

Principles of Chemical Engineering

Heat Transfer

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Syllabus Contents

Heat transfer equipment- Double pipe and Shell and tube heat exchangers.

Objectives

- ▶ To understand the need for various configurations of heat exchangers.
- ▶ To understand the constructional aspects of:
 - ▶ double-pipe heat exchanger
 - ▶ shell-and-tube heat exchanger

Rate of Heat Transfer in Heat Exchangers

$$Q = UA \Delta T_m$$

Where, U is overall heat transfer coefficient.

For thin-walled tubes, where $A_1 = A_2$, we can write,

$$\frac{1}{U} = \frac{1}{h_1} + \frac{x_w}{k_w} + \frac{1}{h_2}$$

$A =$ heat transfer area $= \pi DL$

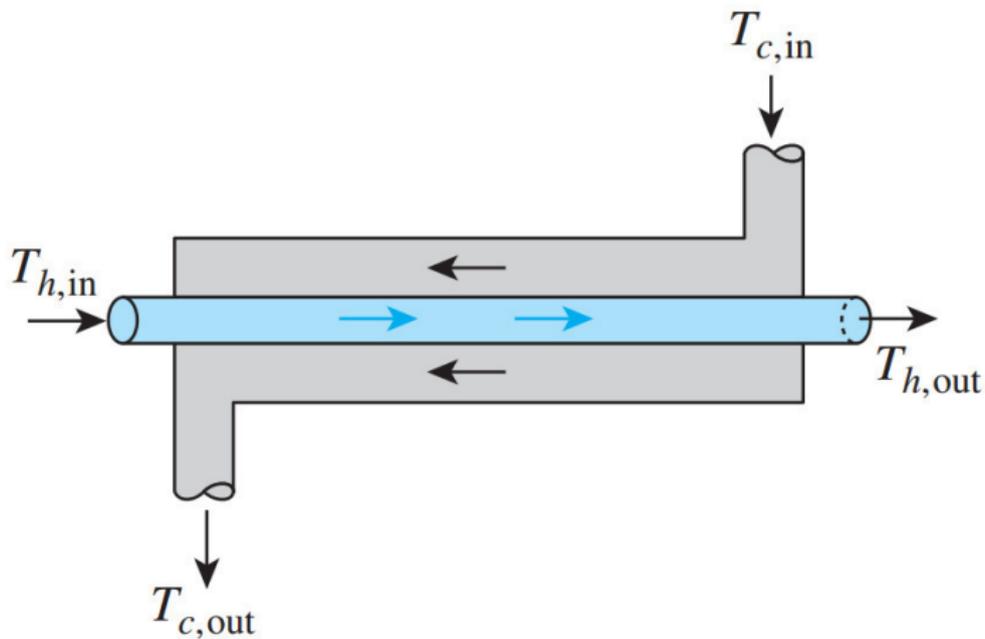
$\Delta T_m =$ mean temperature difference between the two fluids.

