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Helical Coil Heat Exchanger Analytical & CFD Analysis

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Abstract**: *Enhancement in heat transfer due to helical coils has been reported by many researchers. Helically coiled tubes can be found in many applications including food processing, nuclear reactors, compact heat exchangers, heat recovery systems, chemical processing, low value heat exchange, and medical equipment. The heat transfers and hydrodynamic characteristics need to be known for different configurations of the coil, including the ratio of tube radius to coil radius, pitch, and Reynolds and Prandtl numbers. Heat transfers characteristics of helical heat exchangers is the subject of this work.***

In Present thesis work I perform CFD Analysis of Helical Coil Heat Exchanger compare with theoretical calculation. I also studied different parameter of Helical Coil Heat Exchanger like velocity and Pitch on Heat Transfer Value with the help of CFD Tool ANSYS CFX. In this Project Work Validation of CFD Work with Numerical Calculation empower us to utilize CFD as a tool to eliminate costly trial and error Experimental Work.

I. INTRODUCTION

Helically coiled tubes can be found in many applications including food processing, nuclear reactors, compact heat exchangers, heat recovery systems, chemical processing, low value heat exchange, and medical equipment due to the compact structure and high heat transfer coefficient. Computational Fluid Dynamics (CFD) deal with simulation of fluid flows with heat and mass transfer in various engineering objects. Basically it simulates the numerical model. The primary objective of this thesis is to analyse the optimized dimensionalised coil finned-tube heat exchanger by CFD and predicting pressure, velocity and to determine the fluid flow pattern in helical coiled heat exchanger. And quantitative insight into the heat transfer process that occurs when a fluid flows in a helically coiled tube. Nuclear Radioactive stored in the nuclear storage tank at cryogenic temperature. If the temperatures of the radioactive exceed some desired temperature it emits its radioactivity which is very dangerous for that purpose above circuit is used. Liquid nitrogen is circulating in the circuit for cooling purpose.

II. CHALLENGE

Capacity of nuclear storage station will be increased without significant change in the circuit is possible only one way by increasing flow of liquid nitrogen in the nuclear storage tank but if we increase the flow in the HCHE heat transfer characteristics goes down which could be balanced by decreasing pitch of Helical Coil Heat exchanger.

III. PRACTICAL DATA

Drum fluid temperature is 40 K
Average temperature of helical pipe wall is 45.23 K
Coolant Temperature

Inlet temperature is 65 K
Outlet temperature is 51.67 K
Velocity of coolant is 0.2 m/s
Diameter of Helical pipe is 0.010 m
Density of Liquid nitrogen is 0.86 Kg/m3

IV. CALCULATION

Mean Temperature is Tmean or ΔT = $\dfrac{T_{\text{inlet}} + T_{outlet}}{2}$

$$= \frac{65 + 51.67}{2}$$

= 58.335 K

Area of Helical Pipe is

$$A = \frac{\Pi}{4} d^2$$

$$= \frac{\Pi}{4} *(0.01)2$$

= 7.8 * 10-5 m2

Mass Flow Rate is

$$m = A * V * \rho$$

= (7.8 * 10-5) * 0.2 * 0.86

= 1.3e-5 Kg/s

Heat Transfer Rate is

$$Q = m * Cp * \Delta T$$

= 0.1261 * 2.008 * (51.67-65)

= -0.00036156 KW

Overall Heat transfer Co-efficient is

$$U = \frac{Q}{A*(T_{outlet} - T_{mean})}$$

$$= \frac{-0.00036156}{7.8*10^{-5}*(65-58.335)}$$

= -0.690752 KW/ m2 K

Inside Heat Transfer Co-efficient is

$$hi = \frac{Q}{A*(T_{avg.ofwall} - T_{mean})}$$

$$= \frac{9.45}{7.8*10^{-5}*(45.23-58.335)}$$

= 0.3513 KW/ m2 K

V. MODELLING OF HELICAL COIL HEAT EXCHANGER IN SOLIDWORKS

After performing simple calculation, the modelling has been performed on the Solid works 2009 version and then after the analysis work has been performed on the ANSYS 11.0 version

Procedure of CFD Analysis of Helical Pipe Heat Exchanger

1) 3D modeling of Helical Coil Heat Exchanger in the solid works. After creating 3D model in Solid works, it saves as IGES Format.

2) IGES model is transferred in the ANSYS WORKBENCH Meshing Module.

Total Number of Nodes = 48923

Total Number of Elements = 98347

Save mesh file as *.cmdb format.

3) Import mesh file in the ANSYS CFX PRE.

