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Design And Manufacturing Of Straight Helical Coil Heat Exchanger

To find out the effectiveness of tube in tube Heat exchanger and comparing it with other Heat exchanger.

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Abstract — *Heat exchangers are devices that have been used for transferring heat from one medium to another medium. In the present study the thermal performance and pressure drop of the helical-coil heat exchanger with and without helical crimped fins are studied. The heat exchanger consists of tube in tube unit with two different coil diameters. The inner tube diameter is 10mm and the outer tube diameter is 25mm. The hot water enters in the inner tube of heat exchanger and the cold water enters in outer tube. Heat transfer characteristics inside a helical coil for various boundary conditions are compared. The effects of the inlet conditions of both working fluids flowing through the test section on the heat transfer characteristics are discussed.*

Keywords- *Heat exchangers; Helical coils; Heat transfer rate; tube; diameter; working fluid*

I. INTRODUCTION

It has been widely reported in literature that heat transfer rates in helical coils are higher as compared to a straight tube. Due to the compact structure and high heat transfer coefficient, helical coil heat exchangers are widely used in industrial applications such as power generation, nuclear industry, process plants, heat recovery systems, refrigeration, food industry, etc Heat transfer and flow through a curved tube is comprehensively reviewed first by Berger et al. heat transfer from hot fluid to cold fluid is modeled by considering both inside and outside convective heat transfer and wall conduction. In these analyses, we have used temperature dependent values of thermal and transport properties of the heat transfer medium, which is also not reported earlier. As thermal conductivity of copper more thus We use copper material(401) for inner tube and thermal conductivity of plastic material(0.190) is less so we use plastic material for outer tube.

Material	Conductivity (Watts/meter-°C)
Acrylic	0.200
Air	0.024
Aluminum	250.000
Copper	401.000
Carbon Steel	54.000
Concrete	1.050
Glass	1.050
Gold	310.000
Nickel	91.000
Paper	0.050
PTFE (Teflon)	0.250
PVC	0.190
Silver	429.000
Steel	46.000
Water	0.580
Wood	0.130

Table 1.1 thermal conductivity of different materials

II. LITERATURE RIVIEW

1.Vijaya Kumar Reddy K.et al. "CDF Analysis of a Heliacally Coiled Tube in Tube Heat Exchanger" A helical coil tube heat exchanger is generally applied in industrial application due to its compact structure, larger heat transfer area and higher heat transfer capability etc. The importance of compact heat exchangers has been recognized in many industrial applications ranging from chemical and food industries, power production, electronics, environmental engineering, manufacturing industry, air conditioning, waste heat recovery, cryogenic processes and space applications for the last six decades. However, flow and helical coils are extensively used as heat exchangers and reactors due to higher heat and mass transfer coefficients, narrow residence time distributions and compact structure.

2.Sudheer Prem Kumar B.et.al. "CDF Analysis of a Heliacally Coiled Tube in Tube Heat Exchanger" In the present study a tube in tube helically coiled heat exchanger has been modeled for fluid flow and heat transfer characteristics for different fluid flow rates in the inner as well as outer tube. A CFD analysis has been conducted for a TTHC heat exchanger. The geometry was developed in PRO-E 5.0 with meshing performed in ICEM-CFD and was exported to Fluent 14.0

3.Kevin Kunnassery.et.al "Experimental Analysis of Helical Coil Heat Exchanger by Using Different Compositions of Nano Fluids" Nano particles have been a topic of interest to many researchers. The wide range applications and advantages of these materials give them a superior edge over conventional materials. They have surpassing thermo physical properties with a negligible pressure drop. Nano particles have higher heat transfer rates which make them an apt choice where a higher heat transfer rate is required for smooth functioning. Common nano particles such as aluminum oxide and titanium.

4.Rishabh Singh. et.al "Experimental Analysis of Helical Coil Heat Exchanger by Using Different Compositions of Nano Fluids" The effectiveness of this type of heat exchanger is augmented using screw inserts which help in creating additional turbulence. We have prepared a review of some researchers who have used helical coil with screw inserts as their setup and used nano particles as the working fluid to augment the heat transfer rates. The various results and conclusion have been stated.