The Variables U and A of Heat Exchangers

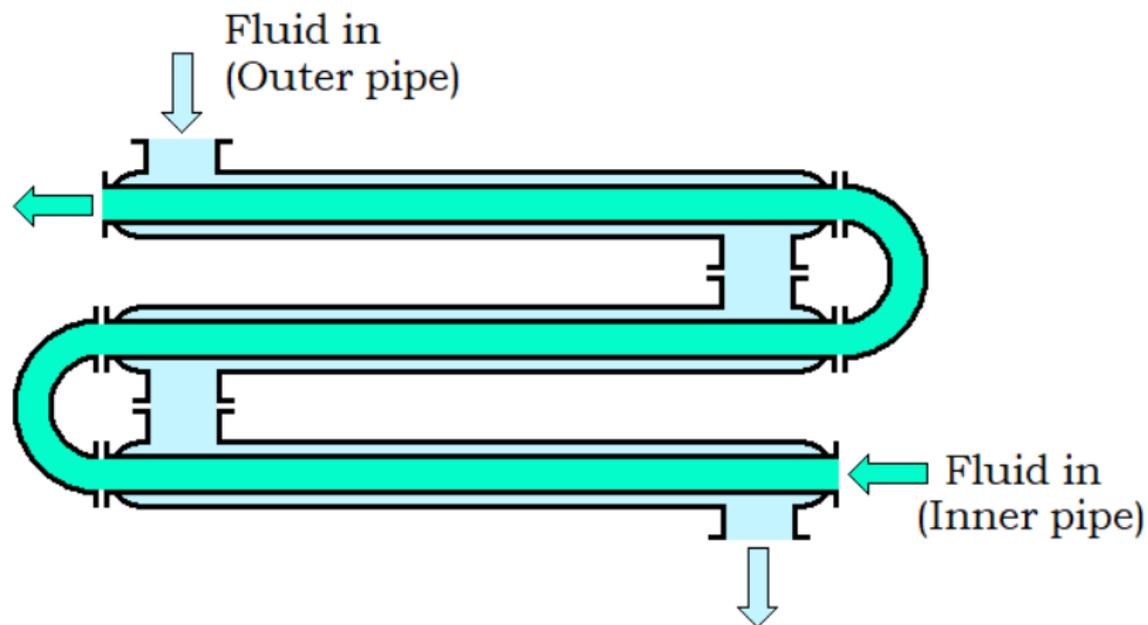
$$Q = UA \Delta T_m$$

- ▶ Increasing U leads to the requirement of increased h of the fluids. This leads to increasing the power required for pumping. This leads to increasing the operating cost.
- ▶ Increasing A leads to the requirement of increasing the length and diameter of exchanger. This leads to increasing the fixed cost.
- ▶ Optimizing U and A , so as minimize the total cost (= fixed cost + operating cost) is the task of engineer.

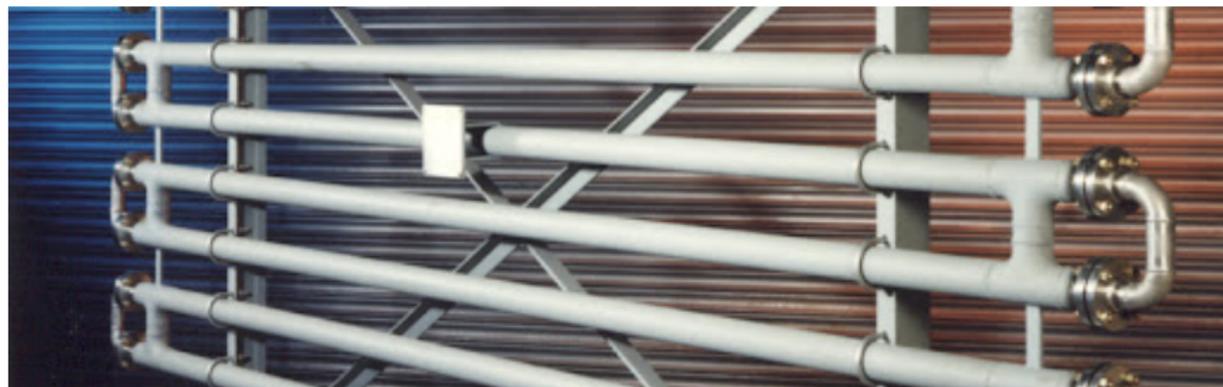
Double-pipe Heat Exchanger



Double-pipe Heat Exchanger



Double-pipe Heat Exchanger



Double-pipe Heat Exchanger (contd..)



For larger heat transfer rates, double-pipe heat exchangers are not suitable, as they require large space.