Run the Analysis

Get the Results

Temperature Contour

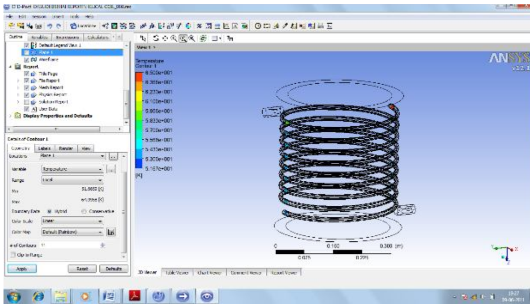

Fig 1Temperature Contour

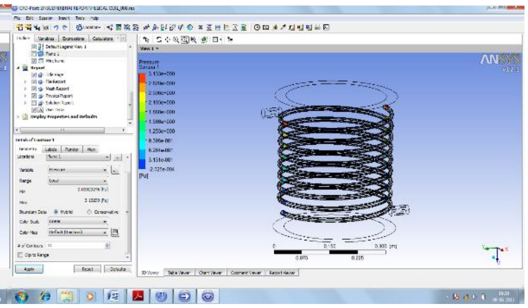

Fig 2 Pressure Contour

Same above procedure, we run above analysis for different velocity keeping inlet constant and get the results which shows.

VI. EFFECT OF PITCH CHANGE ON HEAT TRANSFER CHARACTRITICS

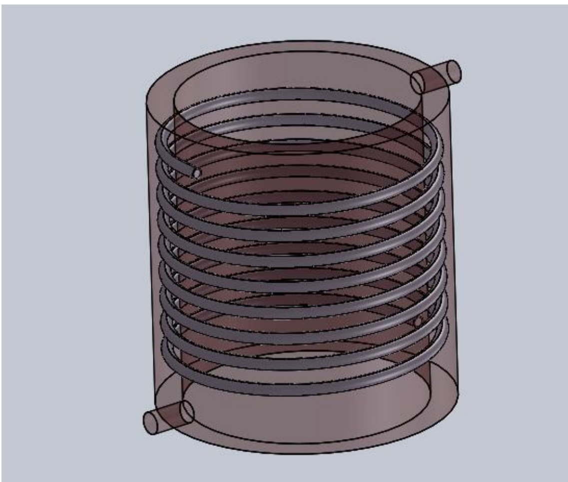

Fig 3 Existing Helical Coil Heat Exchanger (Pitch 30 mm)

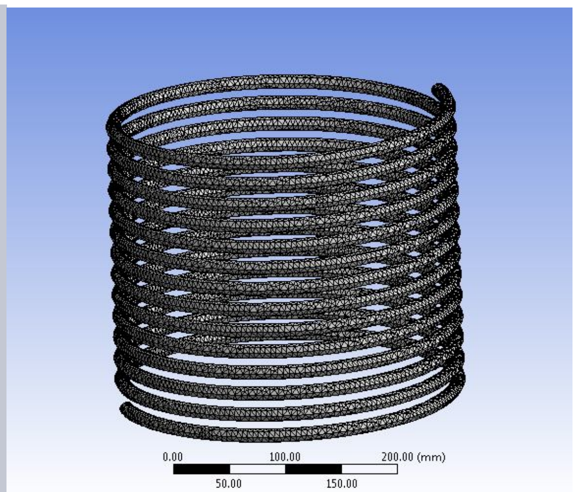

Fig 4 Pitch Changed Meshed Model

Performed CFD analysis on the above pitch changed model as above given Procedure and found below results as shown.

VII. RESULTS AND CONCLUSION

From above analysis, we can conclude that CFD analysis results fairly matches with the Experimental Results. This shows that CFD Analysis is a powerful tool to replace costly experiment and lengthy calculation.

Stated in Problem Definition, achieving our challenge for increasing mass flow rate of liquid nitrogen without increasing Overall circuit of Nuclear Reactor cooling. we have increased velocity in Existing Helical Coil Heat Exchanger and analysed results which shows that as the velocity increase heat transfer decreases.

