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

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 opposite direction.

2. Experimental setup

![FIG.1.2.1](image)
• 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: 5

• Mild Steel Pipe (Outer Pipe) Specification:
  - Length: 1000mm
  - Thickness: 5mm
  - Inner diameter: 50mm
  - Outer diameter: 55mm

• Digital Temperature Indicator Specification:
  - Supply: 4-20 mA /0-1V/0-10V
  - Accuracy: ±0.5°C
  - LED display colour: Red
  - Range: 0 to 400°C

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

3. READING AND CALCULATION

3.1. Nomenclature
  - Qf: Heat transferred between fluids, KJ
  - Cph: Heat capacity of hot fluid, KJ/Kg K
  - Cpc: Heat capacity of cold fluid, KJ/Kg K
  - mh: Mass flow rate of hot fluid, Kg/min
  - mc: Mass flow rate of cold fluid, Kg/min
  - U: Overall heat transfer coefficient, w/m² K

1. The heat transfer rate for hot side

\[ Q_h = m_h \times C_{ph} \times (T_{h1} - T_{h2}) \]

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

\[ Q_c = m_c \times C_{pc} \times (T_{c2} - T_{c1}) \]

Where,
- \( T_{c1} \): Inlet temperature of cold fluid, °C
- \( T_{c2} \): Outlet temperature of cold fluid, °C

3. The Overall heat transfer rate

\[ U = \frac{1}{\left(\frac{4}{r_1^2} + \frac{4}{r_2^2} \ln \left(\frac{r_2}{r_1}\right) + \frac{1}{K}\right)} \]

Where,
- r1: Inner radius of copper pipe, mm
- r2: Outer radius of copper pipe, mm
- hi: Heat transfer coefficient inner, w/m² K
- ho: Heat transfer coefficient outer, w/m² K
- K: Thermal conductivity, w/m K

4. Area of the Heat Exchanger

Area of cylinder (copper) = \( 2\pi(r+h)r \), m²

Area of cylinder (mild steel) = \( 2\pi(h+r) \), m²

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,

\[ \Delta t_1 = t_{h1} - t_{c2} \]
\[ \Delta t_2 = t_{h2} - t_{c1} \]

\[ t_{h1} = \text{inlet temperature of hot fluid, } ^\circ C \]
\[ t_{h2} = \text{outlet temperature of hot fluid, } ^\circ C \]
\[ t_{c1} = \text{inlet temperature of cold fluid, } ^\circ C \]
\[ t_{c2} = \text{outlet temperature of cold fluid, } ^\circ C \]

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

\[ Q = U \times A \times \Delta T_m \]

3.2 Effectiveness By NTU (Number Of Transfer Unit)

1. The Thermal capacity rates of HOT and COLD

\[ C_h = m_h \times C_{ph} \]
\[ C_c = m_c \times C_{pc} \]

Where,

\[ C_{ph}, C_{pc} \text{ specific heat of fluid, KJ/Kg K} \]

2. Heat Capacity Ratio (R)

\[ R = \frac{C_{cmin}}{C_{cmax}} \]

Where,

\[ C_{cmin} = C_h \text{ and } C_c \text{ which are less value } C_{cmax} = C_h \text{ and } C_c \text{ which are higher value} \]

3. Number of transfer unit (NTU)

\[ \text{NTU} = \frac{U \times A}{C_{cmin}} \]

4. Effectiveness for the Parallel and Counter flow

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

- READING WITHOUT BAFFLES

PARALLEL FLOW :-

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Mass Flow rate of cold fluid (Kg/sec)</th>
<th>Mass Flow rate of Hot fluid (Kg/sec)</th>
<th>( T_{h1} ) (°C)</th>
<th>( T_{h2} ) (°C)</th>
<th>( T_{c1} ) (°C)</th>
<th>( T_{c2} ) (°C)</th>
<th>Overall Heat transfer by LMTD (W)</th>
<th>Effectiveness by NTU method</th>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>0.5</td>
<td>0.0111</td>
<td>70</td>
<td>65</td>
<td>27</td>
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COUNTER FLOW :-

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<th>Sr. No</th>
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<th>Mass Flow rate of Hot fluid (Kg/sec)</th>
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<th>( T_{h2} ) (°C)</th>
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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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REFERENCES


