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DESIGN OF CONICAL HELICAL COIL HEAT EXCHANGER.

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ABSTRACT

In helical coil heat exchanger one fluid flows through the coil and other fluid passes through the shell Helical coil has better heat transfer rate as compared to shell and tube heat exchanger, Because of development of secondary flow. Helically coiled tubes are used frequently in heating, refrigerating and HVAC applications and steam generator and condenser designs in power plants because of their large surface area per unit volume. In the presented work the methodology for the design of helical cone coil heat exchanger is suggested. Available correlation of heat transfer coefficient by different researchers for calculation of heat transfer coefficient are used. The values of heat transfer coefficient for inner side has agreement between each other, however outside heat transfer coefficient has no agreement. Also Computational fluid dynamics study of the helical cone cool heat exchanger is carried out to visualize the nature of fluid flow inside the coil and shell, temperature variation from inlet to outlet for parallel and counter flow arrangement for different mass flow rates and Different inlet and outlet temperature conditions.

I. INTRODUCTION

"Heat exchanger in a device which is use to transfer the heat from one fluid to another fluid through the same device”. In this device only helical coils are used for the heat transfer helically coiled tubes sure asked frequently in heating, refrigerating and HVAC applications and steam generator and condenser designs in power plants because of their large surface are per volume. In spite of their widespread use there in no information available on natural convection from such coils however correlation in the literature for natural convection from vertical and horizontal plates are available. The foregoing consideration provided motivation for the present research to fill the gap in the literature. It has been long recognized that heat transfer characteristics of helical tubes is much better than straight one because of the occurrence of secondary and fluid flow in planes normal to the main flow inside helical tubes show great performance in heat transfer enhancement while the uniform curvature of spiral conical structure inconvenient in pipe installation in heat exchanger. Complex structure in both experimental investigations for that purpose this experiment discussed the heat transfer characteristics of helical tube based on numerical simulation. The paper organized as follows firstly the structure of conical tube was introduce turbulent models in the simulation approach heat transfer characteristic of helical tube was analyzed and the effect of different structural parameters on heat transfer of helical tube is discussed and characteristic of the fluid of different cross-section was analyzed. It has been widely observed that the flow inside coiled tube remains in the viscous regime up to much higher Reynolds number than that for straight tube. Helical coils are known to have better heat and mass transfer compared to straight tube the reason for that is the formation of a secondary flow superimposed on the primary flow.

II. LITERATURE SURVEY

Mohamed Ali [1] has performed the experimental investigation of Natural convection made to study; steady type Natural convection was obtained from turbulent natural convection to water. The experiment have been carried for four coil diameter to tube diameter ratio for five and ten coil tubes and for five pitch outer diameter ratio. He correlated Rayleigh Number for two different coil sets and the heat transfer coefficient decreases with coil length for tube diameter do=0.012m but increases with coil length for do= 0.008m. A critical D/do is obtained for a maximum heat transfer coefficient for tube diameter of 0.012 m with either five or ten coil turns.

Yan ke et.al [2] investigated numerical simulation of conical tube bundles. He observed the effect of structural parameters on heat transfer characteristics. Fluid flow characteristics inside tube of different cross section also investigated result shows that cone angle cross section have been significant effect inside heat transfer. Also helical pitch has little influence on heat transfer enhancement. He also includes that the secondary fluid become intensive along the tube due to increase of tube curvature. Secondary fluid flow from another tube and flow direction of each tubes are different due to this heat transfer rate increases.

N.Ghorbanii et.al [3] has studied thermal performance shell and coil heat exchanger in the purpose of this article is to access the influence of tube diameter, coil pitch shell side and tube side mass flow rate over the performance coefficient and modified effectiveness of vertical helical coiled tube heat exchanger. The calculation has been

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performed for the steady state and the experiment was conducted for both laminar and turbulent flow inside coil. It was found that the mass flow rate of tube side to shell ratio was effective on the axial temperature profiles of heat exchanger. He concluded that with increasing mass flow rate ratio the logarithmic mean temperature difference was decreased and the modified effective's decreases with increasing mass flow rate.

