offer tube support, let the shell-side fluid flow can retain a desired velocity, and keep the tubes form wobbling. The shell-side flow is additionally guided forward through the tube bundle by baffles, boosting fluid velocity and heat transfer coefficient. Heat transfer was boosted with the most widely used single segmental baffles because the baffles direct the shell side fluid to flow inside a zigzag pattern between both the tube bundle, increasing turbulence intensity and local mixing [5].

The single segmental baffles, but at the other hand, have several intrinsic flaws due to the structure's limitations:

- Fouling forms with in stagnation zone along the shell wall and also the back of baffle plates;
- When baffles obstruct fluid flow, a large pressure drop occurs, and flow separation occurs towards the baffle edge. As a result, additional pumping power is frequently required to compensate for the increased pressure loss under the same heat load.
- Significant bypass streams and leakage streams due to manufacturing tolerances;
- Flow-induced tube vibration causes short operating lifespan [6, 7].

As a result, various baffles must be investigated in order to reduce the shell side pressure drop and hence the heat exchanger's operating cost.

STHX with single segment baffles, helical baffles at varied helix angles, and flower baffles was researched and compared in enhancing performance, according to the literature review. Furthermore, simulations involving single, double, triple segmental baffles, helical baffles, and flower baffles have not been compared using the same STHX specification and input circumstances.

As a result, a unique idea was developed to investigate the impacts of multiple baffle designs in shell and tube heat exchangers (STHX), including such single, double, triple segmental baffles, helical baffles, and flower baffles, on heat transfer coefficient and pressure drop.

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