# *CEN 3311 HEAT TRANSFER*

# PRINCIPLES OF HEAT FLOW IN FLUIDS:

Heat transfer from a warmer fluid to a cooler fluid through a solid wall separating the two fluids is common in chemical engineering practice.

The heat transferred may be:

- Latent heat accompanying a phase change such as condensation or vaporization, (the temp of one fluid is constant)

- Sensible heat from the rise or fall in the temperature of a fluid without any phase change.

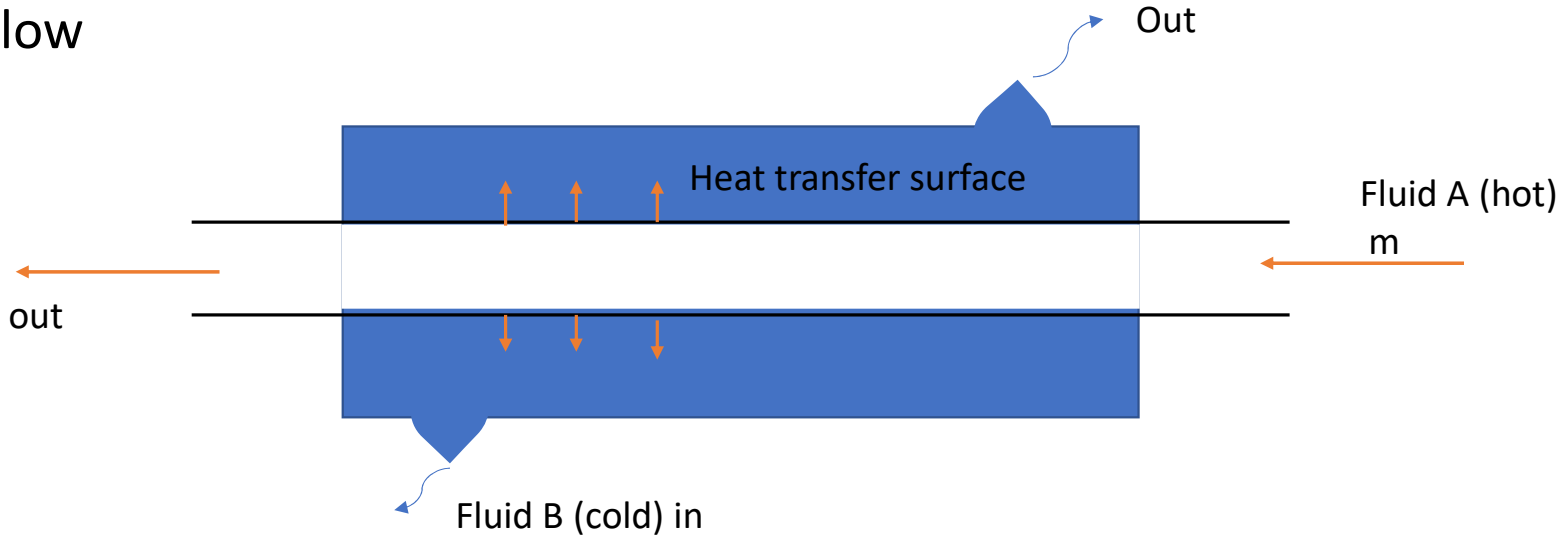
Typical examples are:

- Reducing the temperature of a fluid by transfer of sensible heat to a cooler fluids.
- Condensing steam using cooling water.
- Vaporizing water from a solution at a given pressure by condensing steam at a higher pressure.

All such cases require that heat be transferred by conduction and convection.

# Typical heat exchanger equipment:

- **Double-pipe heat exchanger**: A simple double-pipe heat exchanger is shown below