R. Patil [4] has suggested design methodology for helical coil heat exchanger heat transfer coefficient based on the inside coil diameter hi, is obtained using method for a straight tube either one of Sieder-Tate relationships or plot of the Colburn factor JH vs Re. Outside heat transfer coefficient is calculated using correlation for different range of Reynolds number. Helical coil heat exchanger is the better choice where space is limited and under the conditions of low flow rates or laminar flow.

III. PROCESS

A. Straight helical coil heat exchanger

In this type of heat exchanger, The secondary flow is generated by centrifugal action and acts in a plane perpendicular to the primary flow. Since the velocity is maximum at the center, the fluid at the center is subjected to the maximum centrifugal action, which pushes the fluid towards the outer wall. The fluid at the outer wall moves in ward along the tube wall to replaces the fluid ejected outwards. This results in the formation of two vertices symmetrical about a horizontal plane through the tube Center. Inside heat transfer coefficient for helical coil and curved tube are greater than inside heat transfer coefficient of straight tube because of secondary flow (Dean vortex) in curved tube and it is characterized by Dean no. which is equal to De= Re*(di/D)^ 0.5. In this type the curvature ratio is constant. Secondary flow become intensive, Which in turn increases(hi). For calculation of outside heat transfer coefficient (ho) correlations found only typical applications and specified ranges of Re, Ra study researchers. Generally correlations for ho, covering entire range of Re, di/D is found due to this we have used the available correlations of straight tube..

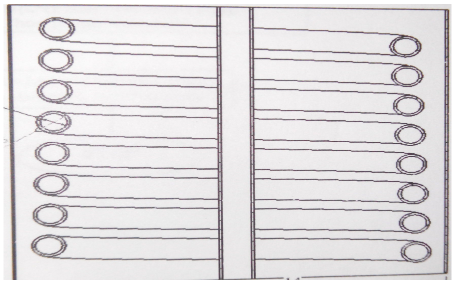

Fig.1 straight helical coil heat exchanger

B. Conical coil heat exchanger

Inside heat transfer coefficient for conical helical coil and curved tube are greater than inside heat transfer coefficient of straight tube because of secondary flow (Dean vortex) in curved tube and it is characterized by Dean no. which is equal to De= Re*(di/D)^ 0.5. In this type the curvature ratio is varying from bottom to top, secondary flow become intensive, which in turn increases (hi). As coil diameter decreases, dean number increases and heat transfer coefficient increases. In conical coil as cone angle decreases from 90, coil diameter start decreasing from bottom to top due to this dean number increases from bottom to top which causes increase in heat transfer. For designing, correlations are not available for inside heat transfer coefficient and outside heat transfer coefficient. Correlation suggested by researchers for straight tube and helical coil are used for calculation of heat transfer coefficient.

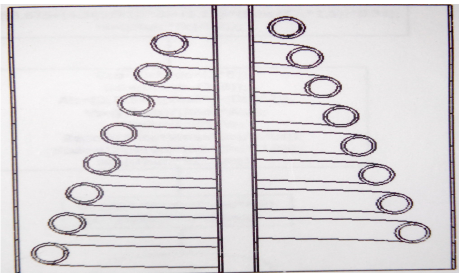

Fig.2 Conical coil heat exchanger

IV. DESIGN PROCEDURE FOR DOUBLE PIPE HEAT EXCHANGER

Concentric tubes are consisting this type of heat exchanger. In one tube cold fluid are flow and another tube having hot fluid flow. Mass flow rate and temperatures of inlet and outlet of fluids flowing through tubes. Due to less area available for heat transfer therefore heat transfer rate is comparatively less. To achieve required heat transfer so it requires more space. Counter flow arrangement is suitable for better heat transfer rate. For designing available correlations are used find out heat transfer rate and length of the tube. This calculated length to can be used for the initial guess required in the design of helical coil heat exchanger.

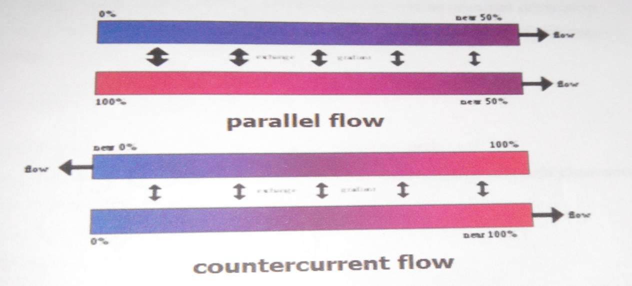

Fig.3 flow arrangement in Heat Exchanger

1. **Parallel Flow:** In parallel flow heat exchanger, at same end the two fluid's are enter in heat exchanger and flow in parallel direction to one another to the other side.

