Heat Transfer CFD Analysis in Different Tube Forms of Heat Exchanger

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Abstract: HEXs are used in a large number of industrial and residential applications. A myriad of heat exchangers have been developed for use in steam power industry sectors, chemical processing facilities, constructing heating and air conditioning devices, power transfer processes, and cooling units. Dual tubes heat exchangers are mechanisms that enable thermal energy to be transferred among two liquids which are at various temperatures. The variables of heat transfer in tubes of several forms, such as triangular and hexagonal are investigated in this research work.

Keywords: Double heat pipe exchanger, heat exchanger.

I. INTRODUCTION

Heat exchangers are critical energy-preserving process machinery in the chemical industry, notably for cryogenic cooling. These natural gas and lighter hydrocarbons were melted at incredibly lower temperatures before even being delivered into distillation stages for extraction utilizing a cryogenic refrigeration cycle.

Dual tube heat exchangers were systems which enable thermal energy to be transferred among two liquids of varying temperatures. That sensitive procedure of heating or cooling liquids, wherein smaller heat exchange surfaces were needed, is the major usage of these heat exchangers. Such procedures can be seen in the oil cooler. The dirty finned, unclean finned, and cleaned finless dual tube heat exchangers utilised as oil refrigerators in ships were evaluated in this research. In thermal architecture, a number of suggested Nusselt mathematical equations were applied, with the outcomes reported in figures and tables. As a result, it's thought that using encrusted dual finned tubes heat exchangers used as oil coolers in warships is the best option.

A twin tubes heat exchangers is made up with one or even more tubes stacked symmetrically inside a bigger tube with appropriate connections to guide the flow through one segment to the next. The bladder (tube side) and the rings (ring side) both have fluid flowing through them (ring). U-shaped returns bends, that are encased in a returned housing, link the internal tube to the outer tube. Figure 1 depicts a conventional dual-pipe heat exchangers.

Figure 1 Heat exchangers with two pipes

In its most basic form, a dual tubes heat exchanger is a tube placed symmetrically inside a bigger tube (hence the name "twin tube"). Including one fluid running through the interior tube and the other flowing across it through the external tube, the interior tube serves as a conducting barriers, generating an annular configuration. Heat is exchanged through the internal tube walls as the external or "shell side" flow crosses over the interior or "tube side" flow. Fork, jacketed tube, jacketed U-tube, as well as tube-in-tube heat exchangers are all terms used to describe them. These can have a tubes or even a bundles of tubes within (similar to shells and tubes exchangers), however the bundles should have 30 tubes as well as the exterior tubes should be 200mm in diameter Otherwise, this exchanger is classified as a unique layout (see For more data see our paper on shell and tube heat exchangers). Longitudinal ribs upon that bladder (s) may promote heat transfer among the two operating fluids even more.

The heated flow flows via the bladder, whereas the cooler flow travels via the outer shell (note this is not always the case). The heat of a streams is transmitted via the interior tube wall, that is built of a conductive substance such as steel or aluminum, in a twin tube heat exchanger. When the fluids in a twin tube heat exchanger travel in reverse directions, it is known as counter flow (as shown above). Dual-tube heat exchangers obtain true counterflow across concentric tubes, and architects take use of this to boost the system's heat transmission coefficients. They can also be utilized in paralleled flow, where both fluids are moving in the similar directions, however the counter current is usually present.

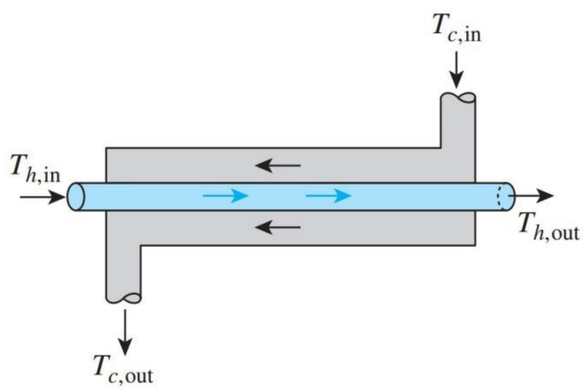

Figure 2 Heat exchangers in use, simplified schematic

The double tubes heat exchanger is a tiny modular structure that can be used in settings where typical tube bundles heat exchangers were either too big or too costly. To easily improve the rate of heat transmission through an unit, dual tubes exchangers can be connected in sequence or simultaneously. Installing fins with U-bends can also improve heat transmission, rendering these systems adaptable, simple to repair and update, and very effective in their operations.

