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Cfd Analysis Of Helical Baffle Heat Exchangers For Shell-Side Heat Transfer Pressure Drop By Nanofluid

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Abstract – In today's world, the most common type of warm exchanger is the shell and tube warm exchanger, which is widely employed in refineries and other large-scale compound changes due to its high application suitability. Warmth exchangers are essential heat transfer hardware in oil handling, compound construction, natural assurance, and age management, among other applications. Shell-and-tube warm exchangers (STHXs) are commonly utilised in a few modern areas, including as power plants, concoction design, rock oil preparation, and so on. The complete space's shell-side liquid weight and temperature fields are then displayed. Finally, the cycle normal disconnected number of various cycles in the warmth exchanger is examined, and it's discovered that, among the precision allowed in building calculation, an occasional model for one cycle is used to investigate the warmth exchange and weight drop attributes for various warmth exchanger to save a lot of machine supply.

Keywords: Numerical simulation, Shell-and-tube heat exchanger, Comprehensive performance, Trefoil-hole baffle, Helical baffle, Segmental baffle

I. Introduction

Traditional heat exchangers with segmental befuddlements in the shell have a few flaws that result in a low weight drop into a useful warmth exchange. Every liquid mechanics study and testing of warmth exchange, as well as the weight drop on examination offices and modern instrumentation appeared to have a clearly better execution of helically confused device as compared to standard ones. These results in a high estimate of shell angle warm exchange stable, low drop, and low fouling from the shell viewpoint. Shell-and-tube heat exchangers (STHXs) are widely used in a variety of industries, including power plants, chemical engineering, crude oil refineries, food processing, and so on. According to Master, shell-and-tube heat exchangers account for 35-40% of all heat exchangers due to their strong pure mathematics construction, ease of maintenance, and potential upgrades. The baffle is a critical shell-side component of STHXs. The baffles provide a flow path for the shell-side fluid in addition to supporting the tube bundles.

The most commonly employed baffle is the segmental baffle, which compels the shell-side fluid to flow in a zigzag pattern, improving heat transmission at the expense of an excessive pressure drop penalty. This type of heat exchanger has been widely developed and is arguably the most widely used of the shell-and-tube heat exchangers. The most significant drawbacks of standard shell-and-tube heat exchangers with segmental bewilders (STHXsSB) are threefold: first, it causes an unusually large shell-side weight drop; second, it causes a no man's land in each compartment between two adjoining segmental bewilders, resulting in an expansion of fouling obstruction; and third, the emotional crisscross stream design additionally causes a high risk of vibration disappointment on tube package. To overcome the first disadvantages of the typical segmental design, a variety of upgraded structures were offered for reasons such as increased warmth exchange consistency, reduced tube vibration, and reduced fouling with a mild incrimination.

1.2 Heat Exchanger

In today's world, the most common type of warm exchanger is the shell and tube warm exchanger, which is widely employed in refineries and other large-scale compound changes due to its high application suitability. Warmth exchangers are essential heat transfer hardware in oil handling, compound construction, natural assurance, and age management, among other applications. Shell-and-tube warm exchangers (STHXs) are widely employed in a variety of modern fields, including power generation, concoction design, rock oil preparation, and maintenance. The complete space's shell-side liquid weight and temperature fields are then displayed. Finally, the cycle normal disconnected number of various cycles in the warmth exchanger is examined, and it's discovered that, among the precision allowed in building calculation, an occasional model for one cycle is used to investigate the warmth exchange and weight drop attributes for various warmth exchanger to save a lot of machine supply.

1.3 Classification of Heat Exchangers

Warm exchangers are classified in this field mostly based on their evolution, according to Garland (1990). (see Figure 1.1). The first level of organization is to categories warm exchanger components as recuperative or regenerative. A Recuperative Heat Exchanger has separate stream ways for each liquid and liquids stream, all while trading heat via a divider that isolates the stream ways. A Regenerative Heat Exchanger has a single stream path via which the heated and cold liquids pass.

