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A STUDY OF OPERATIONAL PARAMETERS ON HEAT TRANSFER COEFFICIENT

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ABSTRACT

An extensive literature assessment, including both experimental and computational investigations of conical heat exchangers, forms the basis for the comparative analysis. The main concern is how well these exchangers function in contrast to their more traditional equivalents in terms of heat transfer efficiency, pressure drop, and overall performance. The effect of variables such fluid flow rates, shape, material qualities, and operating circumstances on heat transfer performance is investigated. This analysis sheds light on the state of the art and current developments in the field of conical heat exchangers. In order to better comprehend and use conical heat exchangers in real-world settings, the abstract also indicates prospective topics for further study and development. The results of this research shed light on the mechanics of heat transfer in atypical heat exchanger geometries and provide recommendations for improving their functionality across a range of sectors.

KEYWORDS:- Operational Parameters, Heat Transfer Coefficient, computational investigations, conical heat exchangers

INTRODUCTION

Heat exchangers may be more efficiently designed if the performance of the heat transfer and the pressure drop are both optimized at the same time. A significant correlation exists between enhanced heat transfer performance of heat exchangers and enhancements in heat transfer coefficients. Increasing the pressure drop in a heat exchanger is a common drawback of modifications made to boost the heat transfer coefficient. Because of this, choosing the best configuration is crucial during heat exchanger design. Chemical processing, nuclear reactors, power plants, heat recovery systems, the food industry, and refrigeration and air conditioning are just a few of the many uses for heat exchangers. In heat exchangers, the improved heat transfer coefficient has two major effects. It does two things: increases efficiency and decreases heat exchanger footprint. There are a wide variety of active and passive approaches used to improve heat transmission in practical settings. Due to its high heat transfer coefficient and compact shape, the coiled tube design is an essential passive heat transfer improvement approach. Some pieces of heat transfer equipment, including heat exchangers and reactors, benefit greatly from the helical coiled shape because it allows them to fit a large heat transfer surface into a relatively small amount of space. Because of the centrifugal force created in the fluid, secondary flow patterns are induced by the tube's curvature. The secondary branches formed in the coiled tubes look like what is seen in Fig. 1.

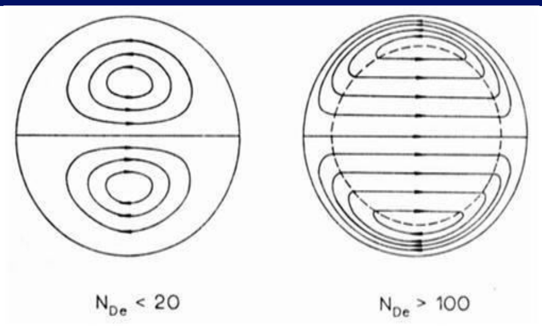

Figure 1 Secondary flow for low and high Dean Number

This secondary flow raises the pressure drop across the coiled tube, but it also allows for better fluid mixing at the same flow rate, which improves the heat transfer coefficient.

The strength of the secondaries formed in the coiled tube is a key factor in the increase, as pointed out by Shah and Joshi. Secondary flow created is more powerful when the coil and tube diameters (D and d) are smaller. The Eustice first saw the flow of liquids in a curved conduit. Since then, several investigations on fluid flow in curved pipes, such as helical coils, have been reported. They conducted the experimental and numerical study of the flow and temperature fields. They show that De has a major impact on the secondary flow pattern. They also investigated how different flow patterns affect heat transmission. Several studies were given that examined how varying Re and Pr affected flow patterns (De) and heat transmission (Nu). Since the flow pattern in the curved tube was responsible for the majority of the effects seen in the helical coil arrangement, knowing how flows in curved tubes affect things is crucial.

CONICAL COIL HEAT EXCHANGERS

Conical coiled configuration (CCC) is a hybrid of helical and spiral coiled topologies that is defined in this study. Figure 2 depicts the conical coil arrangement.

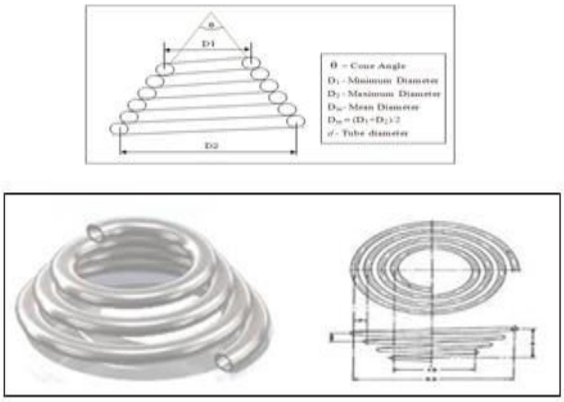

Figure 2 Conical coil configuration for heat exchanger

Conical coil designs may have two extreme angles, either 0 degrees (helical coil) or 180 degrees (spiral coil). The efficiency of a conical coil heat exchanger shifts from helical coil to spiral coil operation when the cone angle moves from 0 degrees to 180 degrees.

