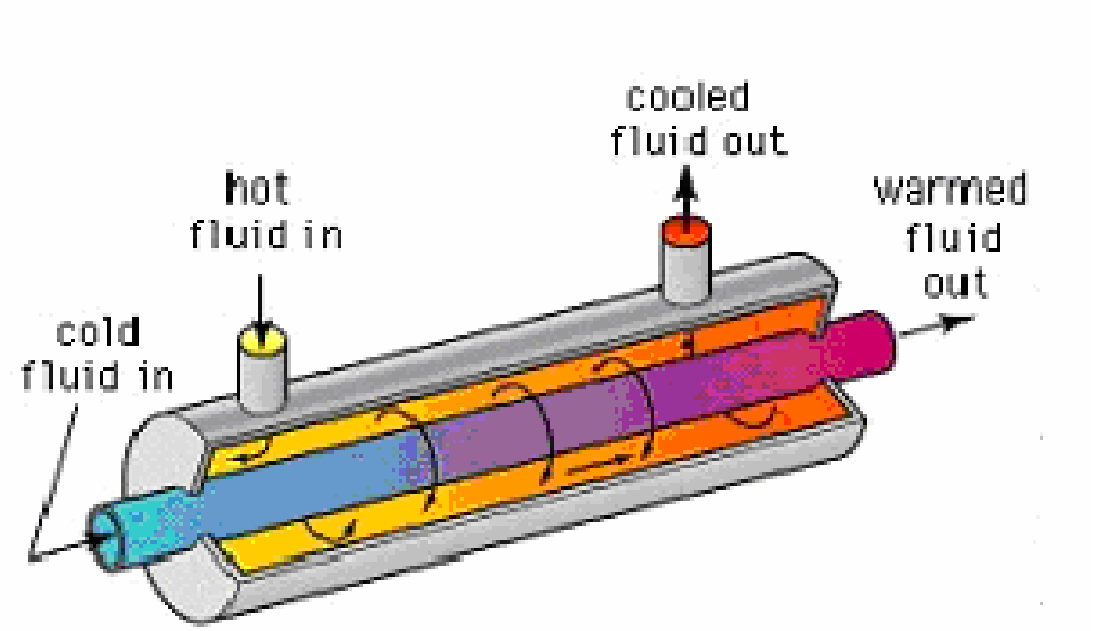
HEAT EXCHANGER