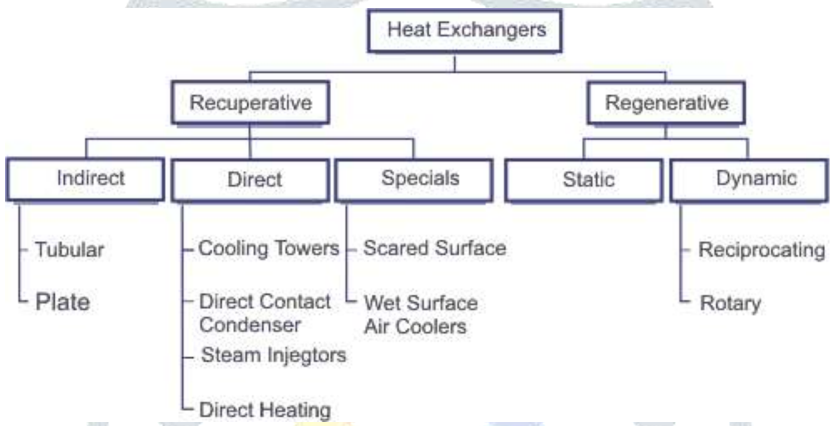

Figure 1.1 Classification of heat exchanger

1.4 Shell And Tube Heat Exchangers

Because of the versatility required by the manufacturer to consider a wide range of weights and temperatures, shell and tube heat exchangers are among the most widely used types of exchanger.

Shell and tube exchangers are divided into two categories.

- Those used in the petrochemical industry, which are usually protected by TEMA (Tubular Exchanger Manufacturers Association) rules.
- Those used in the energy industry, such as feed water warmers and power plant condensers.

Various tubes are installed inside a tube-shaped shell in a shell and tube exchanger. Figure 1.2 depicts a typical unit found in a petrochemical facility. Two liquids can exchange heat by circulating one around the outside of the tubes and the other through the tubes. The liquids can be single or two-stage, and they can flow in a parallel or cross-counter-stream pattern.

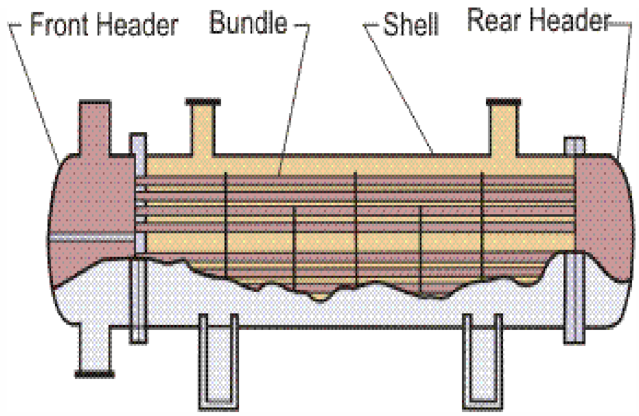

Figure 1.2 Shell and tube exchanger

The shell and tube exchanger is made up of four key components:

- Front Header—this is where the liquid enters the exchanger's tube side. It's sometimes referred to as the Stationary Header.
- Rear Header—in exchangers with numerous tube side passages, this is where the tube side liquid leaves the exchanger or returns to the front header.
- Tube package—contains the tubes, tube sheets, perplexes, tie poles, and other items needed to keep the package together.
- Shell—this is where the tube package is kept. The remainder of this section is dedicated to TEMA-secured exchangers.

1.5Advantages:

• STHEs are suitable for providing a larger surface area for warm exchange while having a shorter length in general due to the quality of varied tubes.

• STHEs can handle higher temperatures and weights, resulting in a higher warmth duty. This is because, in addition to providing a better overall warmth exchange coefficient, increases can also be made to eliminate warm extension effects and the thickness can be altered (more in the following point)

• Versatility of all the warmth exchangers, STHEs are the most versatile in terms of structure. Heads/terminations of any form and thickness can be used because the tubing is fit like a violin. Working conditions can determine the number of tubes and tube pitch. Development cries can be used to reject warm extension effects, it's unclear if various cuts and dividing can be used to influence the overall warmth exchange coefficients, and there's something known as a coasting head that can be added to refute warm extension of the tubes. The number of passes on the shell and tube sides can also be varied.

II. Method

Cad Modeling

Creo 2 software is used to create a CAD model of the shell and serpentine heat exchanger, which is based on the dimensions listed in table 5.1 below. Part modelling and assembly are used to create the CAD model. PTC's Creo is a sketch-based, feature-based parametric 3d modelling programme with bidirectional associativity and a parent-child connection.

