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A Review Article of thermal Analysis of Shell and Tube Heat Exchanger Using Artificial Neural Network

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***Abstract*- This review explains the effective utilization of artificial neural network (ANN) modeling in various heat transfer applications like steady and dynamic thermal problems, heat exchangers, gas-solid fluidized beds etc. It is not always feasible to deal with many critical problems in thermal engineering by the use of traditional analysis such as fundamental equations, conventional correlations or developing unique designs from experimental data through trial and error. Implementation of ANN tool with different techniques and structures shows that there is good agreement in the results obtained by ANN and experimental data. The purpose of the present review is to point out the recent advances in ANN and its successful implementation in dealing with a variety of important heat transfer problems. Based on the literature it is observed that the feed-forward network with back propagation technique implemented successfully in many heat transfer studies. The performance of the network trained were tested using regression analysis and the performance parameters such as root mean square error, mean absolute error, coefficient of determination, absolute standard deviation etc. The authors own experimental investigation of heat transfer studies of tube immersed in gas-solid fluidized bed using ANN is included for strengthening the said review. The results achieved by performance parameters shows that ANN can be used reliably in many heat transfer applications successfully.**

***Keywords*- Artificial Neural Network, back propagation, heat exchanger, heat transfer, multi layer perceptron.**

I. INTRODUCTION

Heat exchangers have a special place in chemical process industries. The shell and tube heat exchanger is commonly used for heating or cooling of process fluids. The various parameters to be taken into account for developing a model are inlet and outlet temperatures of shell and tube side fluids and their flow rates. The control of heat exchanger is complex due to its nonlinear dynamics, and particularly the variable steady-state gain and time constant with the process fluid. Linear controllers designed based on linear models will be effective only in a small region around the operating point.

The artificial neural network (ANN) technique is used to control the hot and cold fluid temperature. Artificial Neural Networks (ANN) is effective in modeling of non-linear multi variable relationships and also referred to as the black box models. In earlier attempts1-3 the authors used ANN for modeling of heat exchanger. Artificial neural network. An Artificial Neural Network (ANN) is an information-processing paradigm that is inspired by the way the biological nervous system, such as the brain, processes information. It is composed of large number of highly interconnected processing elements (neurons) working in unison to solve specific problem4. The most common for chemical engineering application is Multi Layer Perception (MLP), which is a feed forward neural network. It consists of multilayer hierarchical structure, which apart from input and output layers, has at least one layer of processing units in between them. The layers between the input and output layers are termed "hidden" since they do not converse with the outside world directly. The nodes between the two successive layers are fully connected by means of weights. That is outputs from the input layer are fed to the hidden layer units, which in turn, feed their outputs to the next hidden nodes.

II. RESEARCH MOTIVATION

Heat exchangers are widely used in manufacturing and process industries for several applications. The choice of heat exchanger for a given application is dependent on several factors such as the application, available floor area, available resources, connections in the field, cost, and many more. In a highly competitive environment, it is essential that the heat exchanger must deliver the required heat transfer, occupy less space, weigh less, and yet be priced competitively.

In this project, a shell and tube heat exchanger is designed for heating hot oil. Hot oil is used for a certain process heating application and steam is the heating medium. The heat exchanger shall be designed such that the hot oil flows through the tubes and steam through the shell side of

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the heat exchanger. It is assumed that large steam flow rate is available to provide the required heating for the hot oil in the shell and tube heat exchanger.

A conventional ε-NTU approach and LMTD approach shall be used to design the shell and tube heat exchanger. Performance tables and charts describing the variation of shell and tube heat exchanger's performance with respect to capacity rate ratio and NTU were developed.

Dimensionless parameters such as capacity rate ratio and NTU provide concise information on the heat exchanger as they account for material characteristics, flow characteristics, physical and thermal properties, construction and fouling. Likewise, the developed tables and charts can also be employed during the regular working phase of the shell and tube heat exchanger to understand its performance.

III. CATEGORIES OF HEAT EXCHANGER

1. Adiabatic Wheel Heat Exchanger:
This type of heat exchanger uses an intermediate fluid or solid store to hold heat, which is then moved to the other side of the heat exchanger to be released. Two examples of this are adiabatic wheels, which consist of a large wheel with fine threads rotating through the hot and cold fluids, and fluid heat exchangers.

