PERFORMANCE ANALYSIS OF A DOUBLE PIPE HEAT EXCHANGER WITH AND WITHOUT TRIANGULAR BAFFLES

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Abstract - *In double pipe heat exchanger, there is continuously requirement on improving the performance and effectiveness. In order to achieve this, many parameter is to be changed like flow of fluid, tube diameter, number of tubes, baffle arrangement, different types of baffles shapes and baffle spacing. This experiment is performed on the double pipe heat exchanger for parallel flow and counter flow using baffles and analysing and comparing it with double pipe heat exchanger with and without baffles .*

***Key Words*: Heat Exchanger, Double Pipe, Parallel Flow, Baffles, Triangular Baffles .**

1.INTRODUCTION

Heat exchanger may be defined as it is an devices which transfers the energy from hot fluid to a cold fluid which have maximum rate and less investment and running cost. The rate of heat transfer is depends on thermal conductivity of dividing wall & convective heat transfer coefficient between the fluids and wall. Heat transfer rate also changes according to the boundary conditions like insulated wall condition or adiabatic condition.

1.1 Double pipe heat exchanger

A double pipe heat exchanger (also sometimes referred to as a 'pipe-in-pipe' exchanger) is a type of heat exchanger comprising a 'tube in tube' structure. As the name suggests, it consists of two pipes, one within the other. One fluid flows through the inner pipe (analogous to the tube-side in a shell and tube type exchanger) whilst the other flows through the outer pipe, which surrounds the inner pipe (analogous to the shell-side in a shell and tube exchanger).

1.2 Types of Fluid Flow

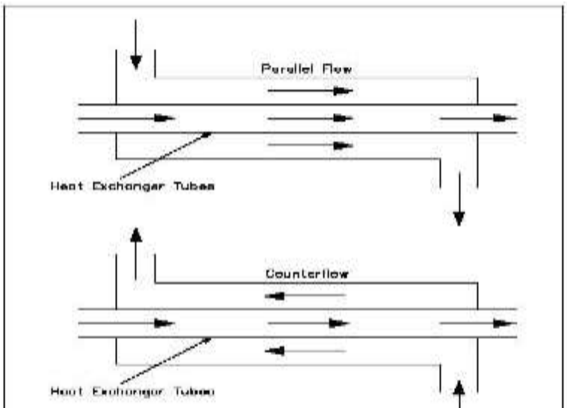


FIG.1.2.1

In double pipe heat exchanger there are two types of flow parallel flow and counter flow .In parallel flow hot fluid and cold fluid in the double pipe heat exchanger flow in a same direction and in a counter flow hot fluid and cold fluid flow in apposite direction.

2. Experimental setup

FIG.2.1

- **Copper Pipe (Inner Pipe)** Specification :-

  Length - 800mm
  Thickness - 2mm
  Inner diameter - 25mm
  Outer diameter - 27mm

- **Copper Pipe With Baffles** Specification :-

  Baffles dimension - 48 × 48 × 48 mm
  Baffles thickness - 5mm
  Number of baffles is - 5

- **Mild Steel Pipe(Outer Pipe)** Specification :-

  Length - 1000mm
  Thickness - 5mm
  Inner diameter - 50mm
  Outer diameter - 55m

- **Digital Temperature Indicator**

  Specification :-

  Supply - 4-20 mA /0-1V/0- 10V
  Accuracy - J,K Thermocouple +/-1
  LED display colour : Red Range : 0 to 400 °C

- **Thermocouple** Specification :-

  Thermocouple - Type J (iron - constantan)
  Range - -40 °C to +750 °C

3. READING AND CALCULATION

3.1. Nomenclature

Qf - Heat transferred between fluids ,

Cph - Heat capacity of hot fluid , KJ / Kg K

Cpc - Heat capacity of cold fluid , KJ / Kg K

m_h - mass flow rate of hot fluid , Kg/min

m_c - mass flow rate of cold fluid , Kg/min

U – Overall heat transfer cofficient , w/m_2 k

1. The heat transfer rate for hot side $Q_h = m_h \times C_{ph} (T_{h1} - T_{h2})$

Where ,

T_{h1} - inlet temperature of Hot fluid , °C

T_{h2} - outlet temperature of Hot fluid , °C

2. The heat transfer rate for cold side

$Q_c = m_c \times C_{pc} (T_{c2} - T_{c2})$

Where ,

T_{c1} = inlet temperature of cold fluid , °C

T_{c2} = outlet temperature of cold fluid , °C

3. The Overall heat transfer rate

$$U = \frac{1}{\left(\frac{r2}{r1\,hi}\right) + \left(\frac{r2}{K}\right) \ln\left(\frac{r2}{r1}\right) + \left(\frac{1}{ho}\right)}$$