Table 5.1: Dimensions of shell and serpentine heat exchanger

HEAT EXCHANGER LENGTH	1300mm
SHELL OUTER DIAMETER	200mm
SHELL THICKNESS	3.2mm
TUBE OUTER DIAMETER	30mm
TUBE THICKNESS	1.5mm
NUMBER OF SERPENTINE TUBE	1

CFD SIMULATION USING ANSYS

STEP 1: The first step is to use the import tool to import a CAD model into ANSYS Workbench, and then use other tools to clean up the geometry.

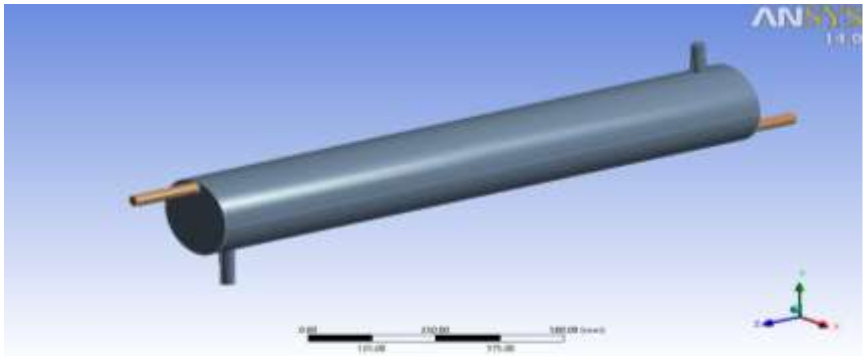

Figure 1.3 Imported CAD model in ANSYS

The Creo CAD model is transformed to the iges file format, which is interoperable with other design and analysis software. Cleanup tools are used to fix harsh edges, gaps, and other issues.

STEP 2: Brick elements are used to mesh the model, with set parameters and mesh density. The mesh size is fine, the inflation is normal, and the relevance is 100. Smoothing is set to medium, transition is slow, and the span angle is fine.

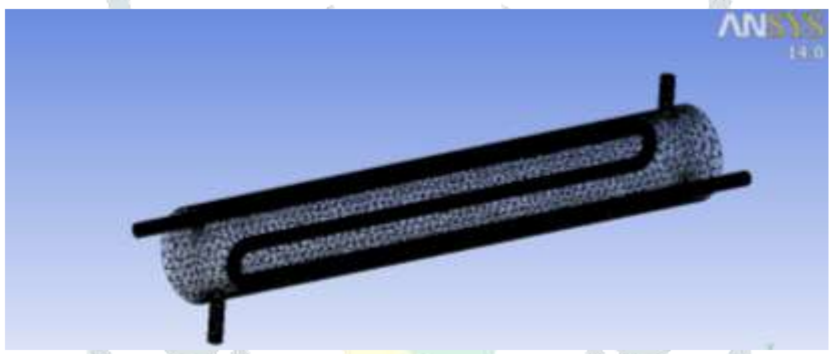

Figure 1.4 Wireframemeshed model in ANSYS

STEP 3: Three separate domains are provided for shell, tube, and tube coating. A reference pressure of 1 atm, a turbulence model of k-epsilon, a domain definition of fluid, material water, and a nano fluid are used to define the shell domain. 1%, 2%, 3%, 4%, and 5% are reserved for future research.