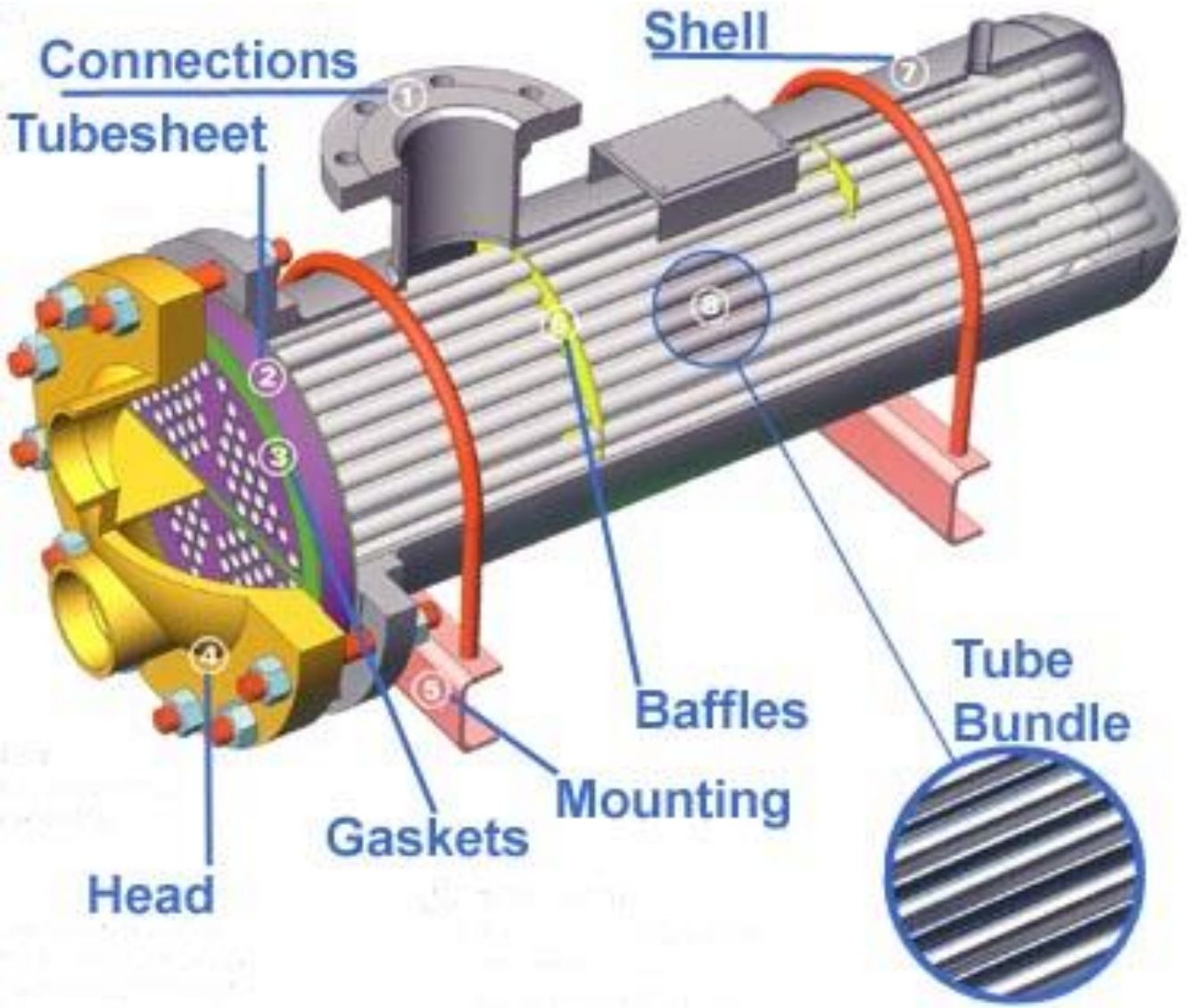
(Alat Penukar Panas)

WHAT IS A HEAT EXCHANGER?