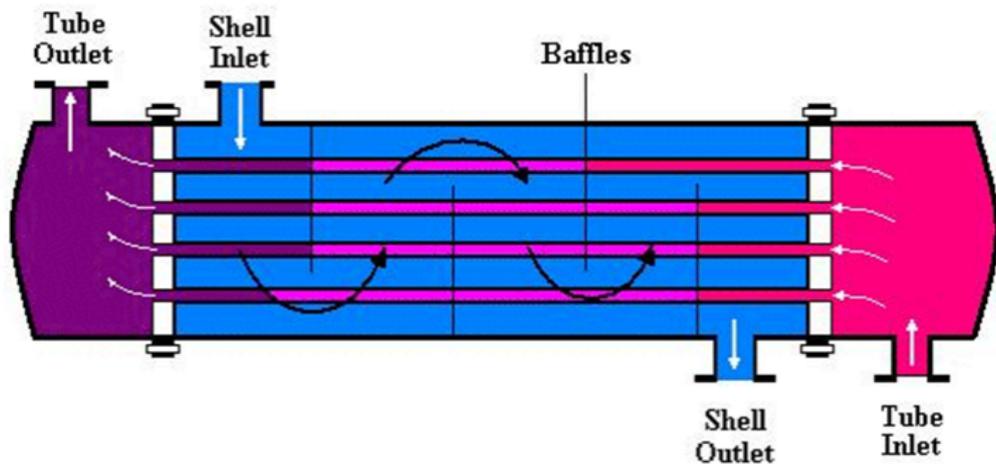
Shell-and-Tube Heat Exchangers

Instead of surrounding each pipe with another outer pipe, a large number of pipes can be surrounded by a single shell; thereby reducing the number of outerpipes, and reducing the space required. This is the arrangement of shell-and-tube exchanger.



Shell-and-tube heat exchangers are the most common heat exchangers.

Shell-and-Tube Heat Exchangers (contd..)



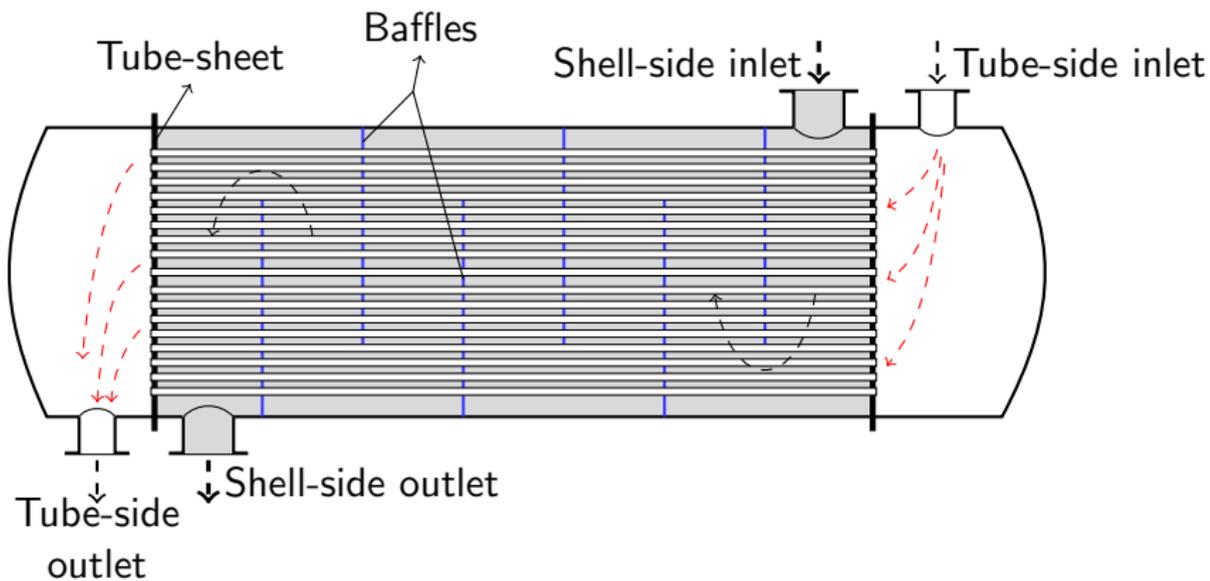


Figure: Shell & Tube Heat Exchanger (1 shell pass; 1 tube pass)

