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Thermohydraulic Analysis of Double Pipe Heat Exchanger with Corrugated Tubes

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Abstract

In addition, the current crop of micro-heat exchangers make use of twisted tape inserts, baffles, and fins to increase surface area while yet retaining compact dimensions. To improve the heat exchangers' thermohydraulic performance, a double-pipe design using corrugated pipes is presented in this study. The hot fluid is transported via the inner corrugated pipe, while the cold fluid is sent through the annulus. The rate of heat transmission must be raised in proportion to the growing contact area. This study use computational fluid dynamics (CFD) to examine pressure loss and heat exchange in DPHE. For this reason, the finite volume approach is employed to solve the general governing equations, and a commercial computational package called ANSYS is used to do so. The analysis takes into account mass flow rates consistent with those seen in practical, contemporary refrigeration systems. The DPHE operating temperatures taken into account in this research are consistent with real-world situations. Optimizing the mass flow of the refrigerant via the DPHE was the focus of a number of case studies conducted for this study. In addition, the desired pressure drop was realized as a result of the piping's corrugations. The compressor in the refrigeration device will function more efficiently thanks to the reduced pressure in the DPHE, resulting in a lower COP. In the present study, we investigate the friction factors and Nusselt Numbers that apply to corrugated DPHE.

Keywords: Studies in thermohydraulics, coefficients of performance (COP), design heat transfer (DHPE), and computational fluid dynamics (CFD).

1.**Introduction**

The importance of heat exchangers in an industrial power system cannot be overstated. Equipment used in thermal power, the chemical industry, the refining business, the food processing industry, utilities, and other sectors frequently accounts for 20 percent or more of the overall cost of equipment [1]. The development of sophisticated heat-exchange apparatus is a multifaceted endeavor. Energy and material consumption, as well as the cost of heat exchange equipment, may be reduced by increasing the number of activities aimed at intensifying heat exchange, shrinking the size and weight of heat exchangers, and boosting their productivity. There is little left to be discovered about the true

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rationalization of heat exchanger design [2]. Tubular heat exchangers are often employed in the food processing sector for the purpose of heat treating liquid products [3]. The fundamental need for heat exchangers is the high heat transfer performance and low flow resistance losses, compact dimension and light exchange intensity. The feasibility, chosen intensification approach are contingent on the resources at hand.

The corrugated tubes can withstand temperatures up to 150 °C and pressures of 25 kg/cm2 without buckling or bursting. They are also unfazed by water stress or defrosting. Because of their resistance to corrosion and high tube strength, these tubes have a long useful life, and they are also reliable and resistant to external and internal mechanical and thermal stresses.

because of the material's great pliability and elasticity, hydraulic loads. When it comes to heat exchangers, corrugated tubes in their many forms are the most efficient means of enhancing their thermal and hydraulic performance. The thermal boundary layer is thinned due to the corrugated tubes' ability to generate turbulence close to the surface of the tube wall. By separating the disturbance at the tube wall from the main stream, we may raise the heat transfer coefficient of heat exchange systems and improve the mixing of the liquid at the tube wall.

Heat transmission and efficiency of DPHE were studied by Sivakumar et al. [4] using a variety of stream flow orientations. A CFD program was used to create a 3D model of a heat exchanger for this investigation (ANSYS). Finally, numerical results are used to verify the experimental evaluation.

Erika and coworkers[5] Non-Newtonian fluid flow characteristics via a plate heat exchanger in steady laminar mode at constant wall temperature have been calculated. It is common practice to employ single-pass U-type heat exchangers on several flat plates, both weight. Only by increasing heat exchange rates can these needs be met. One of the most important paths for progress in contemporary heat-exchange equipment is the enhancement of heat transfer. In most cases, a cost advantage over reference samples motivates interest in increasing heat security, and dependability of the with and without blanks. Using the number of plates and their distance from one another as a vector, we investigated how these variables affect heat transmission and pressure drop. On the basis of the ratio and the generalized Reynolds number, a statistical relationship between the friction factor and the time required for the flow trajectory was created. Nusselt number dependence on the peclet number was also seen by modifying the Sieder-Tate equation.

According to Mohanty and colleagues [6]. Computational analysis was used to the building of a double-pipe heat exchanger with specified flow conditions at the heat exchanger's inlet. Multiple heat exchange configurations have been studied, each requiring a unique twisted tape insert with a unique twisting ratio, twisting frequency, and protrusion. An analysis of how the various configurations affect the heat exchanger's performance was conducted. There was both a graphical and tabular display of the results showing increased efficiency.

The primary objective of this study is to examine the pressure drop, friction factor, and heat transfer between fluids in an outside corrugated pipe. For further estimates of heat exchanger thermal efficiency, heat transmission across both fluids must be studied.

The research aims to accomplish the following particular tasks:

• To learn about the friction factor and pressure drop in DPHE to calculate pumping power.

One purpose is to see how turbulence behaves in the outer corrugated pipe.