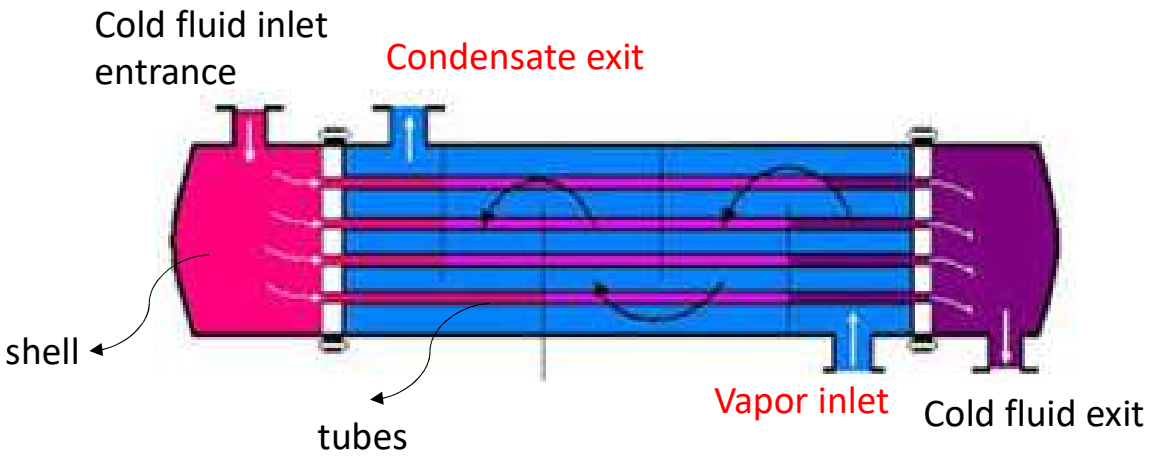

- Double-pipe exchangers are useful when not more than 100 to 500 $ft^2$ of surface area is required.

**Tubular heat exchangers  condensers**
**(Shell and tube heat exchanger condensers):**

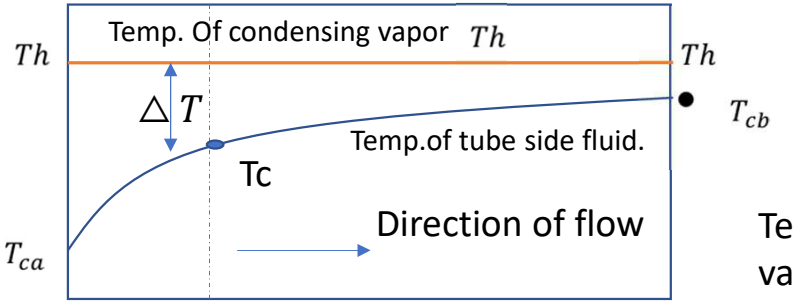
Shell and tube condensers consist of a bundle of parallel tubes. The bundle tube is inside a cylindrical shell.

This kind of equipment is also used as heat exchanger (not only condenser).

A typical angle pass tubular condenser is shown below:



- The temperatures of condensing vapor and of the liquid are plotted against the tube length in the following Figure.



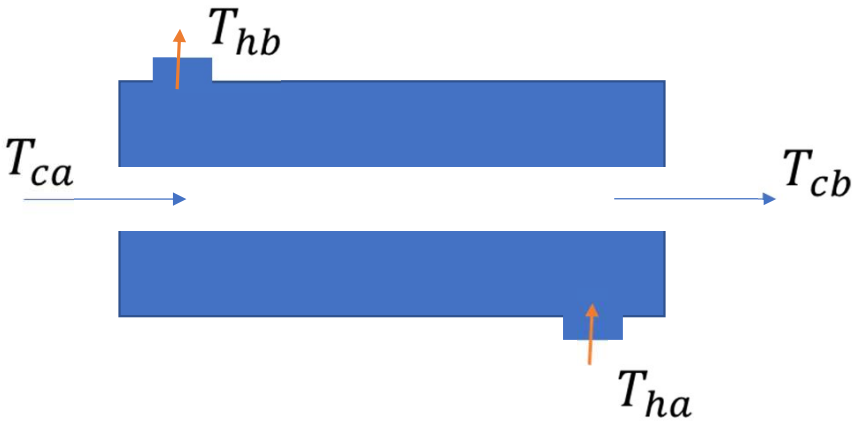

Temperature of the condensing vapor is constant

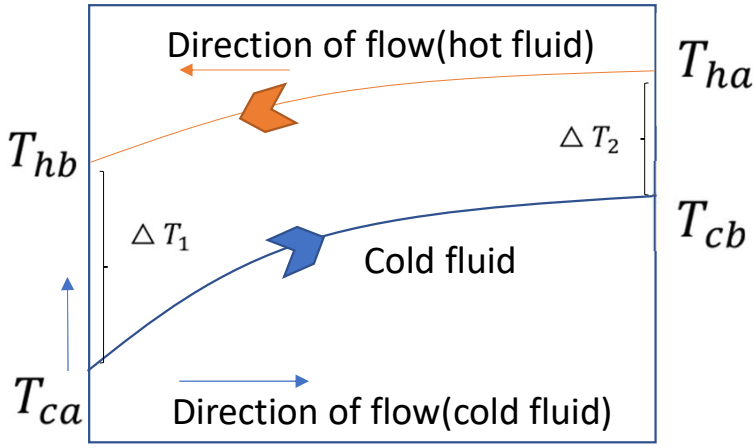
- The horizontal line represents the temperature of the condensing vapor. The curved line represents the rising temperature of the tube side fluid.
- During condensation, the temperature remains constant.