Due to its basic structure, a dual tube heat exchangers is one of the simplest kinds to build, install, and maintain. They have distinct benefits over several of the more complicated heat exchanger layouts, but they also have considerable disadvantages. The following are the key advantages of employing a double-pipe heat exchanger:

Extreme pressure and high temperatures can be managed effectively, and their components have been standardised as a result of their widespread use, making it easier to locate and replace parts

They are one of the most adaptable models, allowing for easy component addition and removal.They have such a tiny footprint and need little to no upkeep, but they distribute heat well..

II. LITERATURE REVIEW

(Sun et al., 2020) [1] Thermohydraulic effectiveness in spherical heat exchanger tubes containing several rectangular fin vortex producers is investigated in this study. Multilongitudinal eddies are generated, enhancing fluid blending in the pipes, according to numerical simulations.. The impacts of geometric variables such as the numbers of rectangular fin perimeters (N = 4, 6, 8), the height ratios (HR = 0.05, 0.1, 0.2), as well as the pitch ratios (PR = 1.57, 3.14), 4.71) are investigated. experimentally. Because of enhanced fluid mingling efficiency generated by multi-longitudinal eddies having greater turbulent kinetic energy, the friction factor and Nusselt value increases as the proportion of heights to numbers of rectangular fins increases. The friction coefficient and Nusselt numeric proportions are correspondingly 1.46 and 11.63 and 1.15 and 2.32 for the Reynolds values studied.. For HR = 0.05, raising the numbers of rectangular fins enhances the thermal enhancement factor (TEF), however for the other situations, the reverse pattern is found. 1.27 is the highest TEF. Moreover, relationships for the friction component as well as the Nusselt numbers are obtained for practical applications based on the experimental outcomes.

(C. Hu et al., 2020) [2] As a heat exchangers in turbine engines, this porous medium has immense potential. Furthermore, experimentally achieving heat transfer efficiency by forced convections in porous medium at high velocities (> 20m/s) is problematic. Utilizing the computational fluid dynamics (CFD) technique, the open Kelvin models, also known as sphere reduction and column design, was created to analyse the heat transfer parameters of porous media having high porosity in a velocity range of 4 to 90 m/s. The pressure loss, heat transmission factor, and volumetric heat transmission factor all increased including the IPC (cells per inch) and decreased with rising porosity, according to the findings. Porosity affected the pressure decrease more than the CPI. CPI and porosity have a greater impact on convective heat transmission effectiveness at incredible velocities. The pressure loss is influenced by two important structural variables: the cross-sectional region of the neck as well as the diameter of the skeleton. Due to the rise in velocity, the pressure loss grows quadratically, whereas the volumetric heat transmission coefficient rises logarithmically, resulting in a quick fall in total heat transfer efficiency (j / f). Because fluctuations in porosity with CPI were insufficient to increase j/f at high velocities, pore architecture optimisation is the most important component.

(Culha et al., 2015) [3] In the field of energy conservation, wastewater heat recovering is becoming progressively popular. Heat pumps recapture energy that would otherwise be squandered in wastewater using carefully constructed heat exchangers, that are the core of heat pumps, allowing for long-term, low-emission operations. A wastewater origin heat pump is the name for this hybrid device. This paper gives an outline of wastewater thermal exchangers in wastewater heat pump systems, while wastewater heat exchangers were characterised in depth depending on numerous features, such as their usage and construction process. Furthermore, the capacity of wastewater, as well as the many varieties of wastewater heat pumps with their uses, are briefly reviewed.

(Hussain et al., 2017) [4] Polymeric compounds in heat exchangers have such a number of benefits over metal elements, including price savings, reduced weight, and corrosion resistance. However, developing plastics having excellent heat transmission characteristics, machinability, and requisite strength is difficult. Because pure polymer resins have lesser mechanical and thermal qualities than metals, optimum efficiency necessitates careful consideration of the complete heat exchange system, from components to system layout. The physical characteristics that govern the heat conductivity of polymers including composites, and also the most recent studies on enhancing thermal conductivity, are summarised in this review. The heat conductivity of highly packed composites incorporating carbon or metal has been found to be an order of magnitude greater than those of pure polymers. Critical additive qualities such interfacial compliance, filler form factors, load level, as well as processing method are all investigated. High-volume processing techniques such as injection moulding and extrusion save money for polymers above metals, in addition to lowering material prices. Manufacturing considerations for the most promising polymer composites featuring significant thermal conductivity are hence investigated.