The goal is: • To examine velocity profiles at the edges (inlet and outlet).

To determine the rate of heat transfer at its maximum via both cold and hot fluids.

Corrugation in a DPHE model

ANSYS FLUENT 15.0's design module is used to create the DPHE's corrugated fluid domain for inner and outer flow. In Table 1 we provide the parameters that characterize these fluid domains. Hot water enters from the right and leaves from the left, as seen in Figure 11's inner corrugated fluid domain. The outside, wavy fluid domain represents the arrival and departure of icy water from the right and left, respectively (Figure 11).

Table 1: Specifications of the DPHE fluid domain

Length of DPHE *(mm)*	**Inner pipe Dia *(mm)***	**Outer pipe Dia *(mm)***	**Corrugation Pitch *(mm)***	**Corrugation Depth *(mm)***
518	32	46	10	1

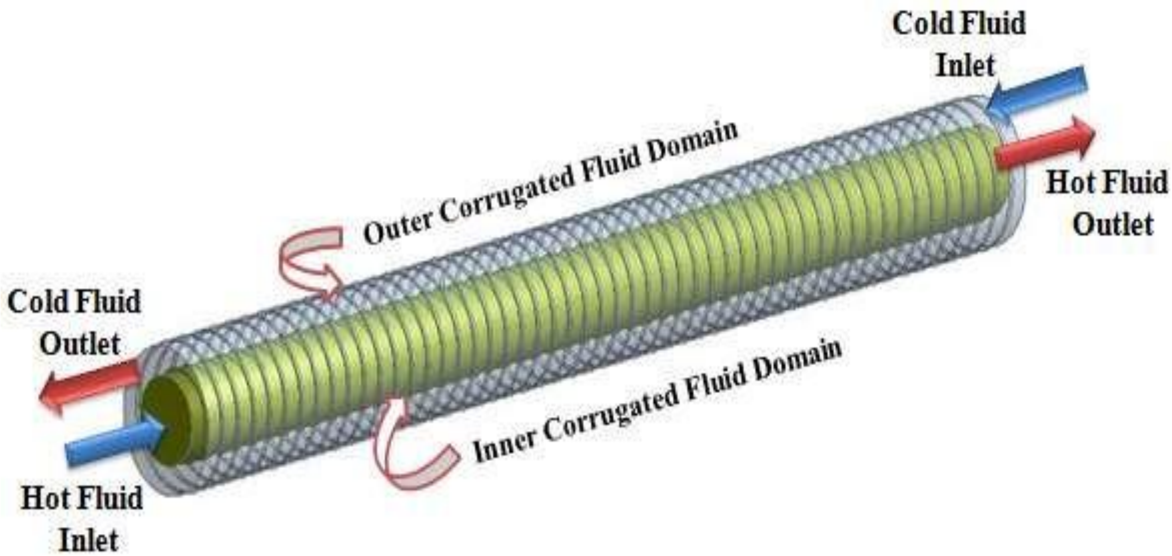


Figure 1. Corrugated Fluid domains of hot and cold water

1.1 Grid independency test

Using ANSYS FLUENT 15.0, a grid independency test was carried out to ensure the independence of the meshing. Figures 2 and 3 show the results of coarse (Figure 2), medium (Figure 3), and fine (Figure 4) meshing, respectively. For medium (403992 elements) and fine (403992 elements), the number of elements does not vary (403992). This means that fine-meshing the fluid domains is not necessary to produce the results with a medium-mesh size..

