A Review on Performance Enhancement of Tube Coil Heat Exchanger by using Helical Tube

[1]S.K.Mandore, [2]Dr. K.P.Kolhe
[1,2]Dept. of Mechanical Engg., JSPM's Imperial College of Engg., Pune, Maharashtra, India

Abstract
Conventional heat exchangers produces dead zone and reduces the heat transfer rate, hence to create turbulence some external means is required. Helical tube in Tube Coil Heat Exchanger (TCHE) provides a compact shape with its geometry offering more fluid contact and eliminating the dead zone, increasing the turbulence and heat transfer rate. By taking the reference of designing helical coil in shell heat exchanger will design the helical tube in TCHE and experimental set up also has to prepare as per TEMA guidelines. This review paper deals with the performance improvement of the helical tube in TCHE with parallel and counter flow configuration of various correlations with specific data. The readings of mass flow rate and temperature difference of hot oil fluid and water are recorded. Logarithmic Mean Temperature Difference LMTD, capacity ratio, universal heat transfer coefficient and effectiveness are calculated and compared for Parallel flow and Counter flow configuration The increased in the intensity of secondary's flow developed in fluid flow it increases Nu, which gives effective value in proposed helical coil in TCHE in counter flow configuration.

Keywords
Helical Tube in TCHE, Shell Coil Heat Exchanger, Universal Heat Transfer Coefficient.

I. Introduction

The heat exchanger is a device which is used to transfer heat from hot fluid to cold fluid across an impermeable wall which is build for efficient heat transfer from one fluid to another fluid. Fundamental of heat exchanger principle is to facilitate an efficient heat flow from hot fluid to cold fluid. This heat flow is a direct function of the temperature difference between the two fluids, the area where heat is transferred, and the conductive properties of the fluid and the flow state. This relation was formulated by Newton's law of cooling, which given by Equation:

$Q = h*A*\Delta T$

It has been long recognized that heat transfer characteristic of helical tubes is much better than the straight ones because of the occurrence of secondary fluid flow in planes normal to the main flow inside the helical structure .Helical tubes show great performance in heat transfer enhancement, while the uniform curvature of spiral structure is inconvenient in pipe installation in heat exchangers

II. Design Methodology

For designing the Helical Tube in Tube Coil Heat exchanger referring given input data.

A. Input Data

Table 1: Input Data

Input data	Inner Tube (Veg.oil base)	Annulus (water)
Mass flow rate M (kg/h)	0.3	600
Inlet temperature (°C)	75	30
Outlet temperature (°C)	40	42
Specific Heat Cp (KJ/kg k)	1.67	1
Thermal Conductivity k (w/mK)	0.78	0.609
Viscosity of oil µ (kg /m h)	1.296	1.12

B. Schematic Cut Way of Heat Exchanger

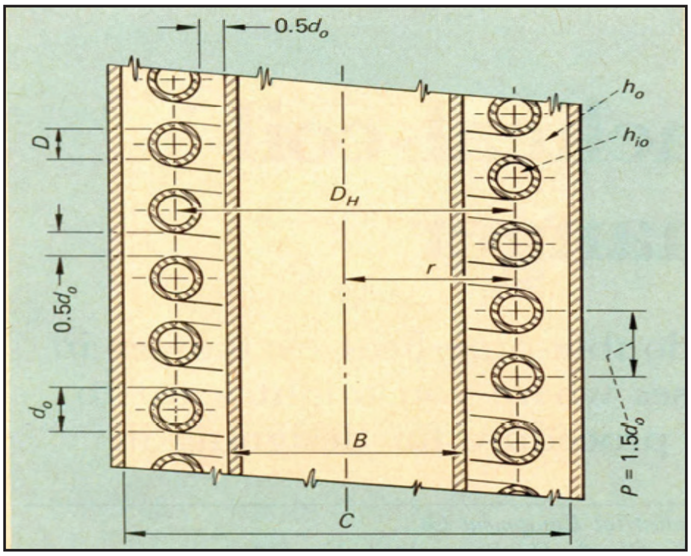

Fig. 1: Schematic Cut-Way of Heat Exchanger

C. Reference Data

The Following data is taken as Input to design the Heat Exchanger

- Diameter Of Inner Tube (do) = 6.4 mm
- Diameter Of Annulus (D) = 12.5 mm
- Mean Coil radius (r) = 62.5 mm
- Pitch (p) = 1.5 d0 = 1.5 * 6.4 = 9.6 mm , but I took pitch p = 30 mm