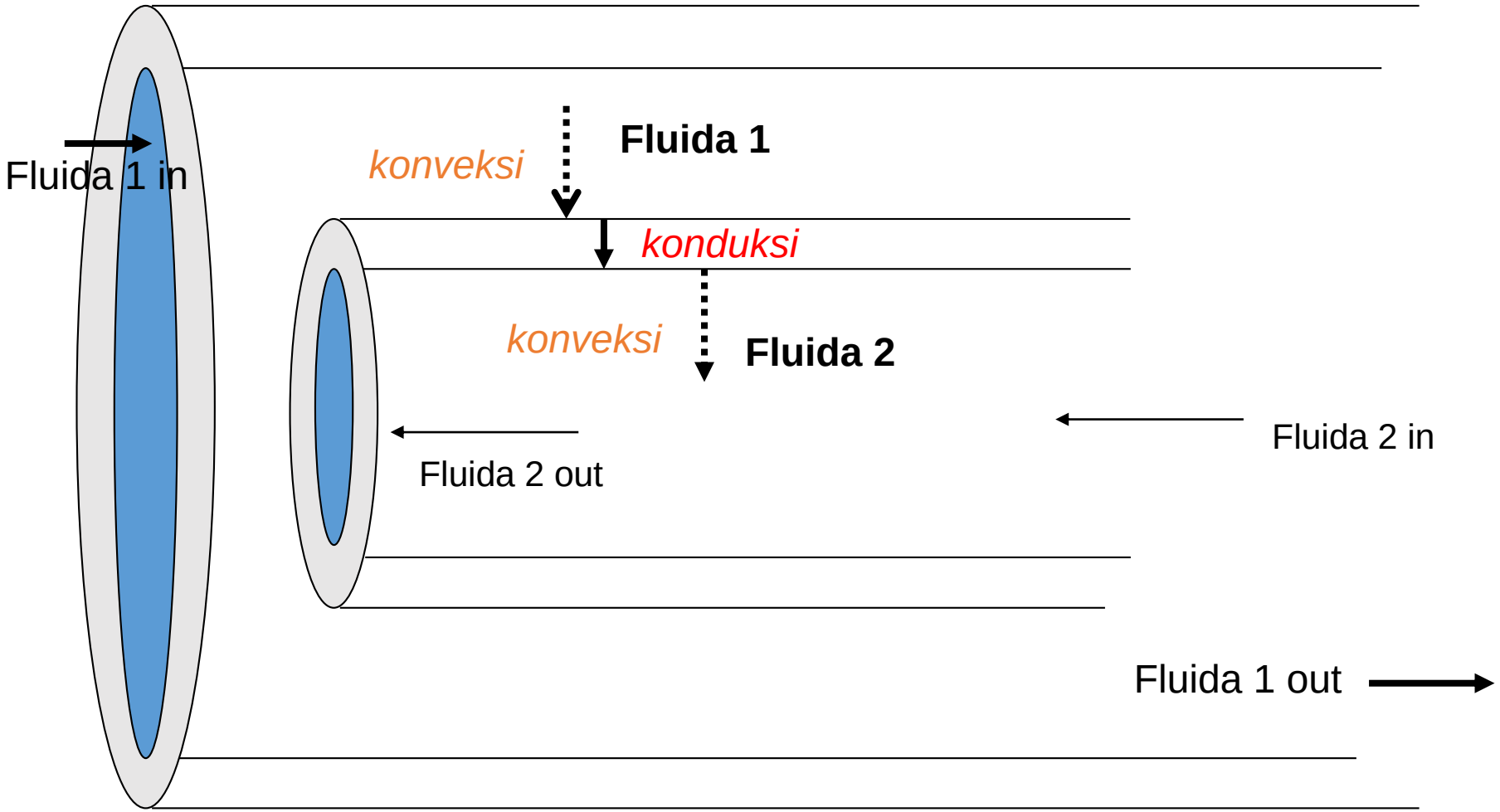


Alat yang secara khusus dirancang untuk memperoleh transfer panas yang efisien dari suatu fluida ke fluida lain melalui permukaan padat.

Penampang HE



DOUBLE PIPE HE

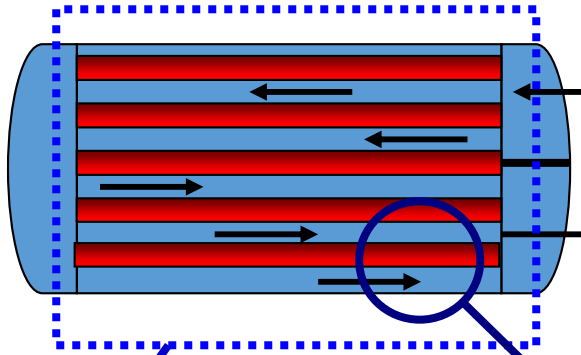


Principle of Heat Exchanger

- First Law of Thermodynamic: *"Energy is conserved."*

$$\frac{dE}{dt} = \left(\sum_{in} \dot{m}.\hat{h}_{in} - \sum_{out} \dot{m}.\hat{h}_{out} \right) + \dot{q} + \dot{w}_s + \dot{e}_{generated}$$