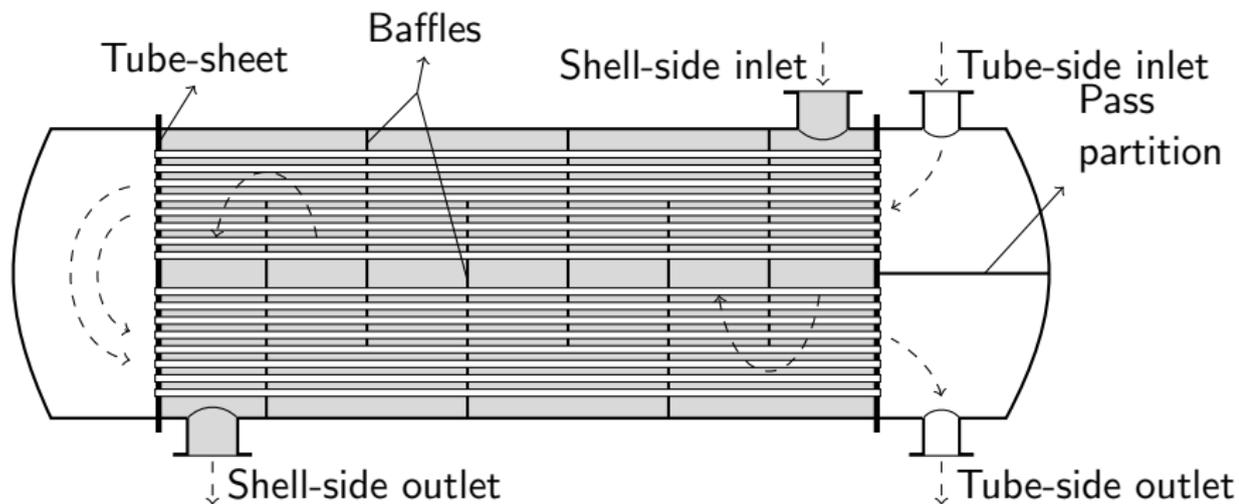
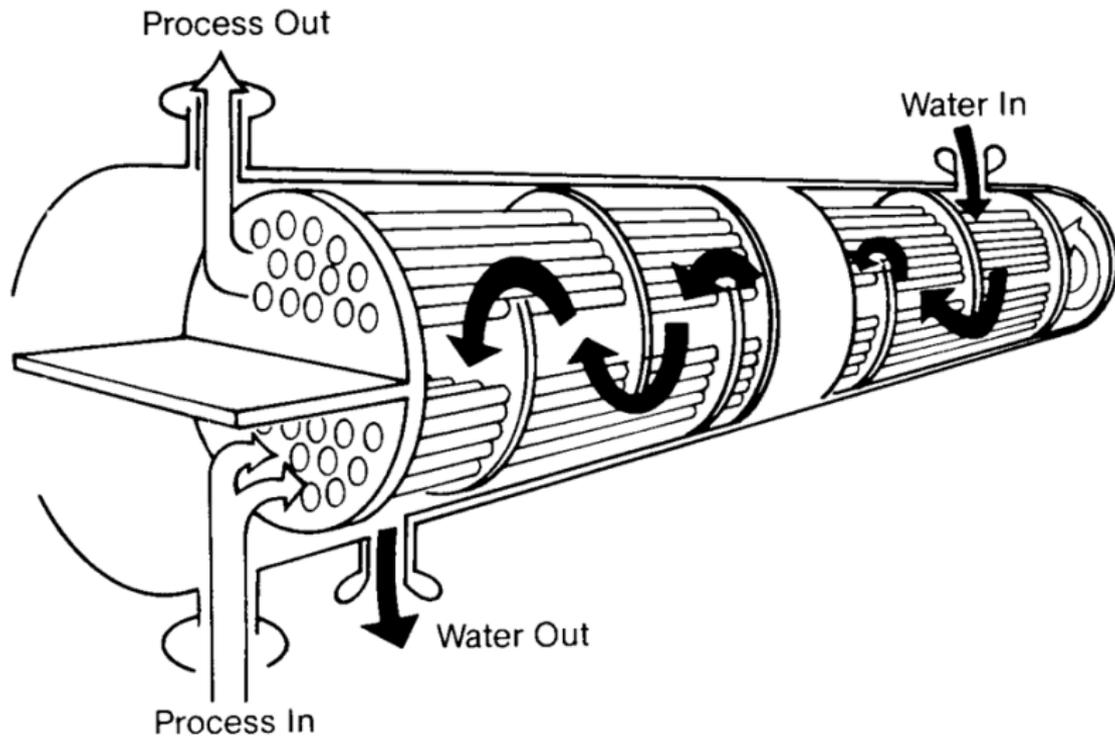