2. Plate Fin Heat Exchanger:
This type of heat exchanger uses "sandwiched" passages containing fins to increase the effectively of the unit. The designs include cross flow and counter flow coupled with various fin configurations such as straight fins, offset fins and wavy fins. Plate and fin heat exchangers are usually made of aluminiumalloys, which provide high heat transfer efficiency. The material enables the system to operate at a lower temperature and reduce the weight of the equipment. Plate and fin heat exchangers are mostly used for low temperature services such as natural gas, helium and oxygen liquefaction plants, air separation plants and transport industries such as motor and aircraft engines.Advantages of plate and fin heat exchangers: High heat transfer efficiency especially in gas treatment Larger heat transfer area Approximately 5 times lighter in weight than that of shell and tube heat exchanger able to withstand high pressure.

3. Pillow Plate Heat Exchanger:
A pillow plate exchanger is commonly used in the dairy industry for cooling milk in large direct-expansion stainless steel bulk tanks. The pillow plate allows for cooling across nearly the entire surface area of the tank, without gaps that would occur between pipes welded to the exterior of the tank. The pillow plate is constructed using a thin sheet of metal spot-welded to the surface of another thicker sheet of metal. The thin plate is welded in a regular pattern of dots or with a serpentine pattern of weld lines. After welding the enclosed space is pressurized with sufficient force to cause the thin metal to bulge out around the welds, providing a space for heat exchanger liquids to flow, and creating a characteristic appearance of a swelled pillow formed out of metal.

4. Fluid Heat Exchangers:
This is a heat exchanger with a gas passing upwards through a shower of fluid (often water), and the fluid is then taken elsewhere before being cooled. This is commonly used for cooling gases whilst also removing certain impurities, thus solving two problems at once. It is widely used in espresso machines as an energy-saving method of cooling super-heated water to use in the extraction of espresso.

IV. LITERATURE REVIEW

Mohammed and Abed numerically studied laminar forced convection heat transfer and fluid flow characteristic in a corrugated channel. Temperature of the channel walls was maintained constant which was higher than fluid temperature. Effect of wavy angle and Reynolds number were studied on fluid flow and heat transfer. The range of the Reynold`s number was carried out for the solution was found out to be 500 to 2500, wavy angles range was from 0° to 60° and Prandtl number was 0.7. It was found that the optimum values of the heat transfer enhancement and pressure drop were 3.6 and 1.11 times higher than those from the plane channel at wavy angle $\lambda = 40°$, respectively [1].

Khan and Kumar described performance and exergy of corrugated plate heat exchanger in parallel or in counter flow. Plate had sinusoidal wavy surface with corrugation angle of 45°C. Heat exchanger contained 3 Channels. Hot fluid flow at the middle channel which was cooled by water through outer channels. Hot water temperature was in the range of 40°C to 60°C. Reynolds number was in the range of $900 < Re > 1300$ for hot and cold fluid. After performing experiment performance or effectiveness of corrugated plate heat exchanger for counter flow was found out to be 44.5% more as compared to parallel flow arrangement. As well as exergy loss in counter flow is 7.2% less as compared to parallel flow [3].

Rao et.al in their investigation used corrugated plate heat exchanger with corrugation angle 30°, 40°, 50°. Water was taken as heating medium while Glycerol was taken as test fluid. The inlet and outlet temperature of hot fluid and test fluid was measured by means of four thermo couples. From the experimental investigation it was found that 50° corrugation angle heat transfer increased. It is also found that 60% Glycerol had high rate of heat transfer as compared to the 50%, 60% and water. Hence in investigation it has been found that with the increase of corrugation angle as well as with the

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increase of viscosity of fluid heat transfer rate increases [4].

Rao et.al has done an experimental study in three different types of corrugated plate heat exchangers and their length is 30 cm whereas width is 10 cm. Three different corrugation angles were used in these studies which were 30°, 40° and 50°. Water was taken as heating fluid. The temperature of the wall was measured along the length of heat exchanger at seven different locations by thermocouples. The outlet and inlet temperatures of test fluid and hot fluid were measured by means of four more thermocouples.

In this study effect of corrugation angle on heat transfer rates has been discussed. After completion of the experiment, heat transfer coefficient at different corrugation angle heat exchanger is compared to each other and it has been observed that the heat transfer coefficient of 50° corrugation angle heat exchanger is higher as compared to 30° and 40° corrugation angle heat exchanger. At higher corrugation angle, high turbulence is created due to which heat transfer rate becomes higher [5].