$\frac{dE}{dt} = 0$, $\dot{q} = 0$, $\dot{w}_s = 0$, $\dot{e}_{generated} = 0$

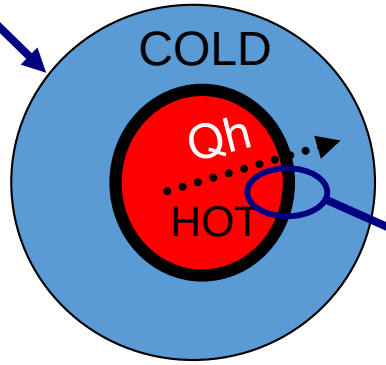


$$Q_h = A.\dot{m}_h.C_p^h.\Delta T_h$$

$$Q_c = A.\dot{m}_c.C_p^c.\Delta T_c$$

$$\sum_{in} \dot{m}.\hat{h} = -\sum_{out} \dot{m}.\hat{h}$$

•Control Volume



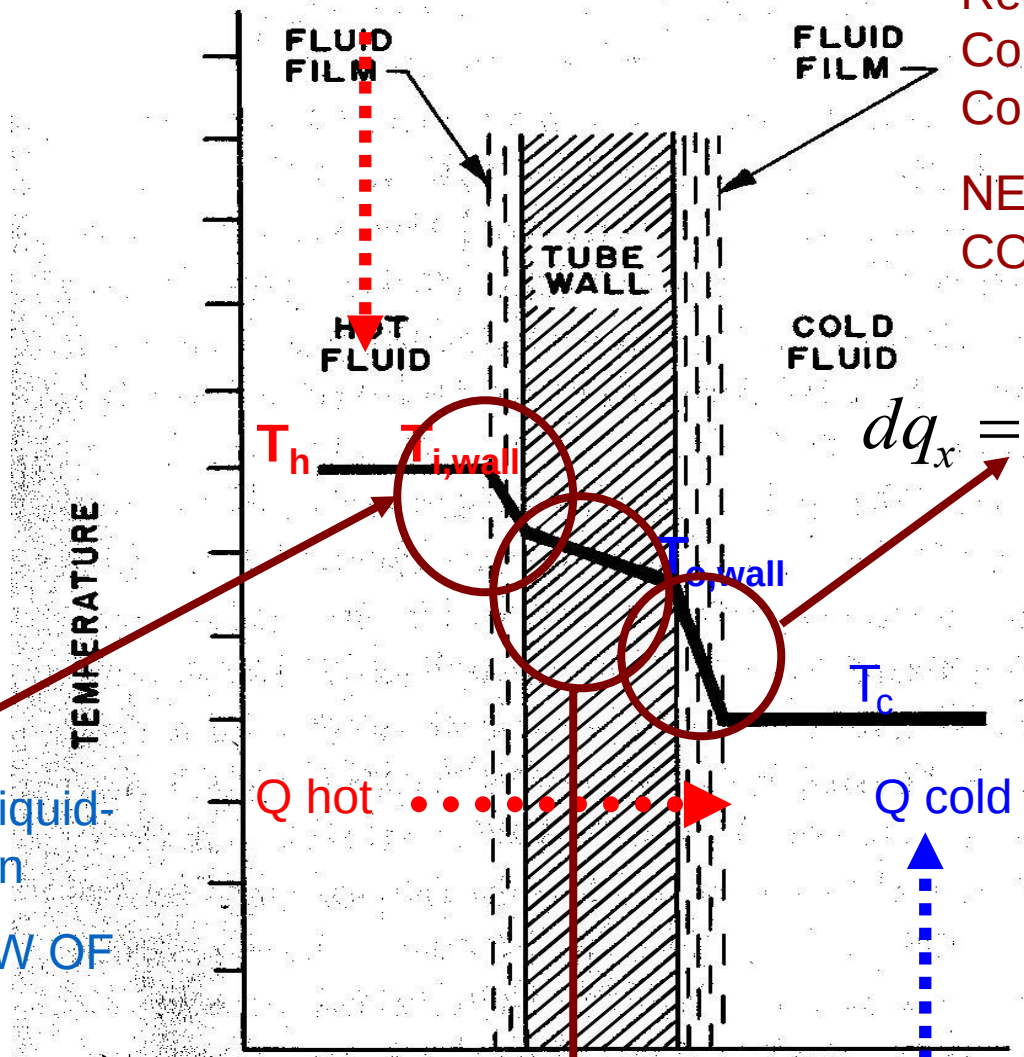
Cross Section Area

Thermal Boundary Layer

THERMAL

BOUNDARY LAYER

Energy moves from hot fluid to a surface by convection, through the wall by conduction, and then by convection from the surface to the cold fluid.