Figure 2. Meshed Geometry with Coarse size

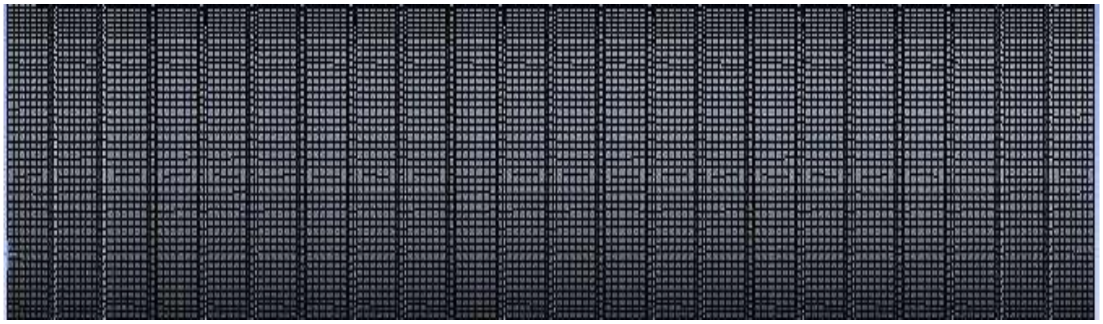


Figure 3. Meshed Geometry with Fine size

1.2 **Fluid Properties**

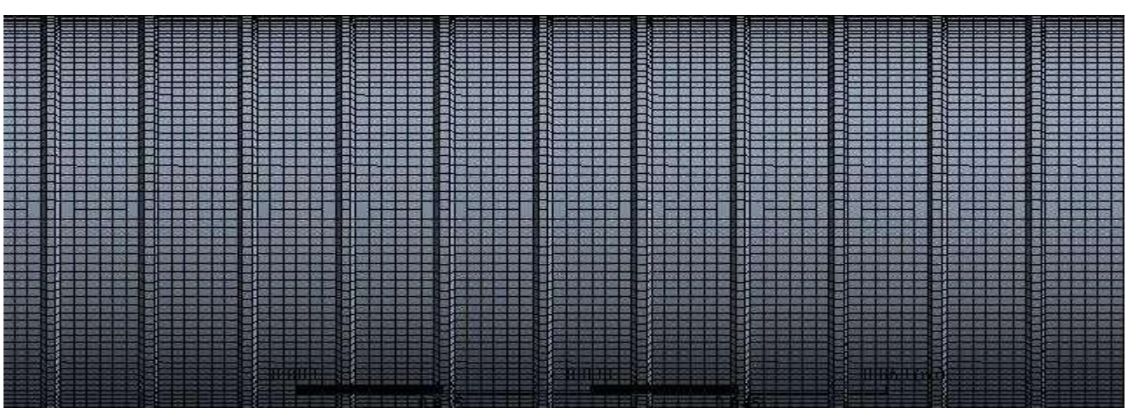
First, in the FLUENT interface of DPHE, the fluid characteristics for both the inner and outside corrugated fluid domains must be defined. Since hot water at 350K is being introduced into the inner domain, the characteristics of water at that temperature have been incorporated into the interface. Water's 293K characteristics are put into the boundary in the event of an outer fluid domain.

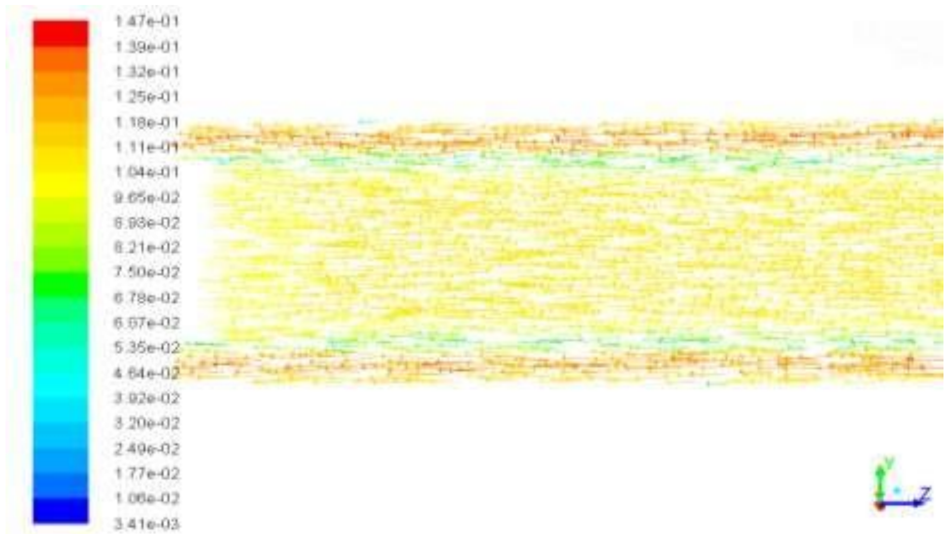
1.3.1 Boundary Conditions

Table 2 contains the boundary conditions employed in this study. Specifically, the gauge pressure at the outflow boundary is set to zero atmospheres while the operational pressure is 700 kilopascals.

Table 2 Different inlet and outlet boundary conditions for hot and cold fluid

Water	**Inlet Mass Flow Rate (kg/s)**					**Temperature (K)**	**Outlet**
Hot	0.05	0.06	0.07	0.08	0.09	350	Pressure Outlet
Cold	0.03	0.035	0.045	0.055	0.065	293	Pressure Outlet





illustrating the velocity vector distribution inside the heat exchanger. Velocity magnitude for hot fluid, which is flowing into the inner corrugated pipe is lower than the cold fluid flowing inside the outer corrugated pipe. Velocity vector arrow represents the flow direction for both the fluids inside heat exchanger.

3. **CONCLUSION**

This research used ANSYS FLUENT 15.0 to do a computational analysis of corrugated DPHE. After producing coarse meshing, software was used to build corrugated fluid domains, and turbulent flow analysis was performed using the Realizable 2 Equation Viscous Model. Analysis was done taking into account the range of mass flow rates for both cold and hot fluids shown in Table. Error! leads to a number of inferences. An appropriate reference could not be located. into a Trap! No matching citations were found. These are some of them:

Increasing mass flow rates need more energy to pump both hot and cold fluids, and a length of 518 mm for the heat exchanger is insufficient for a well-developed flow in the inner corrugated pipe.

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