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Enhancement of heat transfer coefficient by using helical coil heat exchanger

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In this paper to study, a numerical analysis of a helical coil (tube-in-tube) heat exchanger is carried out for various B.Cs (Boundary Conditions), and the optimal heat transfer conditions are identified for various D/d ratios. For analysis purposes, the turbulent flow model with counterflow heat exchanger is taken into consideration. For various boundary conditions, the impact of D/d ratio on heat transfer rate and pumping power is observed. The D/d ratio varies between 10 and 30 with an interval of 5-point gap. For various D/d ratios, it is possible to determine the Nu (Nusselt number), friction value, power, and LMTD variation of the inner fluid with respect to Re (Reynolds number).

Key words: Optimization, Heat Transfer, LMTD, D/d ratio, Turulent flow.

1. Introduction

To transfer heat b/w two fluids that may or may not be in direct touch with one another and may or may not flow in separate tubes or channels. Heat exchangers have a wide range of uses in modern life. Heat exchangers are utilised in thermal power plants. Likewise, radiators and oil coolers are employed as heat exchangers in the automotive industry.W.Wises et al [1]. predict rate of heat transfer rate analyzed under different conditions. It's showed that air and water temperatures at the outlet are influenced by the rate of mass and temp taken as input. With an increase in the mass of water, temp. of the air at the outlet. Enthalpy and moisture efficiency decrease as air and water mass flow rates rise. Kumar.A et al [2]. studied and investigated on the hydro loading and temperature properties of heat exchangers The results showed enhancement of overall heat transmission factors of inner and outer tubes. In addition, that Nusselt numbers and friction factor coefficients were calculated and compared to numerical values obtained from the FLUENT ANSYS. J. Kumar et.al [3] studied about experimental and numerical research on coil type exchangers taking fluid as heat transfer into account. It's identified through observation that the temperature transmission is erroneous when the thermal parameter mediums are constant. Kharat et.al [4] investigated the temperature transmission rate on a coil heat and create the correlation for the heat by use of CFD simulation. The results can be enhanced the heat for the heat exchanger's gas-containing tube has enhanced. kumar Jaya et.al [5] studied about the numerical and experimental to determine the local Nusselt number variation throughout a helical tube's length and circumference. It was discovered that changing the pitch diameter, pitch tube, and diameter of pipe had an impact on the rate of heat transfer. According to the literature, a lot of research had been done to identify the heat transfer characteristics of helical coil heat exchangers operating under conditions of constant wall temperature and constant heat flux. Additionally, a relationship between heat transmission and working fluid was found. It is not adequately explored how the D/d ratio effects thermal characteristics. For various D/d circumstances, the optimal parameters based on the Nu and friction value has not yet been calculated.

2. Definition of Problem

In this study, the tube in tube helical coil heat exchanger with two no. of turns is taken into consideration. For mathematical analysis two turns were considered but in real-practical situations, more no. of turns required depending on the circumstances. The coil diameter (D) varied b/w 81 to230mm, or 120mm, 160mm, and 200mm, respectively, over a 40mm space. The dimension of the coil (L) rises along with the coil dia. 8mm is the inner tube's (d_1) dia. In addition, thickness tube (t) was restrained at 0.4mm. The 16mm outer tube dia, or d_2, is restrained. coil's pitch is set at 30 mm, making the tube's overall height 60 mm. It was made of copper, the heat exchanger. For purposes of analysis, the liquid attribute is taken to remain continuous. After modeled geometry in Fluent ANSYS doing meshing followed by various boundary conditions. The turbulent fluid flow condition as indicated in Fig. 2.1 was taken into consideration for the problem analysis.