Figure: Shell & Tube Heat Exchanger (1 shell pass; 2 tube passes)

1-2 Shell-and-Tube Heat Exchanger



Heat Exchangers

Flow Arrangement

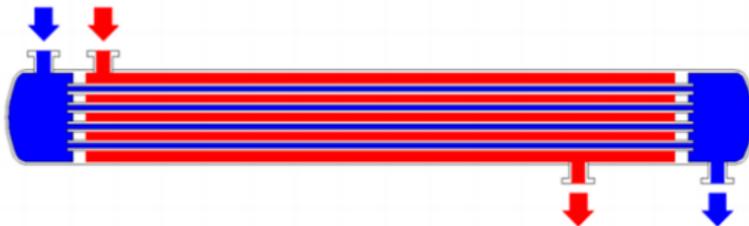


Figure: 1-1 Exchanger

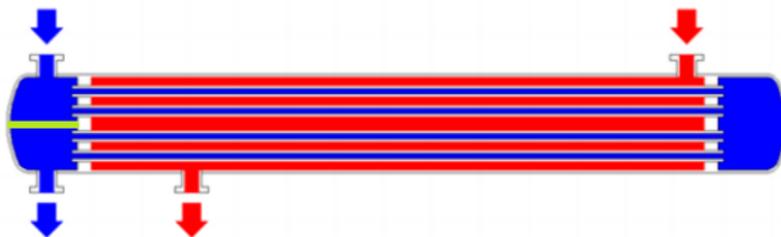


Figure: 1-2 Exchanger

Heat Exchangers

Flow Arrangement (contd..)

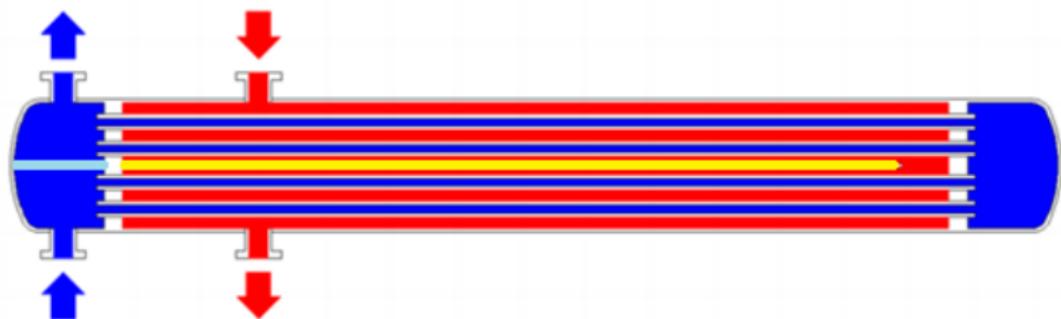


Figure: 2-2 Exchanger

Quiz

1. What are the advantages of shell-and-tube heat exchanger over double-pipe heat exchanger?
2. What are the roles of (i) baffles, (ii) tube pass-partition, in shell-and-tube heat exchangers?
3. Draw the schematic of 1-2 shell-and-tube heat exchanger. What do you mean by the term '1-2'?