The conical coil structure is more compact than the helical coil heat exchanger and has a better heat transfer coefficient and lower pressure drop than the spiral coil. While a spiral coil exhibits lowest fluid bypass and maximal pressure loss across the coil, a helical coil shape exhibits the opposite behavior in heat transfer applications. When compared to helical coils and spiral coils, conical coils have less fluid bypass and lower pressure drops.

These benefits suggest that it deserves consideration as a possible replacement for the traditional methods now used in heat transfer analysis.

While extensive research has been done on analyzing helical coil heat exchangers, no such information exists for conical coil heat exchangers. With flow rates in the laminar region (Re Recritical), this is the first effort to investigate the impact of cone angle on thermal performance.

The purpose of this study is to conduct an experimental investigation of the heat transfer and pressure drop characteristics of conical coil heat exchangers as they relate to geometric and operational factors. Diameter (di), radius (R), and cone angle () are the geometric characteristics used for this investigation. The input temperatures of the fluids in the shell and the tubes, as well as the mass flow rates of the fluids in the shell and the tubes, are the specified operational parameters. It is also argued that Nu is functionally related to Re, that Pr is functionally related to, and that f is functionally related to Re.

FLOW PATTERN IN CURVED TUBES

The first person to notice how curvature affects flow in coiled tubes was Grindley and Gibson. Researchers examined how a coiled tube's shape affected fluid movement. In their work on curved tubes, Williams et al. used this reference to show that the centrifugal force acting on the fluid flowing through the curved tube causes the site of the maximum axial velocity to be displaced toward the outer wall of the curved tube.

Eustice examined the difference (increase) in resistance to flow when comparing the flow in curved tubes with that in straight tubes. They found that the resistance went up in proportion to the curvature ratio (). However, they did see substantial deformation of the tube's cross section in several of the experiments when chilling the tube was involved. Curve tubes, U-tubes, and elbows were employed in the studies, and the ink injection method was used to aid with visualizing. To study the behavior of fluids in curved pipes under turbulent flow conditions, he employed sand. In turbulent flow, the same flow patterns were seen.

Attempts were attempted to mathematically explain the flow in a coiled tube by Eustice The researchers analyzed the motion of an incompressible fluid in a coiled conduit with a circular cross section. They noticed that the flow rate drops at low velocities because of a geometrical parameter, [2(Re)2r/R]. These efforts focused on the lower curvature ratio (). In the investigation, it was found that analytical calculations are only used for streamline flows, which is a crucial point to remember. The fluid particles, he saw, were bouncing back and forth between the straight section of the tube and the curve. The energy dissipated as a consequence of these vibrations was created by centrifugal forces acting on the fluid within the pipe as a result of its curvature. White investigated the behavior of fluids like water and mineral oil flowing through curved pipes under laminar circumstances. He came to the conclusion that the flow parameter (Re or De [De = Re(r/R) 1/2]) was not sufficient to determine the onset of turbulence. The resistance to flow in the curved pipe is a function of the De and the Re, and he also pointed out that the flow stability in curved pipes is greater than that in straight pipes. He also found that, for De 11.6, there was no difference in the flow resistance between curved and straight tubes.

After analyzing experimental and computational data, Koutsky and Adler concluded that the velocity profiles of both laminar and turbulent flows are more flattened out than they would be in straight tubes. The influence of Pr and Re on the flow structure and Nu was also addressed. The completely developed flow for big De in a curved tube with a homogeneous heat flux was given by Mori and Nakayama. Both practical and theoretical examinations of the temperature and flow field were conducted. All in all, their investigation of secondary flow characteristics for evolved laminar flow discovered a similar discovery, namely that the maximum velocity migrated towards the outer wall. This causes the secondary vortices to speed up and move closer to the wall.