Region I : Hot Liquid-Solid Convection

NEWTON'S LAW OF COOLING

$$dq_x = h_h.(T_h - T_{iw}).dA$$

Region II : Conduction Across Copper Wall

FOURIER'S LAW

$$dq_x = -k.\frac{dT}{dr}$$

Region III: Solid – Cold Liquid Convection

NEWTON'S LAW OF COOLING

$$dq_x = h_c.(T_{ow} - T_c).dA$$

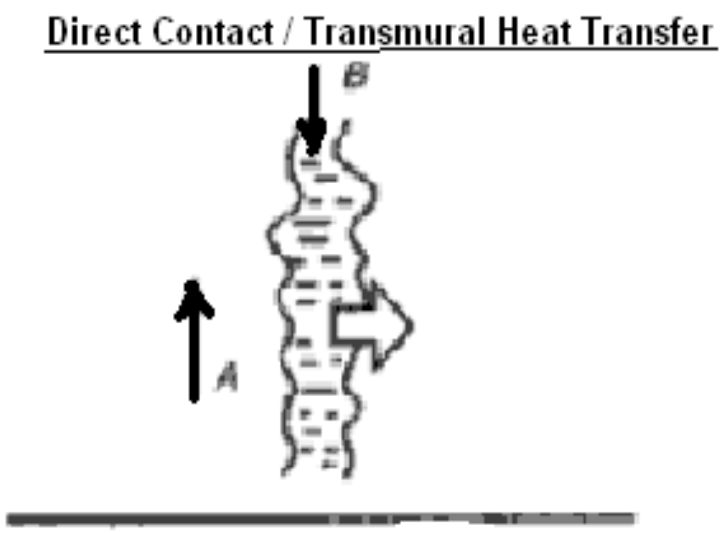
CLASSIFICATION OF HEAT EXCHANGERS

❖ Heat exchangers may be classified according to the following main criteria:

- **Transfer processes :** direct contact and indirect contact
- **Geometry of constructions :** tubes, plates and extended surfaces
- **Phase change mechanisms :** condensers, reboilers and evaporators
- **Flow arrangements :** parallel, counter and cross flow