Where,

r1 = inner radius of copper pipe , mm

r2 = otuer radius of copper pipe , mm

hi = heat transfer coefficient inner , w/m_2

h_o = heat transfer coefficient outer , w/m_2

K = Thermal counductivity, w/m k

4. Area of the Heat Exchanger

Aera of cylinder(copper) = 2πr(h+r) , m_2

Aera of cylinder (mild steel) = 2πr(h+r) , m_2

Aera of Heat Exchanger (A) = Aera of cylinder (MS) – Aera of cylinder (copper)

5. LMTD equation for parallel and counter flow

$$\Delta T_m = \frac{\Delta t_1 - \Delta t_2}{\ln\left(\frac{\Delta t_1}{\Delta t_2}\right)}$$

Where ,

$\Delta t_1 = th_1 - tc_2$

$\Delta t_2 = th_2 - tc_1$

th_1 = inlet temperature of hot fluid , °C

th_2 = outlet temperature of hot fluid , °C

tc_1 = inlet temperature of cold fluid , °C

tc_2 = outlet temperature of cold fluid , °C

6. The overall heat transfer coefficient can be calculated by using following formula :-

$Q = U \times A \times \Delta Tm$

3.2 Effectiveness By NTU (Number Of Transfer Unit)

1.The Thermal capacity rates of HOT and COLD

$C_h = m_h \times Cp_h$

$C_c = m_c \times Cp_c$

Where ,

Cp_h , Cp_c speciic heat of fluid , KJ/Kg K

2. Heat Capacity Ratio (R)

$$R = \frac{C_{min}}{C_{max}}$$

Where ,

$C_{min} = C_h$ and C_c which are less value C_{max} =

C_h and C_c which are higher value

3. Number of transfer unit (NTU)

$$NTU = \frac{UA}{C_{min}}$$

4. Effectiveness for the Parallel and Counter flow

$$\varepsilon_{\text{parallel flow}} = \frac{1 - \exp[-NTU(1+R)]}{(1+R)}$$

$$\varepsilon_{\text{counter flow}} = \frac{1 - \exp[-NTU(1-R)]}{1 - R\exp[-NTU(1-R)]}$$

- **READING WITHOUT BAFFLES**

PARALLEL FLOW :-

Sr No.	Mass Flow rate of cold fluid (Kg/sec)	Mass flow rate of Hot fluid (Kg/sec)	Th1 (°C)	Th2 (°C)	Tc1 (°C)	Tc2 (°C)	Overall Heat transfer by LMTD (W)	Effectiveness by NTU method
1.	0.5	0.0111	70	65	27	30	48.50	0.235
2.	0.5	0.030	70	66	27	32	55.51	0.093
3.	0.5	0.125	70	68	27	33	45.10	0.023
4.	0.142	0.125	70	65	27	30	48.50	0.022
5.	0.42	0.125	70	66	27	33	61.10	0.022
6.	0.5	0.125	70	68	27	35	53.62	0.024

COUNTER FLOW :-

Sr No.	Mass Flow rate of cold fluid (Kg/sec)	Mass flow rate of Hot fluid (Kg/sec)	Th1 (°C)	Th2 (°C)	Tc1 (°C)	Tc2 (°C)	Overall Heat transfer by LMTD (W)	Effectiveness by NTU method
1.	0.5	0.0111	70	65	27	30	48.50	0.235
2.	0.5	0.03	70	66	27	32	55.51	0.093
3.	0.5	0.125	70	68	27	33	45.10	0.023
4.	0.142	0.125	70	65	27	30	48.50	0.022
5.	0.4	0.125	70	66	27	33	61.10	0.022
6.	0.5	0.125	70	68	27	35	53.62	0.024