Minimum pitch should be 20 mm, taking into consideration the manufacturing process, the inner tube is covered with outer tube with 12.5 mm diameter thus it is not possible to maintain pitch of less than 25 mm, hence pitch is taken to be 30 mm

III. Experimental Setup

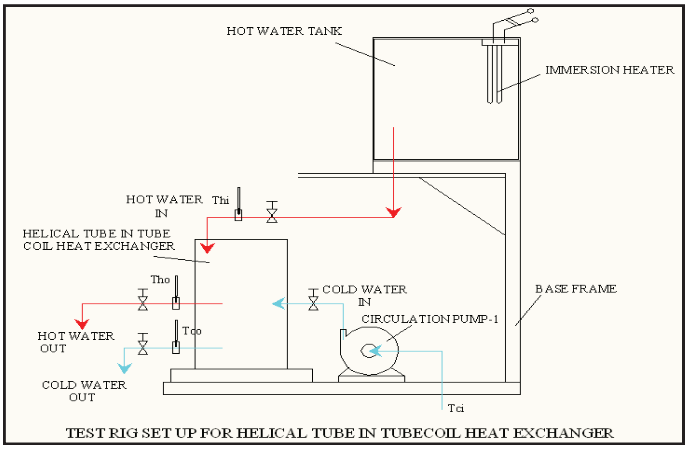

Fig. 2: Experimental Set-Up

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IV. Fabrication of Coil

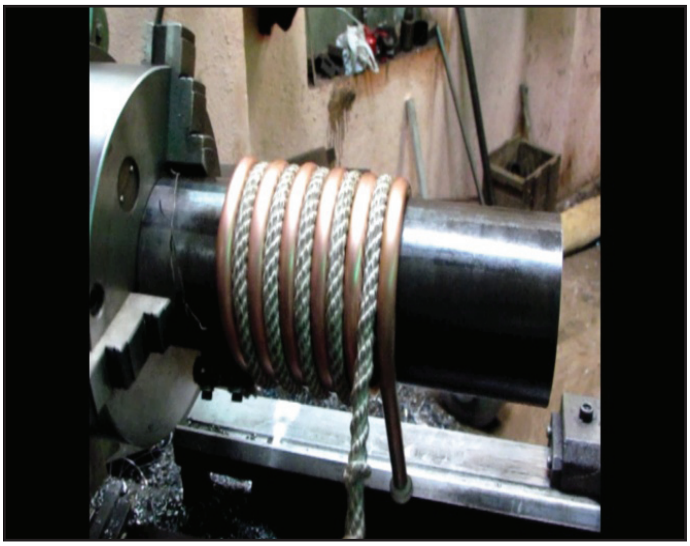

Fig. 3: Helical Coil Fabrication

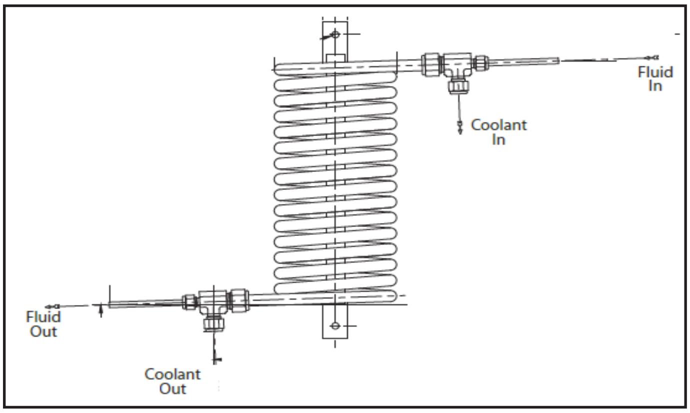

Fig. 4: Complete Arrangement of Heat Exchanger in Counter Flow Configuration

V. Design and Development

For testing purposes we heat oil in the tank and allow to flow in downward direction on the same time by starting water pump send cool water to top. Taking mass flow readings for hot oil and cold water reading in it into kg/hr.Also note down the temperature of water at inlet & outlet.