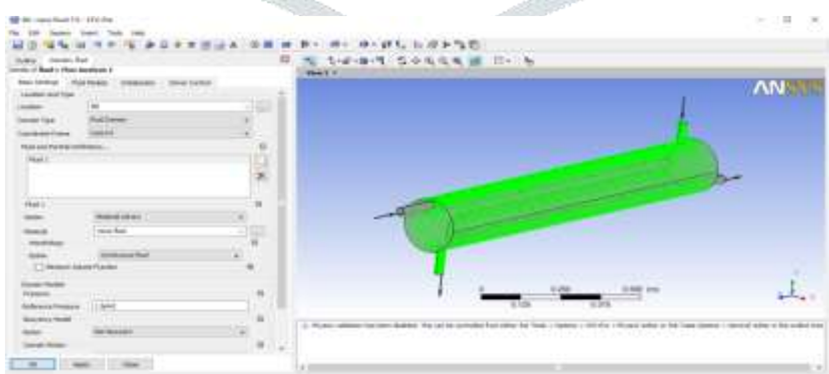

Figure 1.5 Fluid domain

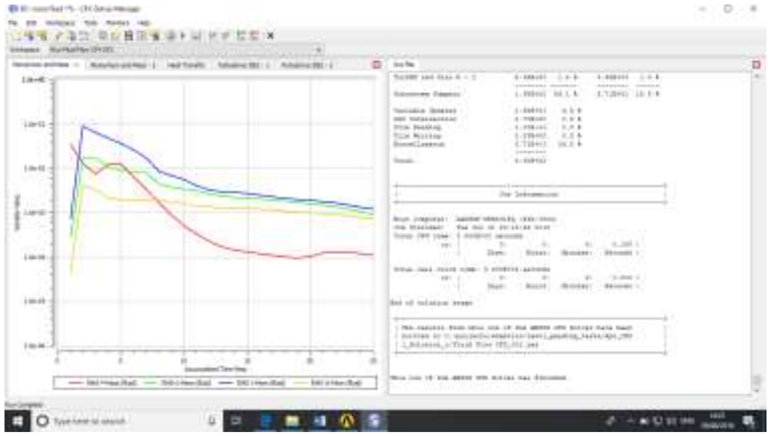

Figure 1.6 RMS residual plots

Data Reduction

The ratio of actual heat transferred to maximum feasible heat that can be transported is the definition of a heat exchanger's effectiveness. It indicates how well a heat exchanger performs in terms of transferring heat between different fluids. It is a criterion for determining the viability of installing a heat exchanger.

Effectiveness = $Q_{actual}/Q_{max\ possible}$

$$\varepsilon = m_cC_{pc}(T_{co} - T_{ci})/C_{min}(T_{hi} - T_{ci}) = C_c(T_{co} - T_{ci})/ C_{min}(T_{hi} - T_{ci})$$

III. Proposed Methodology

Helix Changer

Regular heat exchangers with a segmental baffle on the shell side have a few flaws that result in a low weight drop into a useful heat exchange.

When compared to typical heat exchangers, both hydrodynamic investigations and heat exchange tests, as well as the weight loss on research offices and mechanical gear, demonstrated that helically confounded heat exchangers performed substantially better. These results show a high estimation of the shell side heat exchange coefficient, minimal power drop, and low fouling on the shell side.

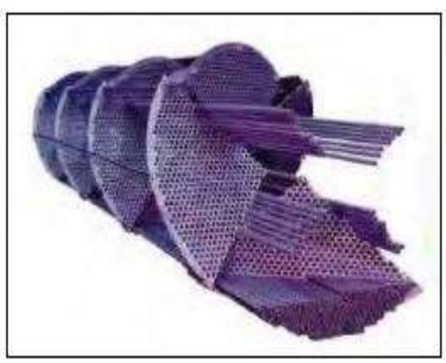

Figure 1.7 Helix changer

Developments In Shell And Tube Exchanger

The enhancements of shell and tube exchangers focus on a better change of power drop into heat exchange by improving the standard layout plans. With single segmental confuses, a significant portion of the overall power loss is wasted in changing the course of the stream; additionally, this baffle strategy causes other undesirable effects, such as dead spots or zones of distribution, which can cause increased fouling, high leakage stream, which avoids the warmth exchange surface, and a large cross stream. The cross stream not only reduces the temperature difference between the inside and outside of the tube, but it also reduces tube vibration.

Design aspects

A well-designed helical baffle course of action is highly dependent on the heat exchanger's operating parameters, but it may be fine-tuned with the right helix position, baffle covering, and tube design.

In the first strategy, a perfect shell-side heat exchange coefficient is duplicated by different modification factors for stream circulation and non-idealities, such as leakage streams, sidestep streams, and so on; in the meantime, some restore factors are not required for helical baffle geometry; in the meantime, new are presented by

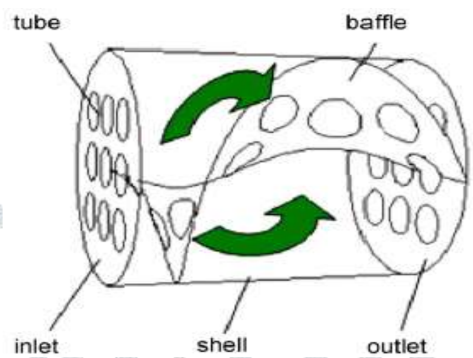

Figure 1.8 Helix changer pitch

Heat Transfer Coefficients and Pressure Drop Calculations

The main components of a design for heat exchangers with a given obligation are heat exchange coefficients and weight drop estimations. Kern and Bell-Delaware procedures, for example, are used in traditional methodologies to calculate the general heat exchange coefficient, warm exchange coefficient, and weight drop.