THERMAL ANALYSIS OF COILED TUBE HEAT EXCHANGER

Heat transfer analysis of coil tube heat exchangers has been the subject of several published works. Many studies on heat transmission and related topics in heat exchangers have been published. Here are a few of the most critical details:

The following two criteria were used as the basis for the analysis:

a. Constant Wall Temperature (CWT)
b. Constant Heat Flux (CHF)

Only a few efforts have been made to analyze the external heat transfer coefficient in coil tube heat exchangers, and they all start with the same two assumptions. Phase change medium is used to approach or accomplish the condition of constant wall temperature on the tube surface (since condensation is a constant temperature process). At a certain temperature, the vapor condenses on the coils outside. A region's potential for condensation of vapor is determined by the local heat flux.

The use of a heating coil in or around the tube wall allows for the creation of constant heat flux heat exchangers. In order to maintain a constant heat flow, a heating element that does so uniformly throughout its length is supplied with a continuous supply of electrical power. Heat may also be generated by applying an electric potential to the tube's ends, provided that the tube is constructed from electrically conductive material.

The third condition, which is neither a constant heat flow nor a constant wall temperature, often develops in practice. This is a common occurrence in heat exchangers when one fluid contacts another. When dealing with such issues, it is helpful to think about the characteristics of both fluids at their respective mean bulk temperatures. Here, LMTD is used as the calculating foundation for the heat exchanger. However, the primary hypothesis is that the heat exchanger will transport heat only by convection. The

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investigation performed using fluid characteristics that vary with temperature shows that this assumption is false. The thermal properties of helical and spiral coiled heat exchangers have been the subject of much study.

Helical coil heat exchangers

There is little information available in the literature about the design of helical coil heat exchangers for use with liquids. While the cleaning procedure is somewhat more challenging than that of a traditional heat exchanger, the self-cleaning propensity in the helical coil structure owing to secondary flow minimizes the number of cleaning cycle's necessary.

There are two obstacles to overcome when trying to estimate the heat transfer coefficient while constructing a heat exchanger;

1. First, steam should be used as the fluid on one side (often the shell side) to maintain a steady heat flow.
2. The second significant challenge is making an estimate of the heat transmission surface area.

The efficiency of the heat exchanger will be reduced under these circumstances.

An additional estimate for the complicated geometry computation is the external heat transfer coefficient. The study in this case is based on the flow via tubes. Prabhanjan brought attention to these issues. These issues are exacerbated by the inefficiency of current techniques for predicting flow around the coil.

According to the research, helically coiled tubes perform better than straight tubes when used for heat transmission. The fluid in the helical coiled tube experiences centrifugal force, causing secondary flow to occur. Increased heat transmission is achieved thanks to secondary flow generated in the tube. In the laminar flow regime, this phenomenon is most prominent. In a liquid-to-liquid setup compared heat transmission in straight tubes and helical coil tubes and found that the latter had a greater heat transfer coefficient.

Spiral coil heat exchanger

Naphon et al. analyzed a spiral coiled tube heat exchanger and looked at how the tubes' curvature affected heat transmission and flow development. Under a constant wall temperature scenario, with cold water supplied at the inmost and flowing out at the outermost turn, he examined this effect using coils with varying curvature ratios () of (0.02 to 0.05). Results were simulated using CFD analysis. Both analyses provide outcomes that are in fair agreement with one another. The investigation revealed that the secondaries formed in the tube contributed to the improvement of heat transmission and pressure drop. They realized that the Nu for the helical tube was around 1.5 times greater than the Nu for the straight tube. They went on to talk about temperature analysis in both dry and wet environments. The input conditions of both fluids were shown to have a significant impact on the heat transfer coefficients, which was another key realization. Heat transfer coefficients on both the tube and shell sides were correlated.

CONCLUSION

Increases in Nu with increasing Qh/Qc suggest that secondary flow in the coil has a greater impact on heat transmission than does fluid stagnation. As the cone angle () climbs from 0 degrees to 180 degrees, the flow ratio, Nu, falls by the same amount. For constant values of flows (Qh and Qc), the performance of a coil tube heat exchanger is significantly impacted by the tube diameter (di). The Nu value for heat exchangers with coiled tubes is much higher than that for those with straight tubes. This demonstrates that coiled tube topologies are superior to straight tube heat exchangers in heat transfer situations with similar pressure drops. As Re increases, the heat exchanger's efficiency drops for all coil orientations. The coil tubes are more effective at transferring heat at low flow rates than at high flow rates. Seven, as Re increases, the friction factor (f) falls. At small values of Re, however, f does not vary linearly as it does in straight tubes. At a certain radius of refraction, Re, the fraction factor grows as the cone angle and tube diameter get larger. Coil tube heat exchangers have a lower tube-side pressure drop (p) than their straight-tube counterparts.

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