Naveen Kumar, 10:5
ISSN (Online): 2348-4098
ISSN (Print): 2395-4752

Design and Thermal Analysis of Double Pipe Heat Exchanger by Changing Mass Flow Rate

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Abstract- Heat exchangers are employed in a variety of applications, included power plants, nuclear reactors in energy production, RAC systems, self-propelled industries, food industries, heat retrieval systems, & chemical handling. The techniques of upgrading can be divided into two categories: active and passive ways. The active approach necessitates the use of peripheral forces. Discrete surface geometries are required for passive approaches. These strategies are commonly utilized to increase heat exchanger performance. Helical tubes have already been designated as among the passive heat transfer enhancement materials. Due the short construction and high heat transfer coefficient, and they will be widely employed in various industrial applications. The thermo-hydraulic performance of various configurations of gas- to-liquid double-pipe heat exchangers featuring helical fins was investigated that used a computational model based on CFD. The heat transmission, pressure drop, unit weight, and overall performance of helical or longitudinal fin configurations studied numerically simulated and the results. The effects of increasing the number of fins and Reynolds number on thermo-hydraulic performance also were investigated..

Keywords- Thermal Analysis, double-pipe heat exchangers, Reynolds number, thermo- hydraulic performance, CFD.

I. INTRODUCTION

Heat exchangers are employed in a variety of applications, included power plants, and nuclear reactors in energy production, RAC systems, self-propelled industries, food industries, heat retrieval systems, & chemical handling. The techniques of upgrading can be divided into two categories: active and passive ways. The active approach necessitates the use of peripheral forces.

Discrete surface geometries are required for passive approaches. These strategies are commonly utilized to increase heat exchanger performance. Helical tubes have already been designated as among the passive heat transfer enhancement materials. Due the short construction and high heat transfer coefficient, and they will be widely employed in various industrial applications [1]. The development of high-performance thermal systems has sparked interest in heat-transfer technologies.

In heat exchangers, raising the convection heat transfer coefficient or expanding the convection surface area improves heat transmission. Inserts inside these pipes/tubes are one means of increasing the convection coefficient within such a heat exchanger [2].

A heat exchanger is devices that allow energy to be transferred between two fluids of different temperatures. A heat exchanger takes the use of fact that energy flows when there has been a difference in temperature. As a result, heat will be transferred from the higher- temperature heat reservoir to the lower-temperature heat reservoir. The temperature differential created by the circulating fluids forces the energy to move between both.

The energy passing through a heat exchanger might be sensible or latent heat of flowing fluids. The fluid that provides the energy is referred to as hot fluid. Cold fluid is a type of fluid that receives energy." In such a heat exchanger, the temperature of the hot

International Journal of Science, Engineering and Technology

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fluid should drop whereas the temperature of the cold would increase. The goal of a heat exchanger would be to either heat or cool the fluid [3].

Whenever one of the fluids experiences a phase shift, the temperature of the other fluid remains unaltered. Condenser and evaporator are two different types of heat exchangers. Heat exchangers featuring convective fluid heat transfer inside tubes are commonly used in a variety of technical applications. A heat transfer improvement strategy to accommodate high heat flux, i.e., to minimize the size and expense of heat exchangers, has gotten a lot of attention in recent years.

Heat transfer improvement the rate of all sorts of thermos-technical apparatus is extremely important to the industry. It results in reduced in size and weight in addition to conserving basic energy. Many heat transfer improvement techniques have been developed up to this point. Twisted-tape is among the most essential members of a improvement techniques used in heat exchangers [4].

II. LITERATURE REVIEW

Lachi et al. (2018) A DPHE and a shell and tube heat exchanger's time constants were investigated. The goal of this study has been to identify the features of these heat exchangers in a transient state, particularly where sudden variations in inlet velocities are taken into account. A model containing two parameters of time delay and time constant was used to conduct this research. So, it is worth noting that the analytical term were calculated using the energy balance equation. Furthermore, it seemed that the numerical data were validated using an experimental approach, with the maximum recorded discrepancy being less than ten percent.

Aicher and Kim (2018) the effect of counter flow with in nozzle portion of a DPHE installed upon that shell side wall were explored. The counter flow with in nozzle portion turned out to have a considerable impact on heat transfer or pressure decrease. It was also determined that when the heat exchanger were small and the ratio of free cross section regions was low enough, the effect is more noticeable. Researchers also demonstrated experimental correlations for predicting the rate of heat transfer in turbulent flow.

Ma et al. (2018) the impacts of supercritical carbon dioxide (SCO2) in a DPHE was researched experimentally, with the impacts of pressure, mass flow, and buoyancy force on the SCO2-side being studied extensively. On just one hand, it must have been discovered that increasing the gas-side pressure significantly reduced both of the overall as well as gas-side heat transfer rates. But at the other hand, it really was clear that now the waterside flow rate, as opposed to the gas-side flow rate, was the most important factor in the heat transfer rate. Furthermore, for predicting heat transfer rate, a mathematical correlation based on Genetic Algorithm has been presented.