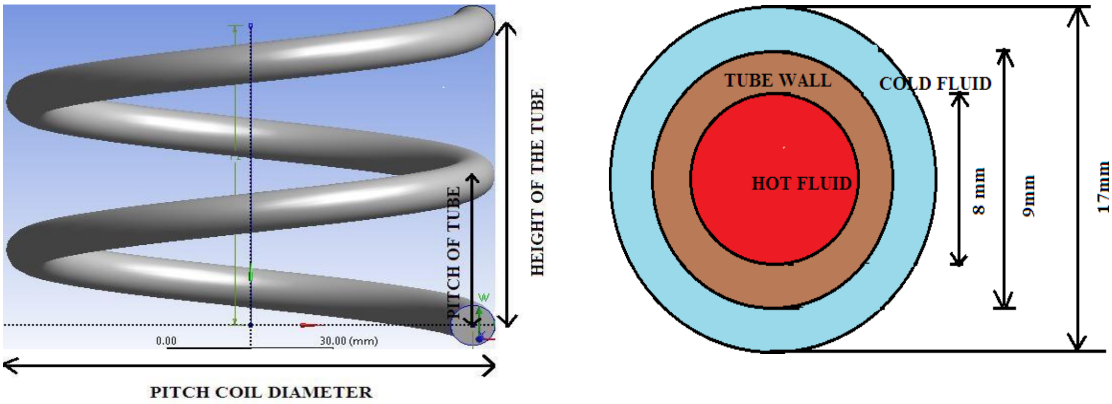

Fig.2.1 Helical coil heat exchanger with dimensions

3. CFD Modeling

3.1. Geometry creation

The counter flow heat exchanger was taken into consideration to study turbulent fluid flow for analysis. According to Schmidt's correlation [6] calculation, both boiling and cold liquids flow at a vel. where the (Re) is higher than the serious (Re). To determine the heat transfer rate, friction value, have the least amount of pressure loss and the most amount of heat transfer, the flow velocity of the cold fluid was kept constant while the flow velocity of the hot fluid was adjusted. Even though it is a three-dimensional problem, Fig. 3.1 representation of it in three dimensions makes it easier to understand the boundary condition.

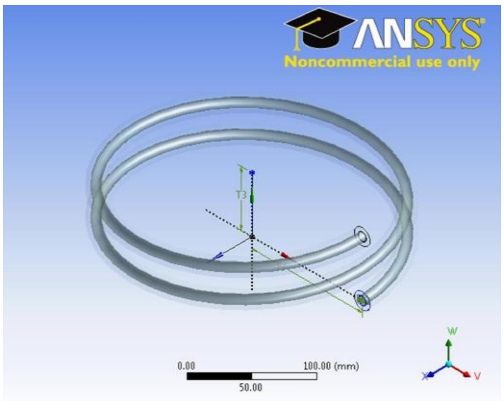

Fig.3.1 Double tube helical coil heat exchanger

3.2 Grid generation

For grid generation, select the mesh selection from the mesh tree first, formerly click create

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mesh. It will automatically construct a grid. The grid must then be adjusted or made finer so that correct results will be obtained [7]. Choose the size choice, then the Edge to divide the mesh into finer pieces. then indicate the quantity of divisions as displayed in Fig. 3.2.

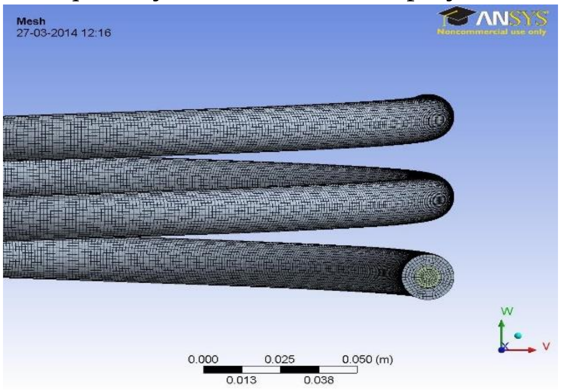


Fig 3.2 Creation of a grid for a double tube heat exchanger with helical coils

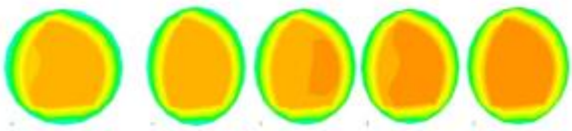
3.3 Grid test

First, multiple D/d ratios were tested in this problem for grid independence. The grid size was modified from 6366 to 137665, starting with D/d=5, taking into account the outer wall insulation state, keeping the hot fluid inlet velocity at 1.51m/sec (Re=11000), and retaining the temperature at 350K. Temp.of cold and boiling fluid at the outlet, as well as compression at the hot fluid's input and outflow, are the properties taken into account while determining grid independence [8].