The Kern (1950) technique, which attempted to connect information for standard exchangers using a simple condition akin to stream in tube conditions. However, this technique is restricted to a predetermined confuse cut (25 percent) and can't adequately depict actual to-shell leakages.

Despite the fact that the Kern condition isn't particularly precise, it provides for a simple and quick prediction of shell side coefficients and weight loss, and it has been used successfully since its inception. The Bell-Delaware strategy was the next step in the evolution of shell side counting techniques (Bell-1963). Adjustment parameters for confound leakage affects, and so on, are included in this technique. Are offered based on the results of the test. This method is widely used and forms the basis of the methodology outlined in the Heat Exchanger Plan Handbook.

Nanofluids

Nanofluids are two-stage blends made by dispersing nanometer-sized particles in base liquids with diameters less than 100 nanometers (Sarit K. Das et al. 2008). Nanoparticles, nanofibers, nanotubes, nanowires, and nanorods are the nanometer measured particles used for scattering in base liquids. Metal oxides (e.g., alumina, silica, zirconia, titania), oxide pottery (e.g., Al2O3, CuO), artificially stable metals (e.g., gold, copper), carbon in various structures (e.g., jewel, graphite, carbon nanotubes, fullerene), metal carbides (e.g., SiC), and functionalized nanoparticles are the most commonly used materials as nanoparticles. Oils, water, and natural fluids such as glycols, refrigerants, polymeric arrangements, bio liquids, ointments, and other typical fluids are among the base liquid types.

Nanofluids as Heat Transfer Fluids

When the lighter parts of nanoparticles are disseminated and suspended steadily in a base liquid medium, the thermal characteristics of the base liquids are significantly improved. This nanofluid innovation, which is given critical importance where warm building and nanotechnology collide, has expanded significantly over the last decade. Nanofluids' most important job is to get the best possible thermal characteristics with low molecular weight divisions through uniform dispersion and stable suspension of nanoparticles in a base liquid medium. It is critical to decide on the upgrade of warm vitality transport in fluids in order to achieve this goal. Several designers and researchers have accomplished research achievement in the developing nanofluid period by evaluating astonishing warm features of nanofluids and proposing new components behind enhanced warm properties of nanofluids.

Nanofluid planning and schematic depiction of this warmth exchange liquid appears in figure inside the domain of warm research; nanofluids are manufactured for their strangely boosted warm conductivities, which leads to the notion of utilising nanofluids as heat exchange liquids.

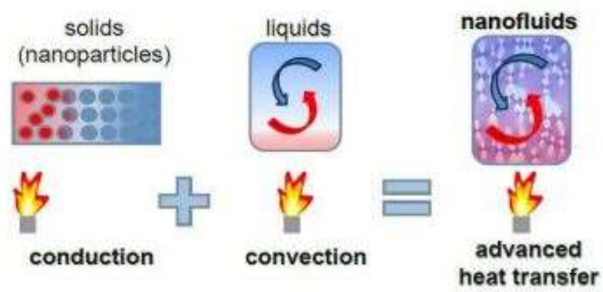

Figure 1.9 Schematic view of heat transfer fluid

Nanofluids' enhanced warm properties provide a better understanding of a massive development for warmth exchange strengthening, which is critical to mechanical divisions such as power generation, transportation, warm treatment for malignant growth treatment, small scale fabricating, metallurgical and synthetic areas, as well as cooling, warming, and cooling.

IV. Results And Discussion

The ANSYS CFX 14.0 version is used to conduct the CFD analysis, and velocity and temperature charts for various fluid scenarios are extracted. There are six examples in the analysis, each with a different combination of base fluids and nano fluids. In each example, the efficiency of the heat exchanger is computed.

CASE 1: Water is the base fluid in this example. In table 6.1, the properties are listed.