5.A.G. Gimadiev. et.al "Study of coil heat exchanger of mechatronic sample conditioning system" The heat exchanger is the main part of mechatronic sample conditioning system. Static and dynamic characteristics of heat exchanger influence on the accuracy of sample temperature maintaining. Adjustable parameter of the heat exchanger is the final sample temperature; the control factor is cooling water flow rate.

III. DESIGN PROCEDURE

- **Cylindrical helical pipe in pipe heat exchanger**
  Internal Condition: -

Hot Fluid	Cold Fluid
Thi=60^0c	tci=30^0c
Tho=40^oc	tco=?
Mh=$1cm^3$/s	Mc= $1cm^3$/s
=$1*10^{-6}$ m^3/s	$1*10^{-6}$ m^3/s

Where,
Mh – Mass flow rate of hot fluid
Mc – Mass flow rate of cold fluid
Heat loss by hot fluid = heat again by cold fluid.
By energy balance equation
Mh*cp (thi-tho) = Mc*cp(tco-tci)
$1*10^{-6}$*4.18(60-40)=$1*10^{-6}$*4.18(tco-30)
(60-40)=tco-30
Tco=30+(60-40)
Tc0=50^0c

- **Find Heat Transfer:-**
  Q_1 =Mh*cp(thi-tho)
  =$1*10^{-6}$*4.18(60-40)
  Q_1=$8.36*10^{-5}$ J/Sec
- Find Thermal Resistance of coil.

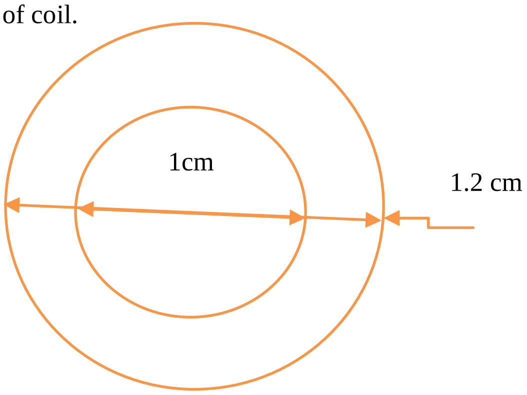

Fig. 3.1 thermal resistance of tubes

- In this cylinder it founds 3 thermal Resistance
  Rth = R_1+R_2+R_3
  = $R_{.Conv}$ + R_{condu}+ R_{cony}
  Rth = 1/hi*Ai +ln (ro/r1)/2π kl +1/ho*Ao

- Find Area of coil I n terms of L
  Ai = π*di*L
  =π*1*10^{-2}*L
  Ai = 0.0314L m^2
  Ao=π*do*L
  = π*1.2*10^{-2} L
  Ao= 0.0376 L m^2

- Find out hi for Thermal Resistance

1.We have to find velocity: -

Flow rate of Ai = $\pi/4(1*10^{-2})^2$
= $7.85*10^{-5}$ m^3/s
Mc =ϱ* Ai*Vc

Vc = mc/ϱ*Ai
Vc = $1*10^{-6}/1000*10^{-5}$
Vc = $1.273*10^{-5}$ m/s

2. We have to find ReynoldsNumber (Rei): -

Where,
μ = Viscosity of water.
Rei = Reynolds Number
Rei= ϱ*vc*di/μ
=$1000*1.273*10^{-5}*1*10^{-2}/0.547*10^{-3}$
Rei = 0.2321
No unit because All Number are dimensionless.