Raghavan (2018) in both parallel & counter flow configurations, a two-pipe helical heat exchanger was examined. Wilson plots have been used to compute the equivalent heat transfer rates of the inner tube or annulus. It really is worth mentioning that the performance evaluation criteria for both configurations were equal, despite the fact that now the heat transfer for such counter flow design was unquestionably larger than just its counterpart due to a bigger temperature differential. “The comparison of heat transfer coefficients between both the improved tube and smooth tube under another pumping power condition is the performance evaluation criterion (PEC) discussed above.”

Dizaji et al. (2018) In a DPHE, I conducted an experimental research of heat transmission and pressure drop of corrugated tubes that proved out to be really important in the area (Fig. 2.1). Concave and convex corrugations were used on both the inner and outer tubes. The working fluids inside the trials was hot and cold water, which went through the heat exchanger's inlet section, respectively. The best efficacy was attained whenever the inner and outer tubes featured convex and concave corrugated designs, accordingly, according to research findings.

Bhadouriya et al. (2018) Heat transfer and pressure drop of such a DPHE were explored both experimentally and statistically, with the main goal being to determine the influence of the inner tube twist ratio and flow parameters. A boundary criterion for the outer flow had been a consistent wall temperature there at inner wall of the annulus. The working fluids with in studies were water and air that ran via the heat exchanger's inner (square duct) and annulus, respectively. In all flow regimes, the results revealed that such a geometry adjustment resulted in an increase in heat transfer rate and just a pressure decrease. The findings of this article will aid engineers in designing more compact heat exchangers. "Nusselt number in the laminar flow regime, unlike smooth tube, was found to be reliant on flow characteristics including physical factors such as Reynolds number or twist ratio.

III. OBJECTIVES OF WORK

The thermal performance of DPHE featuring straight and helical fins was examined in this study. First, the number of straight or helical fins was increased from ten to twelve, and then the thermo hydraulic performance of DPHE was evaluated.

As a result, the following are the study's objectives:
- To compare the thermo hydraulic performance of DPHE with straight and helical fins.
- To investigate the effect of Reynolds number on performance of DPHE with straight and helical fins.
- To compare the thermal performance enhancement of DPHE with straight and helical fins.

IV. RESULTS AND DISCUSSION

Fins improve heat transmission through exposing a wide surface area to convection on the gas side, lowering thermal resistance. Its shape of helical fins allows for a higher heat transfer surface area to be exposed than when longitudinal fins are being used.

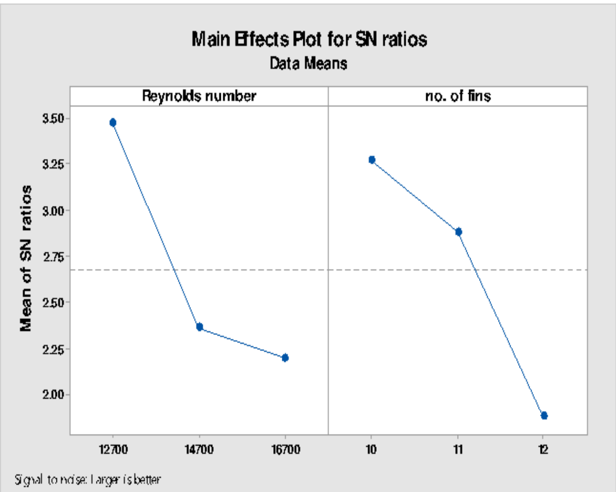

Fig 1. Main-effect plots for Thermal performance enhancement.

The preceding graph shows that Reynolds number seems to have a relatively minor impact on thermal performance enhancement. Even though both Reynolds numbers are linked to improved thermal performance. As well as the fin number From Fig. 1, the optimal combination for SNR- ηf is determined as A1B1.

V. CONCLUSION

The thermo-hydraulic performance of various configurations of gas-to-liquid double-pipe heat exchangers featuring helical fins was investigated that used a computational model based on CFD. The heat transmission, pressure drop, unit weight, and overall performance of helical or longitudinal fin configurations studied numerically simulated and the results. The effects of increasing the number of fins and Reynolds number on thermos-hydraulic performance also were investigated.

The following conclusions are reached as a result of the findings. It is clear that now the Reynolds number has a smaller impact across all parameters, including heat transfer coefficient, Nusselt number, heat transfer rate, pressure drop, and thermal performance enhancement, than that of the number of fins. The ideal factor combination for SNR-ηf is determined to be A3B3. Helical fins have a larger surface area for heat transmission than longitudinal fins.

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