TRANSFER PROCESSES

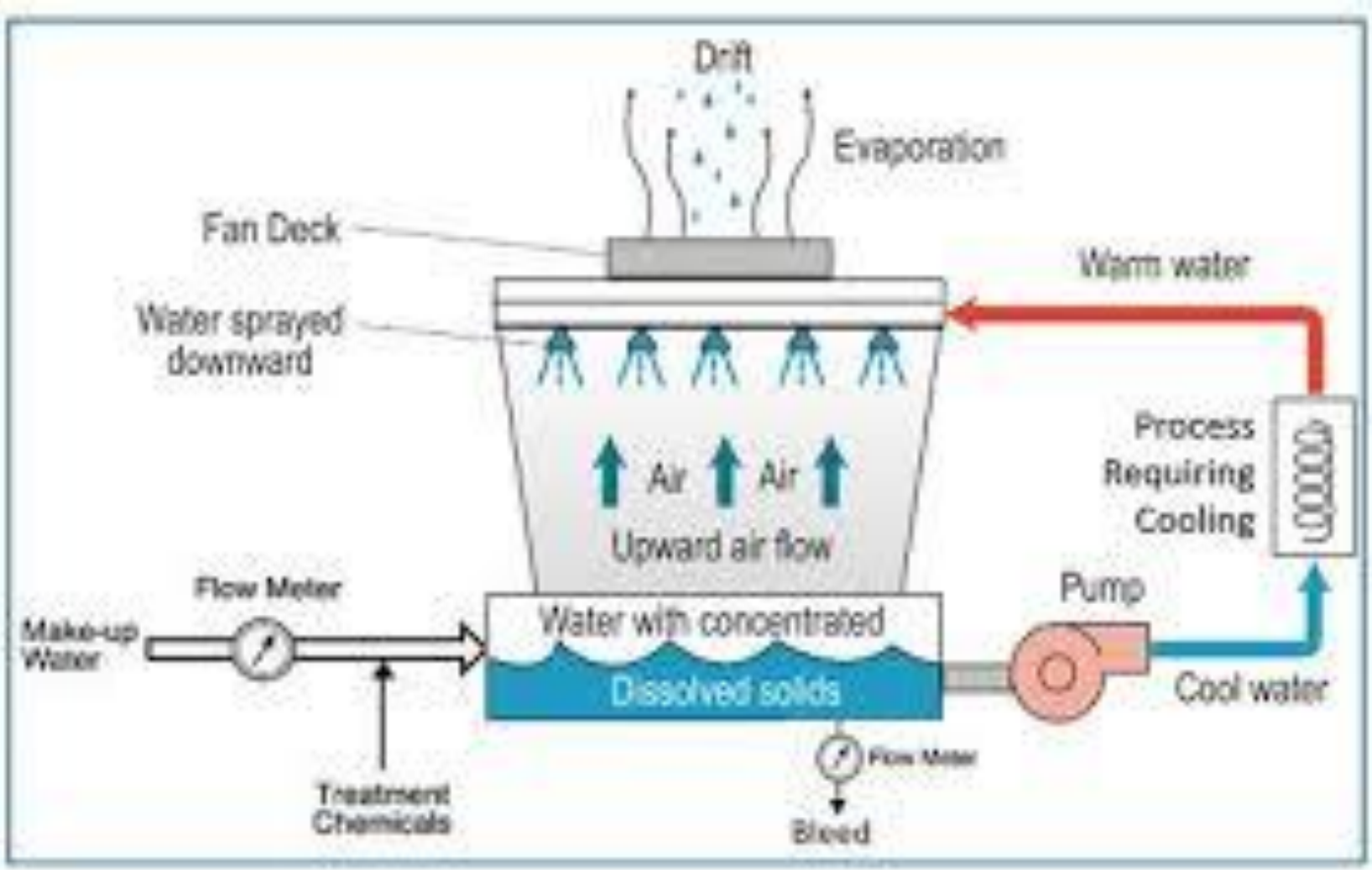
1. Direct contact type heat exchangers:

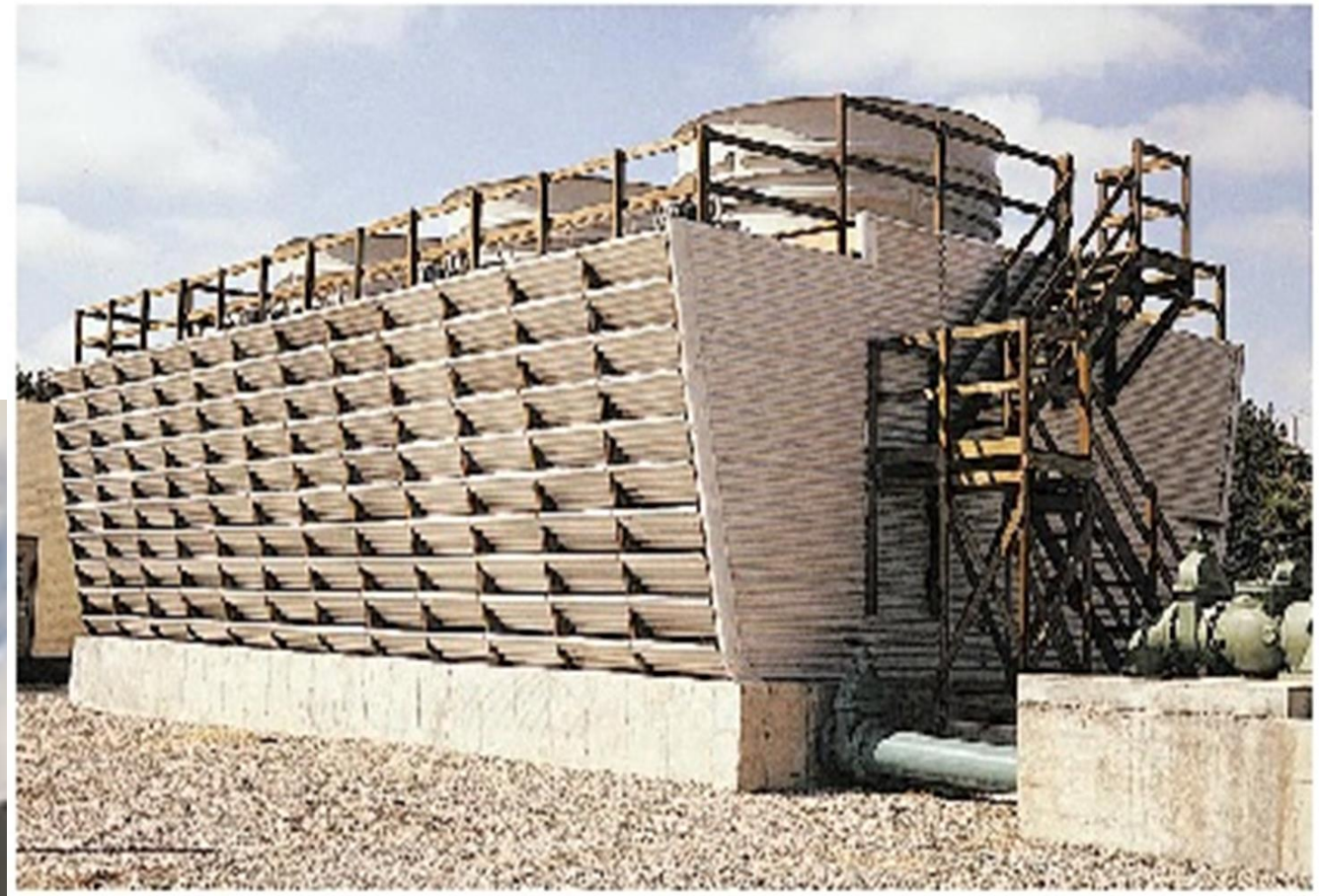


- Heat transfer between the cold and hot fluids through a direct contact between these fluids.
- ***Examples:*** Spray and tray condensers, cooling towers, air fin cooler