2. **Counter Flow**: Fluids flow in opposite directions. These are used for liquid-liquid, condensing and gas cooling applications. Units are usually mounted vertically when condensing vapour and mounted horizontally when handling high concentrations of solids.

V. THEORY OF HELICAL COILS

Fluid flow in curved tubes:

When a fluid flows through a straight tube, the fluid velocity is maximum at the tube center, zero at the tube wall & symmetrically distributed about the axis. However, when the fluid flows through a curved tube, the primary velocity profile indicated above is distorted by the addition of secondary flow pattern. The secondary flow is generated by centrifugal action and acts in a plane perpendicular to the primary flow. Since the velocity is maximum at the center, the fluid at the center is subjected to the maximum centrifugal action, which pushes the fluid towards the outer wall. The fluid at the outer wall moves in ward along the tube wall to replaces the fluid ejected out wards. This results in the formation of two vortices symmetrical about a horizontal plane through the tube center.

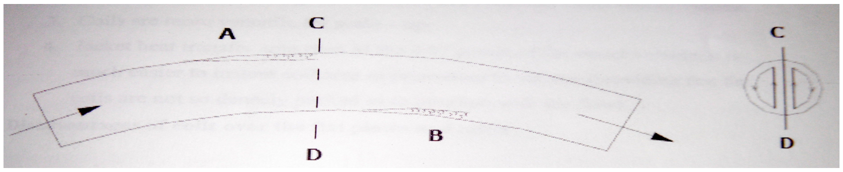

Fig.4 showing the fluid flow through pipes.

In radial direction a pressure gradient is developed to create an acceleration, which acts towards the center of the bend. The pressure at the outside of the pipe is more than the pressure at the inner side. The increased pressure at the outside causes the velocity of the particle to decrease. This creates eddies. Separations takes place at the outer wall. Separation and eddies also occur at point B on the inside of the bend, due to the inertia of the water. Moreover, the pressure which is very low at D increases as the point B approaches & adverse pressure exists. If radial section CD is taken across the bend, a secondary flow as shown in the is found to exist. Along the horizontal diameters, the pressure increases with the radial distance. But the pressure decreases as the low pressure region near the wall is approached. The difference in the pressure causes an outward motion along the wall form C to D. To satisfy the continuity condition, there is a flow from D to C along the radial direction. Thus a secondary flow is developed. This flow is in addition to the main flow which takes place along the axis of the pipe & a complex flow pattern occurs.

VI. FUTURE SCOPE

1. Correlation for hi & ho can be obtained by simulation and comparing with experimental result.
2. To carry out simulation by varying thermal and physical properties of heat exchanger.
3. To obtain correlation for hi and ho for helical conical coil heat exchanger.
4. To observe correctness of existing model.

VII. CONCLUSION

1. Inside heat transfer coefficient for helical coil and curved tube are greater than inside heat transfer coefficient of straight tube because of secondary flow (Dean vortex) in curved tube and it is characterized by Dean no. Which is equal to De = Re* (di /D)^ 0.5
2. Secondary flow become intensive, which in turn increases (hi).
3. In straight helical coil heat exchanger curvature ratio remain constant, hi remain Constant.
4. In Helical cone coil heat exchanger due to conical geometry of coil, curvature ratio increases and causes increase in Dean number.
5. Inside heat transfer (Nui) and (Nuo) are calculated by using correlation recommended by different researches- Ghorbani, Patil, Churchi .
6. Different characteristics length used for Nuo correlation are Deq, DHx, do, etc.
7. Agreement found, between hi correlation, no agreement between ho correlation because correlation are suggested for straight tube or straight helical tube. So, it is necessary to develop ho correlations for helical cone coil.
8. To obtain correct correlation for hi, ho it is recommended to carry out large number of simulations with varying parameters like geometry of cone and shell and properties of fluid.
9. Suggested design methodology for design of helical coil heat exchanger is in primary stage and based on assumptions.

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