Kumar et.al has made an experimental investigation of plate heat exchanger for predicting the exergetic performance and heat transfer characteristics of corrugated plate. Effect of various operating parameters on pressure drop, exergetic performance, friction factor, exergy loss, effectiveness, and dimension less exergy loss are discussed. Results show that with the increase in Number of Transfer Units (NTU) effectiveness of Plate heat exchanger increases. The exergy loss of corrugated type PHE increases with increasing of Reynold's number of cold and hot fluid side, by increasing the inlet temperature of hot water and by decreasing the inlet temperature of cold water. Study shows that the dimensionless exergy loss increased with the increase of friction factor and Number of Transfer Units (NTU) [6].

Sandeep K. Patel A characteristic of heat exchanger design is the procedure of specifying a design. Heat transfer area and pressure drops and checking whether the assumed design satisfies all requirement or not. The purpose of this paper is how to design the shell and tube heat exchanger which is the majority type of liquid – toliquid heat exchanger. General design considerations and design procedure are also illustrated in this paper. In design calculation HTRI software is used to verify manually calculated result.

Karthik Silaipillayarputhur The paper considered a review for the design of a shell and tube heat exchanger. Therein, popular analytical techniques such as log mean temperature difference (LMTD) and effectiveness-number of transfer units (ε-NTU) were considered in the analysis. In the design, analysis, performance charts and tables describing the performance of the shell and tube heat exchanger in terms of crucial dimensionless parameters were developed. These fundamental dimensionless parameters account for the thermal & the physical properties of the fluids and the heat exchanger (HX) material. Using the information from the performance charts and tables, a basic design for the shell and tube heat exchanger can be readily formulated.

V. PROBLEMS FORMULATION DESIGN CRITERIA

Heat exchangers are one of the most important heat transfer apparatus that find its use in industries like oil refining, chemical engineering, electric power generation etc. Shell-and-tube type of heat exchangers has been commonly and most effectively used in Industries over the years.

In this paper we see a review of Outline and Types of Heat exchangers, Thermal Design and Mechanical Design by the use of ASME, TEMA standard take a case study of Modern Shell & Tube type Heat exchanger.

VI. APPLICATIONS AND USES

The simple design of a shell and tube heat exchanger makes it an ideal cooling solution for a wide variety of applications. One of the most common applications is the cooling of hydraulic fluid and oil in engines, transmissions and hydraulic power packs. With the right choice of materials they can also be used to cool or heat other mediums, such as swimming pool water or charge air. [5]

One of the big advantages of using a shell and tube heat exchanger is that they are often easy to service, particularly with models where a floating tube bundle (where the tube plates are not welded to the outer shell) is available. Shell and tube Heat Exchangers have the ability to transfer large amounts of heat in relatively low cost, serviceable designs. They can provide large amounts of effective tube surface while minimizing the requirements of floor space, liquid volume and weight.

Shell and tube exchangers are available in a wide range of sizes. They have been used in industry for over 150 years, so the thermal technologies and manufacturing methods are well defined and applied by modern competitive manufacturers.

REFERENCE

[1] Temperature Analysis of Shell and Tube Heat Exchanger International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 05 Issue: 04 | Apr-2018.
[2] The Design of Shell and Tube Heat Exchangers – A Review International Journal of Mechanical and

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Production Engineering Research and Development (IJMPERD) ISSN (P): 2249-6890; ISSN (E): 2249-8001 Vol. 9, Issue 1, Feb 2019, 87-102.

[3] Design and Analysis of Heat Exchanger for Maximum Heattransfer Rate (Multi model Optimisation Technique) International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395- 0056 Volume: 05 Issue: 01 | Jan-2018.

[4] Shell & Tube Heat Exchanger Thermal Design With Optimization of Mass Flow Rate and Baffle Spacing International Journal of Advanced Engineering Research and Studies E-ISSN2249–8974.

[5] Performance Analysis of Shell & Tube Type Heat Exchanger under the Effect of Varied Operating Conditions IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 11, Issue 3 Ver. VI (May-Jun. 2014.

[6] CFD based study of thermal performance of shell and tube heat exchanger with discharging PCM International Journal of Latest Engineering Research and Applications (IJLERA) ISSN: 2455-7137 Volume – 02, Issue – 11, November – 2017, PP – 93-100.

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