(Aresti et al., 2018) [5] The progress of renewable energy (RES) technology and systems has evolved significantly over the years. Geothermal energy was first introduced in Italy in 1904 and has increased dramatically in terms of efficiency since then. One of the main types of RES, geothermal heat pumps (GSHPs) are used to heat and cool a space when coupled with geothermal heat exchangers (GHEs). GSHPs extract or transfer heat to the ground through a network of pipes. The closed loop system, vertical or horizontal, is the most common of the configurations. Alternatively, the pipes can go all the way down to use natural underground water sources, if any, in an open loop configuration. GHEs outperform standard air-to-air heat exchanger units, and investigation into lowering their prices and increasing their total effectiveness through layout is a hot topic. The architectural features of GHE devices are presented and reviewed in this document. Closed and open devices, vertical and horizontal systems, U-tube or spiral devices, energy stacks, and hybrid devices are all described in detail. There is also a comparative examination of the literature on the many geometric features of GHEs, as well as a geothermal assessment of the soil environment and components utilised in GHE building. Then the experimental and analytical modelling of GHEs is examined, with factors including the thermal resistance of the holes, which have been extensively investigated, discussed in detail, the thermal characteristics, the thermal response tests, as well as the line and cylindrical sources designs, to name a few. The layout of a numerical simulation of a GHE systems is next presented using software that takes into account thermal parameters. Ultimately, a full comparative listing in tabulated form of over 30 arithmetical and/or experimental investigations on GHE is presented, with a concentration on the key elements and findings in each case. The present review study's overall goal is to help enhance the effectiveness and total costs of creating GHEs.

III. METHODOLOGY

The functioning of various measures including such convective heat transmission, conductive heat exchange, and radiative heat transmit all require heat exchange evaluation. The design of heat transferring equipment and energy conversion processes was based on heat exchange laws. For our dissertation, we examined at the foundations of heat transport and perhaps some simple implementations..
Conductive heat transmission is a form of heat transmission in which heat is transferred through an opaque medium that has a temperature variation in a single body. In generally, heat is transferred from a high-temperature zone to a low-temperature zone. The region of transmissions is directly proportional to the absolute gradients of the temperature dispersion via conduction.

Generation of Heat

Heat conduction examination examines the medium via which electrical, nuclear, or chemical energy is turned into thermal radiation. This upgrading mechanism's notion is heat generating. The pace at which heat is produced in a medium varies with both period and location within that period.

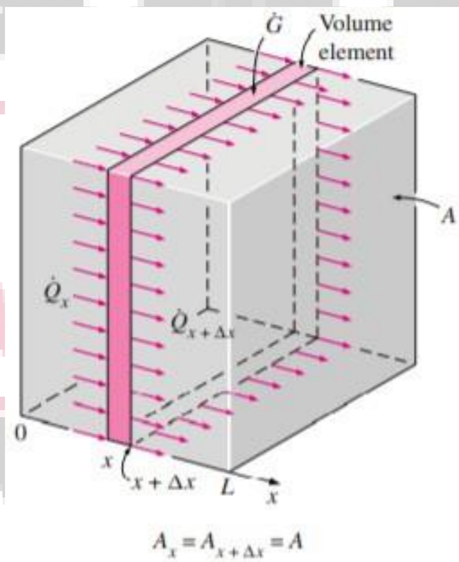

Figure 3: One feature is heat conduction

IV. RESULT AND DISCUSSION

The consequences of heat transmission in the presence of a triangular internal pipes
DPHEX was designed with a triangle shaped inner tube to begin exploring heat exchange over the course of the heat exchange. It was supposed that the outside tube was brass and the inner tube was copper. The internal pipes of the DPHEX is filled with ethanol, whereas the exterior pipe is filled with water. The temperatures of the ethanol were assessed to be roughly 780°C at the tube's intake air, whereas the temperature was calculated to be 100°C..

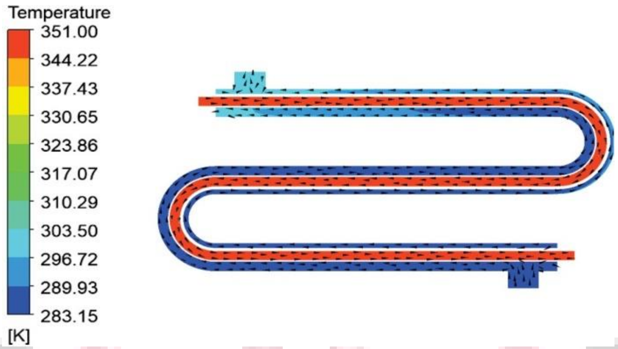

Figure 4: Temperature gradients along the length of the triangle-shaped interior pipes