Base fluid water for both hot and cold

FLUID TYPE	MASS FLOW RATE (Kg/s)	SPECIFIC HEAT (J/Kg K)
COLD FLUID	.05	4179.725
HOT FLUID	.04	4197.178

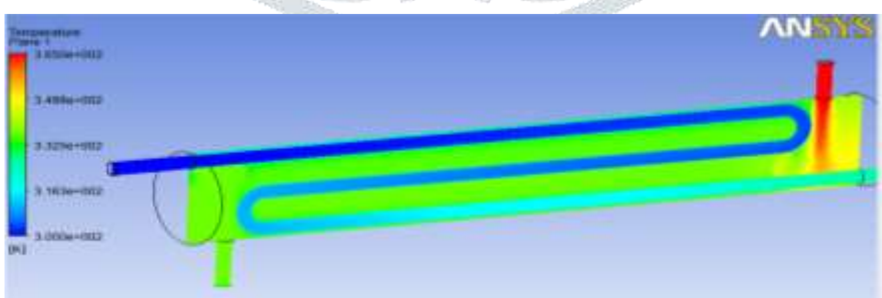

Figure :6.1 Temperature contour using water as fluid

The temperature contour illustrated in fig. 6.1 above heated fluid entering the shell is dark red on the upper right portion of the contour, and the temperature of the hot fluid falls as we move to the left of the shell. The cold fluid entering the tube is shown by a dark blue hue (tube domain), whereas the fluid exiting the tube is represented by a bright blue colour.

CASE 2 : CuO/water nano fluid 1%

Table 6.3: Base fluid water for coldand hot fluid isCuO/water nano fluid 1%

FLUID TYPE	MASS FLOW RATE (Kg/s)	SPECIFIC HEAT (J/Kg K)
COLD FLUID	.05	4179.725
HOT FLUID	.04	4154.7

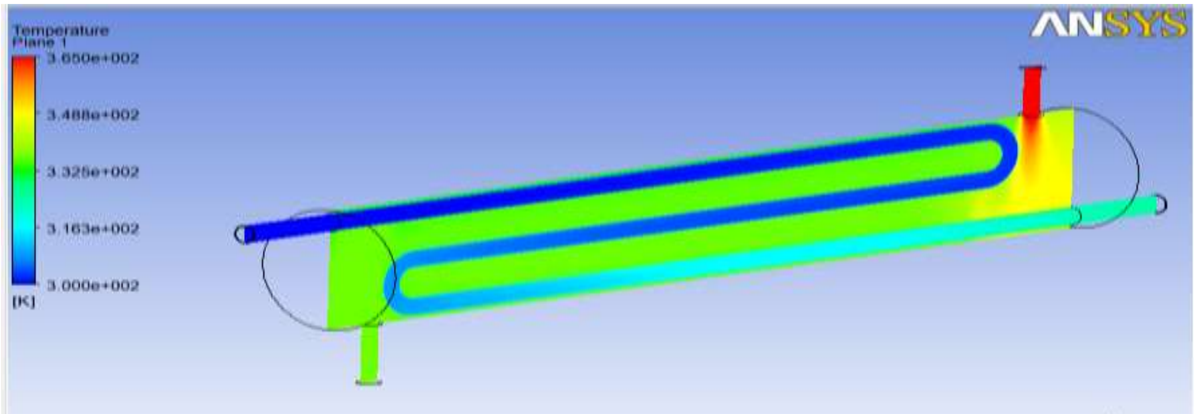

Figure 1.10 Temperature contour for CuO/water nano fluid 1%

The temperature contour illustrated in fig. 6.3 above heated fluid entering the shell is dark red on the upper right portion of the contour, and the temperature of the hot fluid falls as we move to the left of the shell. The cold fluid entering the tube is shown by a dark blue hue (tube domain), whereas the fluid exiting the tube is represented by a bright blue colour.

V. Conclusion

Modeling for Shell-Side Heat Transfer Coefficient and Pressure Drop of Helical Baffle Heat Exchangers and associated study are presented in this dissertation. Correction factors for the helical baffle geometry of heat exchangers are proposed using a model identical to the technique presented for segmental baffles. Furthermore, the findings of code for a case study are compared with the results produced using software and experimental formulas supplied by Zhang in order to assess the validity. The results show that helical baffles provide a reasonable balance between heat transfer and pressure drop characteristics when compared to traditional segmental baffles. While trefoil-hole baffles improve heat transfer significantly, they do so at the expense of a significant pressure loss. Because overlapping has a bigger influence on pressure drop than on heat transfer, utilising large overlapping values is recommended only when heat transfer enhancement is much more important than pressure drop reduction, according to the results obtained during optimization.

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