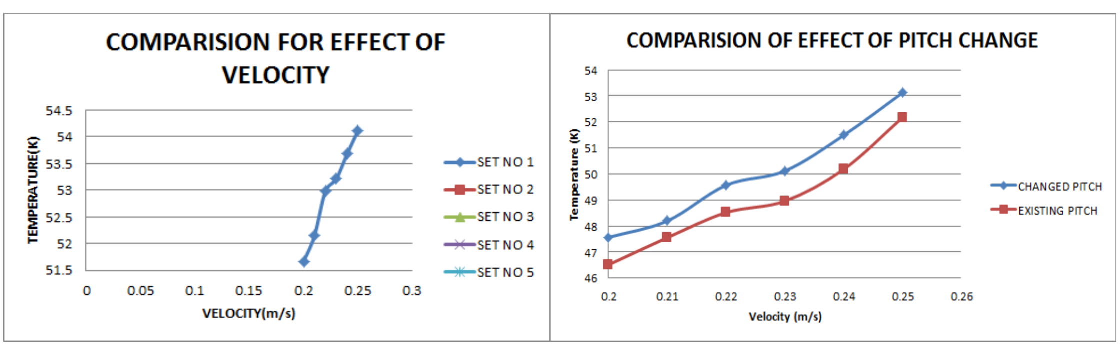

Fig 5 Comparison for Effect of Velocity & Pitch Change

For Recover Heat Transfer Value, we have decrease Pitch and analyse results which shows that as the pitch decrease heat transfer increases.

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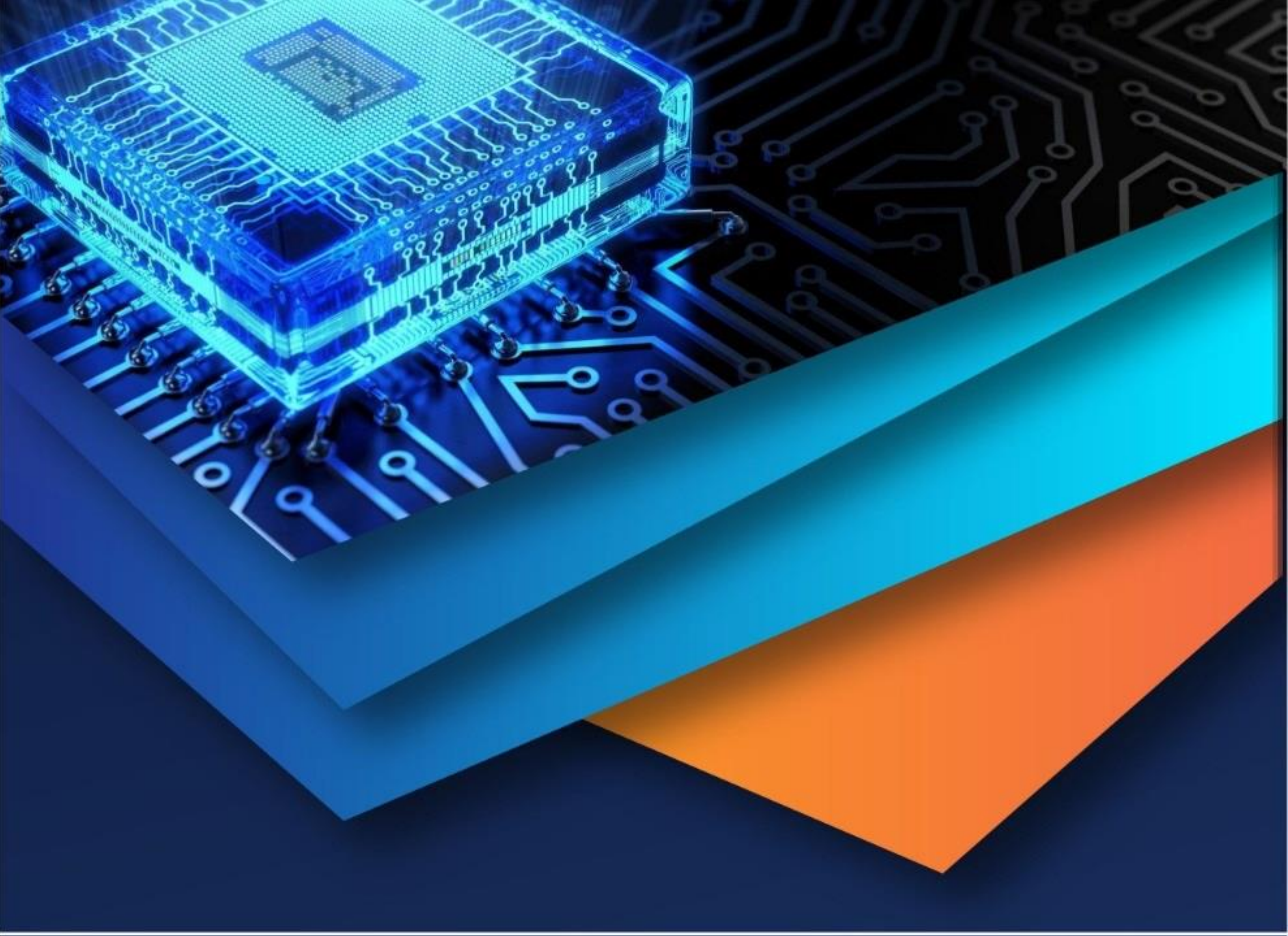

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