- **READING WITH TRIANGULAR BAFFLES**

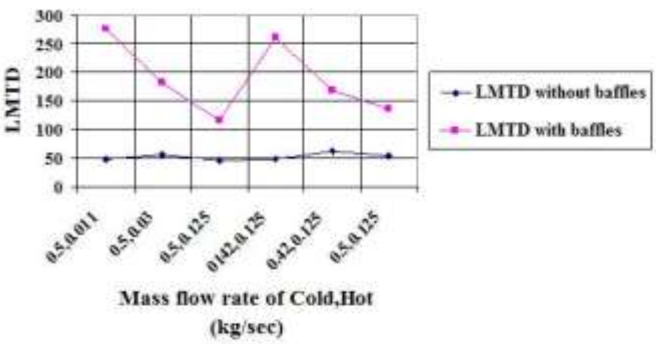
PARALLEL FLOW :-

Sr No.	Mass Flow rate of cold fluid (Kg/sec)	Mass flow rate of Hot fluid (Kg/sec)	Th1 (°C)	Th2 (°C)	Tc1 (°C)	Tc2 (°C)	Overall Heat transfer by LMTD (W)	Effectiveness by NTU method
1.	0.5	0.011	70	51	20	45	277	0.235
2.	0.5	0.03	70	59	20	39	181.30	0.093
3.	0.5	0.125	70	62	20	31	116.68	0.022
4.	0.142	0.125	70	50	20	42	259.91	0.023
5.	0.4	0.125	70	57	20	34	167.13	0.023
6.	0.526	0.125	70	61	20	32	135.87	0.023

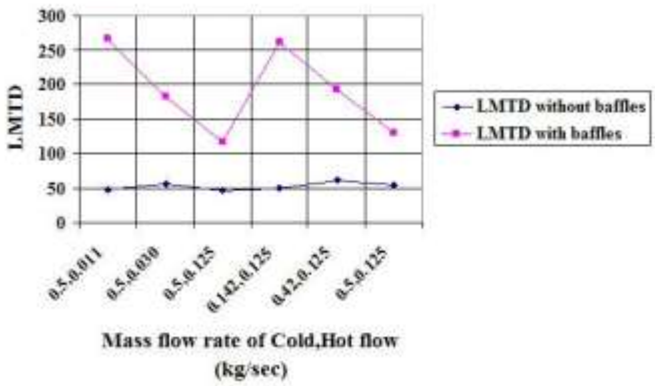
COUNTER FLOW :-

Sr No.	Mass Flow rate of cold fluid (Kg/sec)	Mass flow rate of Hot fluid (Kg/sec)	Th1 (°C)	Th2 (°C)	Tc1 (°C)	Tc2 (°C)	Overall Heat transfer by LMTD (W)	Effectiveness by NTU method
1.	0.5	0.011	70	51	20	44	265.10	0.234
2.	0.5	0.03	70	59	20	39	181.30	0.093
3.	0.5	0.125	70	62	20	1	116.68	0.022
4.	0.142	0.125	70	50	20	42	259.91	0.023
5.	0.4	0.125	70	54	20	35	191.92	0.023
6.	0.5	0.125	70	59	20	30	129.95	0.023

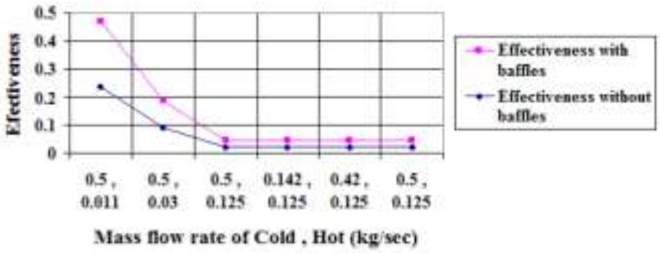
PARALLEL FLOW:-



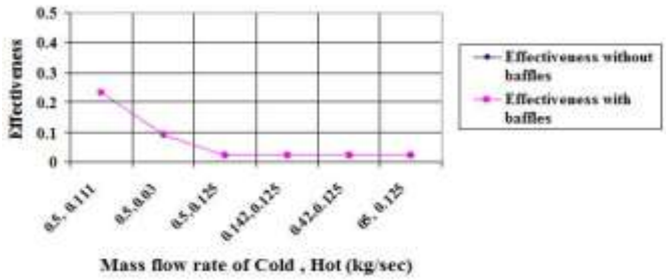
COUNTER FLOW :-



PARALLEL FLOW:-



COUNTER FLOW :-



4. CONCLUSIONS

By performing this experiment we concluded that the heat transfer rate Q is minimum without baffles and maximum with triangular baffles .the hot fluid is vary as low, medium, high and the cold fluid is constant. then the cold fluid is vary as low, medium, high, and the hot fluid is constant this type of setting is used to get the proper reading because of this we know that in the triangular baffles the LMTD and the EFFECTIVENESS is maximum as compare to without triangular baffles. By analysis this experiment we know the maximum heat transfer rate are in triangular baffles as compare to without baffles.

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