4.Results and Discussions

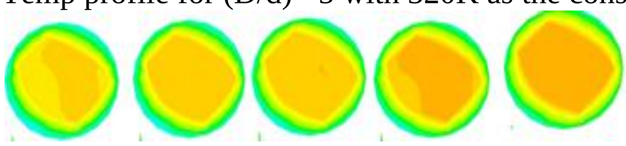
4.1 Constant temperature of the outer wall

The temp. profile of the hot fluid exit as shown in Fig. 4.1 for a constant outer wall condition. In relation to the Reynolds number, the inner Nu, friction value, and power are determined [9].



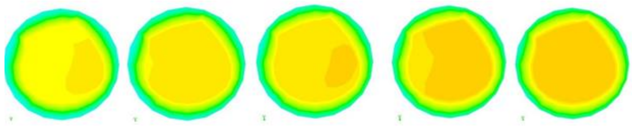
Re=10000 Re=13000 Re=15000 Re=18000 Re=21000

Fig 4.1(a) Temp profile for (D/d) =5 with 320K as the const. wall temp.



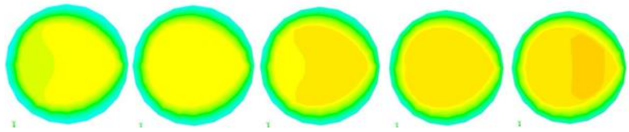
Re=10000 Re=13000 Re=15000 Re=18000 Re=21000

Fig 4.1(b) Temp.profile for (D/d)=10 at the const. wall temp. of 320K.



Re=10000 Re=13000 Re=15000 Re=18000 Re=21000

Fig 4.1(c) Temp. profile for (D/d)=15 at const wall temp. of 320K.



Re=10000 Re=13000 Re=15000 Re=18000 Re=21000

Fig 4.1(d) Temp. profile for (D/d)=20 at const. wall temp. of 320K.

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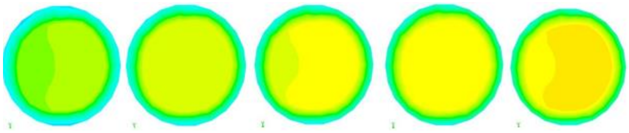


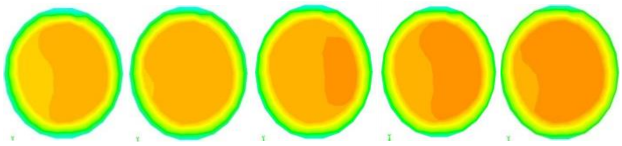
Re=10000 Re=13000 Re=15000 Re=18000 Re=21000

Fig 4.1(e) Temp.profile for (D/d) =25 at const. wall temp. of 320K.

For constant outer wall temperature of 320K and varying Reynolds numbers, the temp. profile of a hot fluid outflow is depicted in Fig.4.1. The average temp.at the outlet increases with a rise in flow velocity or the Reynolds number from the temp. profile of the boiling fluid exit in Fig. 4.1(a) for D/d=5.This is due to the fact that when flow velocity and Reynolds number rise. The constant cold fluid flow rates but rising hot fluid flow rates, which causes the hot fluid to move past the inner tube quickly without having a chance to heat the cold fluid up. The temp. profile of the hot fluid exit for D/d=10 in Fig. 4.1(b). When comparation Fig. 4.1(a) and (b), for the similar Re (for instance, Re=10000), the outlet temp.for D/d=10 is lower than that of D/d=5. This is because the length of the exchanger's tube grows as the D/d ratio rises, increasing the heat exchanger's surface range of exchange. The rate of temperature transmission b/w two fluids rises with increased area of contact. Therefore, when the D/d ratio rises, the hot fluid's output temperature lowers. It is also depicted in Fig. 4.1. (c-e). Figures 4.1 (d) and 4.1(e) shows that the output temperature significantly decreases when the D/d ratio rises from 20 to 25[11].

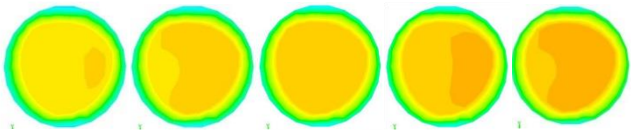
4.2. Constant heat flux for outer wall

In this case the fluid is intense from outside source with const. heat flux. The liquid is transformed to vapor through the temperature exchangers.