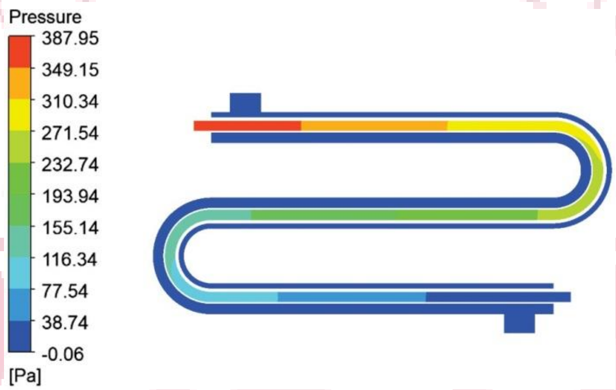

Figure 5: Pressure distribution over the lengths of the triangle-shaped interior pipes

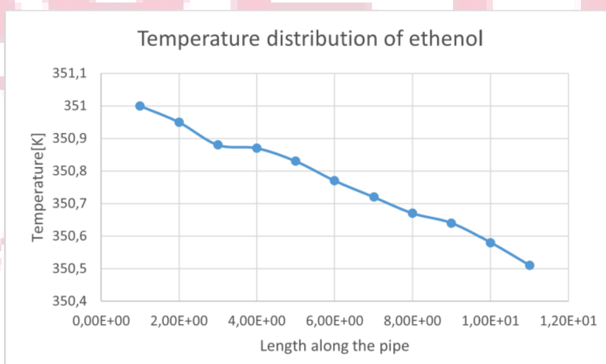

Figure 6: Ethanol temperatures gradient

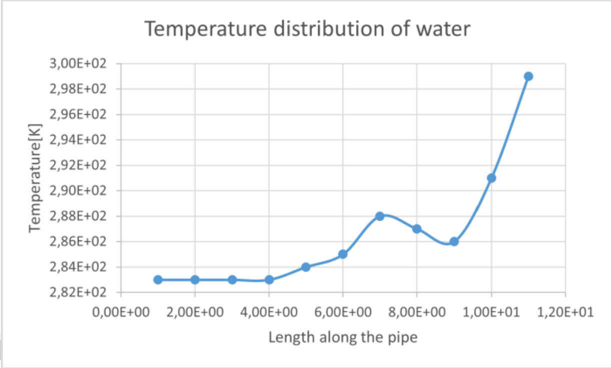

Figure 7: Water temperatures distribution

2 The look of a hexagonal interior pipe with heat exchange implications

In the construction plans of a DPHEX, the heat transmission all along lengths of the heat transmission is tested utilising a hexagon moulded internal pipes. The usage of brass and copper inside the DPHEX's manufacturing is taken into consideration. The exterior pipe is made of brass, while the inner pipe is made of pressurised copper. There at tube's intake, the temperatures of the ethanol were preserved at 780°C, whereas the temperatures of the waters were maintained at 100°C. After the simulations, the temperatures of ethanol steadily reduced from 351 to 316.52 degrees Celsius. Below are the temperatures and pressure counter charts for hexagonal internal pipes.

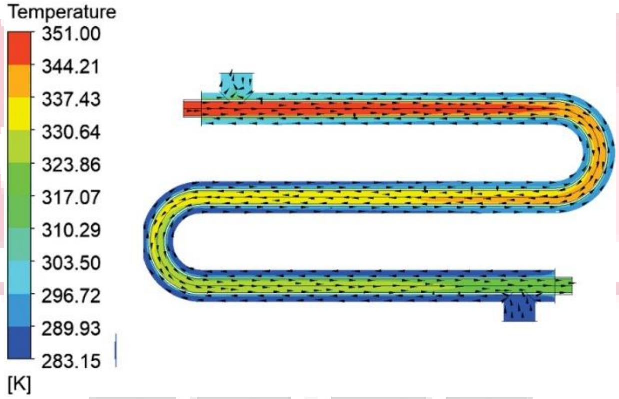

Figure 8: Temperature gradient all along hexagonal internal pipe's diameter

V. CONCLUSION

The heat transfer variables in tubes of several forms, such as triangular as well as hexagonal, are investigated in this research. For this assessment, the standard design of a dual pipes heat exchangers was selected, The standard sizing as well as measurements of cross-sectional region and dimension. Brass is chosen as the material for the exterior pipes of a DPHEX because of its machinability, ductility, wear resistance, and toughness. Copper is utilized for the interior pipes of heat transfer because of its excellent melting point, heat conductivity, and corrosion resistance. Water is utilized as a fluid in the exterior pipes to transport heat from the heat exchangers while maintaining the proper flow of the internal fluid through all the heat transfer... the factors that were taken into consideration throughout the ethanol and water simulations. The temperatures of ethanol at the intake was set to 780°C, and the temperatures of water at the intake was set to 100°C, using standard realistically boundary conditions. The proportion of fluid flowing within the tube were preserved consistent across all of the pipes.

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