3. Find out Dean Number (Deic):-
Deic = $Rei*(di/dct)^{0.5}$
Where, dct = Top coil dia.
Deic = $0.2321*(1*10^{-2}/30*10^{-2})^{0.5}$
Deic = 0.04237

4.To find Nussult Number(Nui):-

Nui = $[(3.675+4.343/(1+197*Deic/per)^2)]+[(1.158*Dei/(1+0.4755/per))^{1.5}]^{0.33}$
Assume,
x_1= $(1+197*Deci/pr)^2$
x_2= (1+0.4755/pr)
The prandlt number of water is in between 1-10 for cold fluid.
∴. The put prandlt number = 4.3
∴.To find x_1
X_1 = $(1+197*Deic/pr)^2$
= $(1+197*0.04237/4.3)^2$
X_1 = 8.650

∴. To find x_2
X_2 = 1+0.4755/4.3
X_2 = 1.11

Put x1 & x2 value in eq^n
Nui= $[3.675+4.343/8.650]^3 +[1.158 x0.04237/1.110]^{1..5]0..33}$

Nui=4.015
To find hi:
Nui=hidi/kc
hi= nu_i xkc/di where kc is thermal diffusivity
hi = $4.015x0.151/1x10^{-2}$

hi=60.62w/m^2

find out ho for thermal resistance

we have to find velocity,

flow area= ao=[π/4x20^2-π/4x12^2]x10^{-6}

ao=2.01x10^{-4}

mh=ao*vh

vh=mh/$.ao

vh= 1x10^{-6}/1000x2.01x10^{-4}

vh=4.97x10^{-6} $m^{3/s}$

5. We have to find Reynolds number (Reo)

Reo=ϱ*Vh*do/μ

= 1000*4.97*10^{-6}*1.2*10^{-2}/0.547*10^{-3}

= 0.109

6. we have to find dean number

deo= reo* [do/dt]$^{0.5}$

=0.109* [1.2x10^{-2}/30x10^{-2}]]$^{0.5}$

Deo=0.0218

7. To find Nussult no(nuo)=

Nuo={3.675+4.343/1+197*deo/pr}$^{2\}}$+{1.158*deo/1+0.4755/pr}$^{1.5\}0.2\}}$

Assume,

X_1={1+197*deo/pr}$^{2\}}$

X_2= (1+0.4755/pr)

The prandlt Number of water is inBet^n 1-10 for hot fluid the prandlt Number = 3.55

8.To find

X_1= (1+197 * 0..218/3.55)^2

X_1=4.882

X_2=(1+0.4755/3.55)

X_2= 1.133

Nuo=(3.675+(4.343./4.882)^3 + [(1.158*0..218/1.133)$^{1..5}$]0.33

Nuo=4.53

9.To find 'ho' :-

ho = Nuo*kc/do

= 4.53*0.157/1.2*10^{-2}

ho= 59.26 w/m^2k

- **To find Out Length**

1. To find LMTD (Δ T)

Thi 60^0

ΔT_1

Tho40^0

Tci 30^0

LMTD = ΔT_1 - ΔT_2 / ln [ΔT_1/ΔT_2]

LMTD =10

When ΔT_1 is same ΔT_2 Then this value is put in LMTD

LMTD =10

2. To find out R_{th}

R_{th} = 1/hi*Ai + ln(ro/ri)/2*π*k*L +1/ho*Ao
= 1/60.62*0.0376L + ln(1.2)/2*π *396*L+1/59.26*0.0376
= 0.438/L+2.204*10^{-3}/L+0.448/L
Rth= 0.888/L
Q1 = LMTD/Rth
8.36*10^{-5} = 10/0.888*L
L = 1.140 m
L is very less for given application for mfg we assume
L = 5m

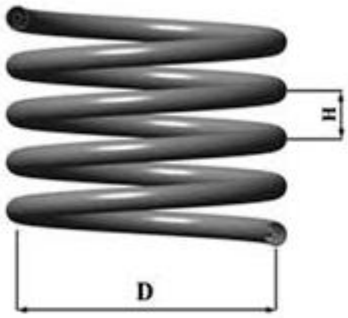

Fig. 3.2 Cylindrical Helical Coil

- **ADVANTAGES**

1. High heat transfer rate.
2. Less floor area required.
3. Weight of the device is less than the other heat exchangers.
4. More efficiency as compared to other heat exchanger.

- **DISADVANTAGES**

1. Water storing Capacity is less.

2. Cleaning and maintenance is difficult since a tube cooler requires enough clearance at one end to remove the tube nest

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