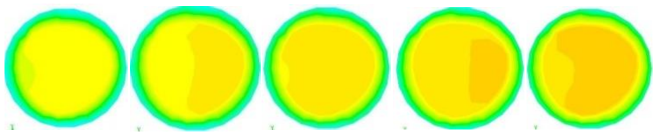
Re=10000 Re=13000 Re=15000 Re=18000 Re=21000

Fig 4.2(a) Temp.profile for (D/d) =5 at const. heat flux.



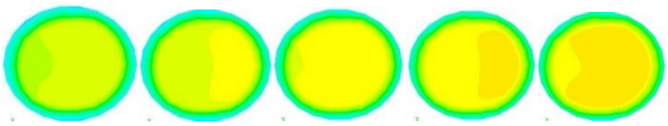
Re=10000 Re=13000 Re=15000 Re=18000 Re=21000

Fig 4.2(b) Temp.profile for (D/d) =10 at const. heat flux.



Re=10000 Re=13000 Re=15000 Re=18000 Re=21000

Fig 4.2(c) Temp.profile for (D/d) =15 at const. heat flux.



Re=10000 Re=13000 Re=15000 Re=18000 Re=21000

Fig 4.2(d) Temp. profile for (D/d)=20 at const. heat flux.

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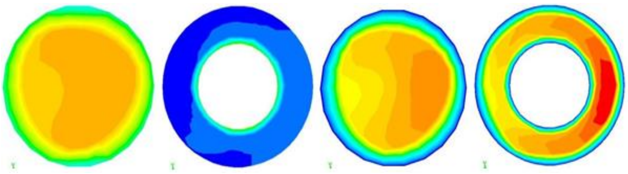
The temp. profile of the hot fluid exit and constant heat flux for (D/d) ratios and 61000W/m^2 at the outside wall respectively is shown in Fig.4.2(a-d). The output temperature tends to be hotter as the Reynolds number rises. When compared the profiles for a specific Reynolds number, the outlet temperature will be lower the greater the (D/d) ratio, as this improves the outward part for temperature transfer. As a result, the temp. of heated fluid at the output drops. For a specific (D/d) ratio and Re, the profiles for const. wall conditions and const. heat flux conditions at the outer wall show that the outlet temp. of the constant wall condition is lower than that of the const.heat flux condition as shown in (Fig. 4.2)

4.3. Insulated exterior walls

This is a typical instance of a heat exchanger, whose primary function is to transmission of heat b/w two fluids that are kept at various temperatures. This kind of heat exchanger is used in research labs, food storage facilities, vehicle manufacturing, and air conditioning plants [12].



(a) **(b)** **(c)** **(d)**

Fig 4.3 (a) Temp. plot for hot fluid (b) Temp plot for cold fluid (c) Vel.profile of outlet for hot fluid (d) Vel.profile of outlet for cold fluid

For D/d=15 at Re = 21000, From Fig. 4.3 temp. and vel. contours of the hot fluid outlet and cool fluid outlet. The temp. profile of boiling fluid at outflow in Fig. 4.3 (a). The internal tube's temperature drops as it moves from the centre to the wall. It reaches its greatest at the annulus's centre and gradually declines toward the outer wall for the outer tube (Fig. 4.3(b)). The vel. profile of boiling and cold liquid is shown in Fig. 4.3(c-d), with minimal velocity at the wall and maximum velocity in the centre.

5.Conclusions and Future scope

- Nusselt number (Nu) for an inner tube rises as the Reynolds number (Re) increases. However, when mas flow rate rises, turbulence between the fluid elements gets worse, which improves mixing and finally increases Nu.
- For a given value of the Re, the Nu will drop D/d ratio, which is the inverse of the curvature ratio, increases. The maximum value of a Nusselt number is D/d=10.
- The results show that the inner Nu is not significantly affected by the outside wall boundary condition.
- The difference between the surface of the roughness and the velocity of the fluid flowing, the friction factor falls as the Re number rises.
- There is no effect boundary condition for tube the rate of heat transfer; any boundary heat transfer from the hot fluid is concerned.

5.1 Future scope:

The intersection of two graphs serves as the optimization condition in this study. The maximal condition should be ascertained using a more precise way. It should be necessary to combine numerical analysis with experimental validation. While only one phase of flow is taken into account in this study, future research may take two or more phases into account.

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