$T_{ca,}\ T_{cb} \rightarrow$ The inlet and outlet temperatures of the fluid.

$Th \rightarrow$ The constant temperature of the vapor.

**Countercurrent flow:** The two fluids enter at different ends of the exchanger and pass in opposite direction through the unit.

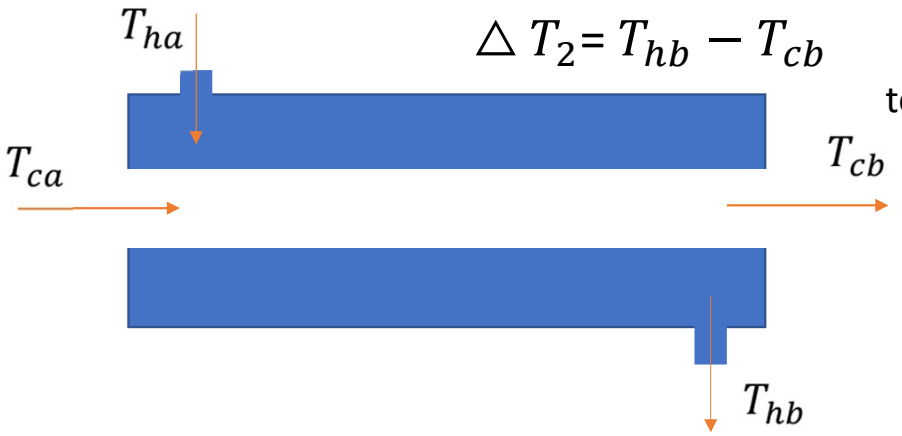


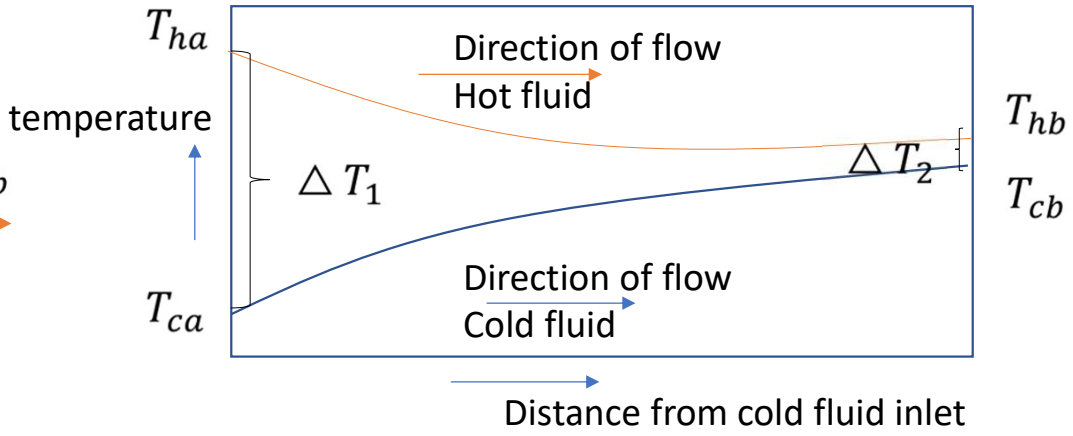




$T_{ha} \rightarrow temperature\ of\ entering\ hot\ fluid$
$T_{hb} \rightarrow temperature\ of\ leaving\ hot\ fluid$
$T_{ca} \rightarrow temperature\ of\ entering\ cold\ fluid$
$T_{cb} \rightarrow temperature\ of\ leaving\ cold\ fluid$

- The approaches are: $\triangle T_1 = T_{ha} - T_{ca}$

$\triangle T_2 = T_{hb} - T_{cb}$




**Parallel flow:** Parallel flow is used in special situations that are:

1. When it is important to change the temperature of one fluid very rapidly
2. When the exit temperature of the cold fluid is limited.