A. Design and Development

1. System design as to and theoretical derivation of dimensions of the inner tube, outer tube, number of coil for desired temperature gradient
2. System Design and theoretical derivation of coil structure as for closed coil structure
3. System Design and theoretical derivations of the hot water tank and cold water tank capacities for desired flow rates.
4. Selection of pump drive for cold water circulation, and head selection for hot water circulation.
5. Selection of material for pipe fittings in circuit , preparation of PID and Flow circuit diagrams from test rig set up
6. Mechanical design of the inner and outer tube structures for thermal stresses using theoretical method and using ANSYS

The following components of the drive will be designed using ANSYS

- Inner tube
- Outer tube

B. Fabrication

By taking the Suitable manufacturing methods of designing Helical Coil In shell Heat Exchanger will design the Helical Tube in TCHE and experimental set up also has to prepare as per TEMA guidelines.

C. Experiential Analysis

1. Testing of Helical tube in tube coil heat exchanger in parallel flow configuration to determine
- LMTD
- Capacity ratio
- Effectiveness
- Number of transfer units (NTU)
2. Testing of Helical tube in tube coil heat exchanger in counter flow configuration to determine
- LMTD
- Capacity ratio
- Effectiveness
- Number of transfer units (NTU)

To check the validity of experimental results with theoretical results.

1. To carry out comparative study of theoretical and experimental analysis results to decide the heat exchanger parameter optimization in parallel flow configuration.
2. To carry out comparative study of theoretical and experimental analysis results to decide the heat exchanger parameter optimization in counter flow configuration
3. Interpretation of results will be done to suggest the modifications to improve the design of heat exchanger for enhanced performance for any given design considerations.

D. Facilities Available

The following facilities to carry out fabrication work are available at sponsorer's site

Centre lathe
Milling machine
Electrical Arc Welding
Brazing set up
Crimping and assembly tool set up
Coil winding fixture set up

5. Input Data For Testing

Hot Fluid through Inner Tube:-SAE 20 W 40 Oil Cold Fluid through Outer Tube (Annulus):-Water

Properties Of SAE 20 W 40 Oil

SPECIFIC GRAVITY = 0.913

SPECIFIC HEAT = 0.406 Btu / lb-F =1.7 KJ/KGK

Note: 1 kJ/(kg K) = 0.2389 kcal/(kg °C) = 0.2389 Btu/(lbm °F)

Hence specific heat of SAE20W40 = 0.406 x1/ 0.2389 = 1.6999 = 1.7 kJ/kg-k

Properties of Water

Specific Heat of water at (25 to 30^{0}C) = 4.187 kJ/kg-k

VI. Conclusion

1. Capacity ratio of designed heat exchanger in counter flow configuration increases with increase in mass flow rate with maximum capacity ratio of 0.215.
2. Capacity ratio of designed heat exchanger in parallel flow configuration increases with increase in mass flow rate with maximum capacity ratio of 0.2.

3. Designed Helical coil in coil heat exchanger in counter flow configuration is 1.27 (ie, 0.66/0.52) times effective than the Helical coil in coil heat exchanger in parallel flow configuration.

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Mr. Mandore Shailendra Kachrulal received B.E. degree in Mechanical Engineering from Anuradha Engineering College, Chikhli Dist Buldana affiliated to Sant Gadgebaba Amravati University in 2011, after completing B.E. he joined “Enercon India Ltd” and worked as Assistant Engineer in Project Installation Department. At present he is Pursuing M.E. (Heat Power) from Imperial College of Engineering and Research, Wagholi, Pune and working as lecturer in Department of Mechanical Engineering, in Imperial college of Engineering from Pune University from Dec 2012 to till date.

Dr Kishor Purushottamrao Kolhe is presently working as a Professor in Department of Mechanical Engineering, JSPM’s Imperial College of Engineering and Research Wagholi Pune. He has published more than 90 Research paper in various National and International Journals/Proceedings. His areas of Interest are design of Agril Machineries and tools and Machineries, Tractor Mounted Hydraulic Elevator, Welding, Ergonomics etc. (in 5-6 lines)