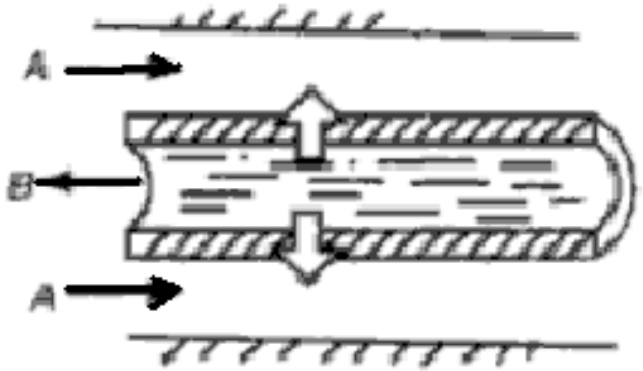
Direct Contact HE

- Cooling tower





2. Indirect contact type heat exchangers:



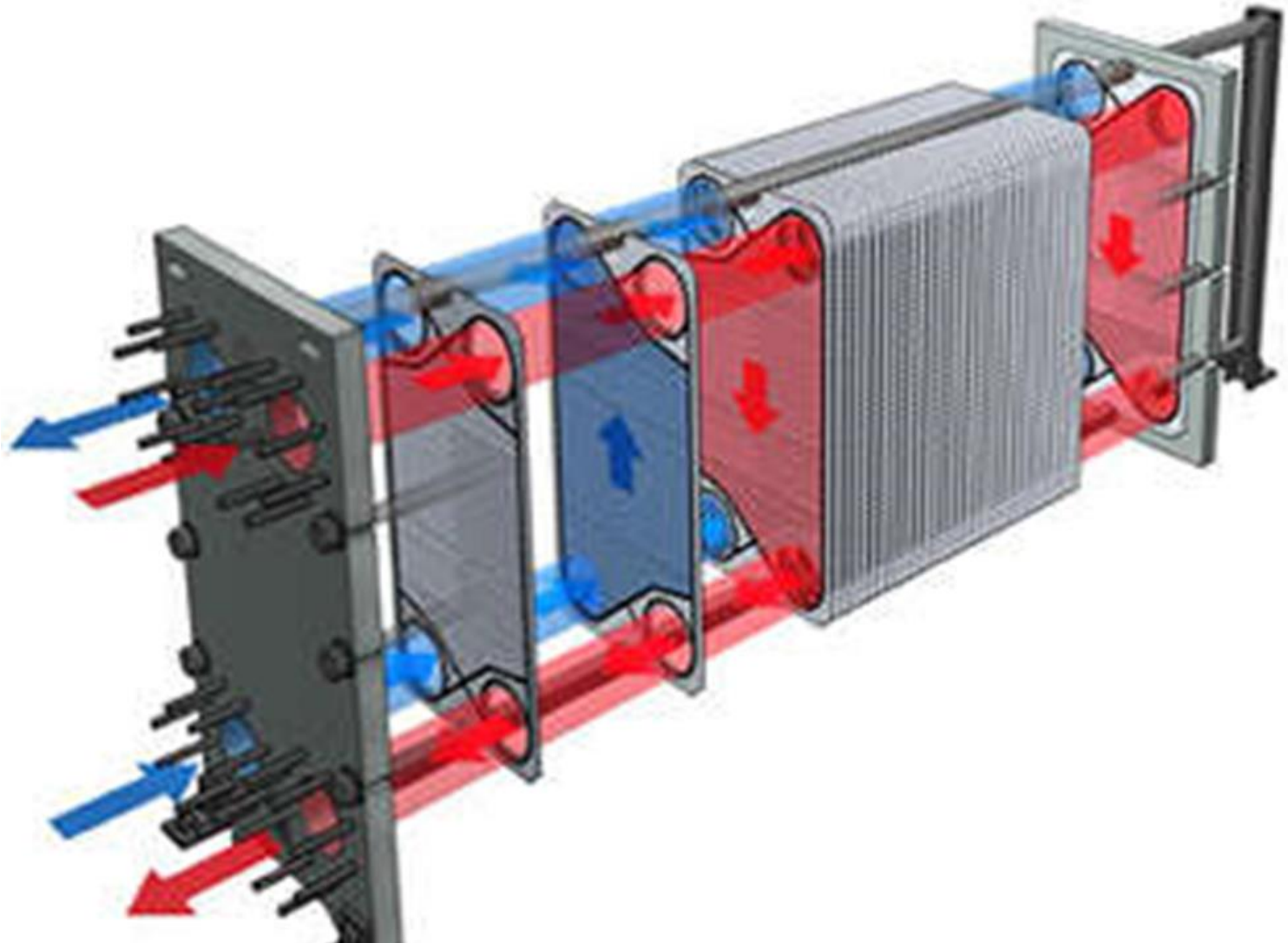
Transmural Heat Transfer
Heat transfer through walls:fluids not in contact

- Heat energy is exchanged between hot and cold fluids through a heat transfer surface.
- The fluids are not mixed
- Ex : DPHE, shell & tube HE, compact HE, PHE

Geometry of Constructions

- Plates → - Plate HE
- Extended Surfaces → - Compact HE
  - Fin
- Tubes → - Shell & Tubes
  - Double Pipe HE

1. PLATE HEAT EXCHANGERS



2. Compact HE

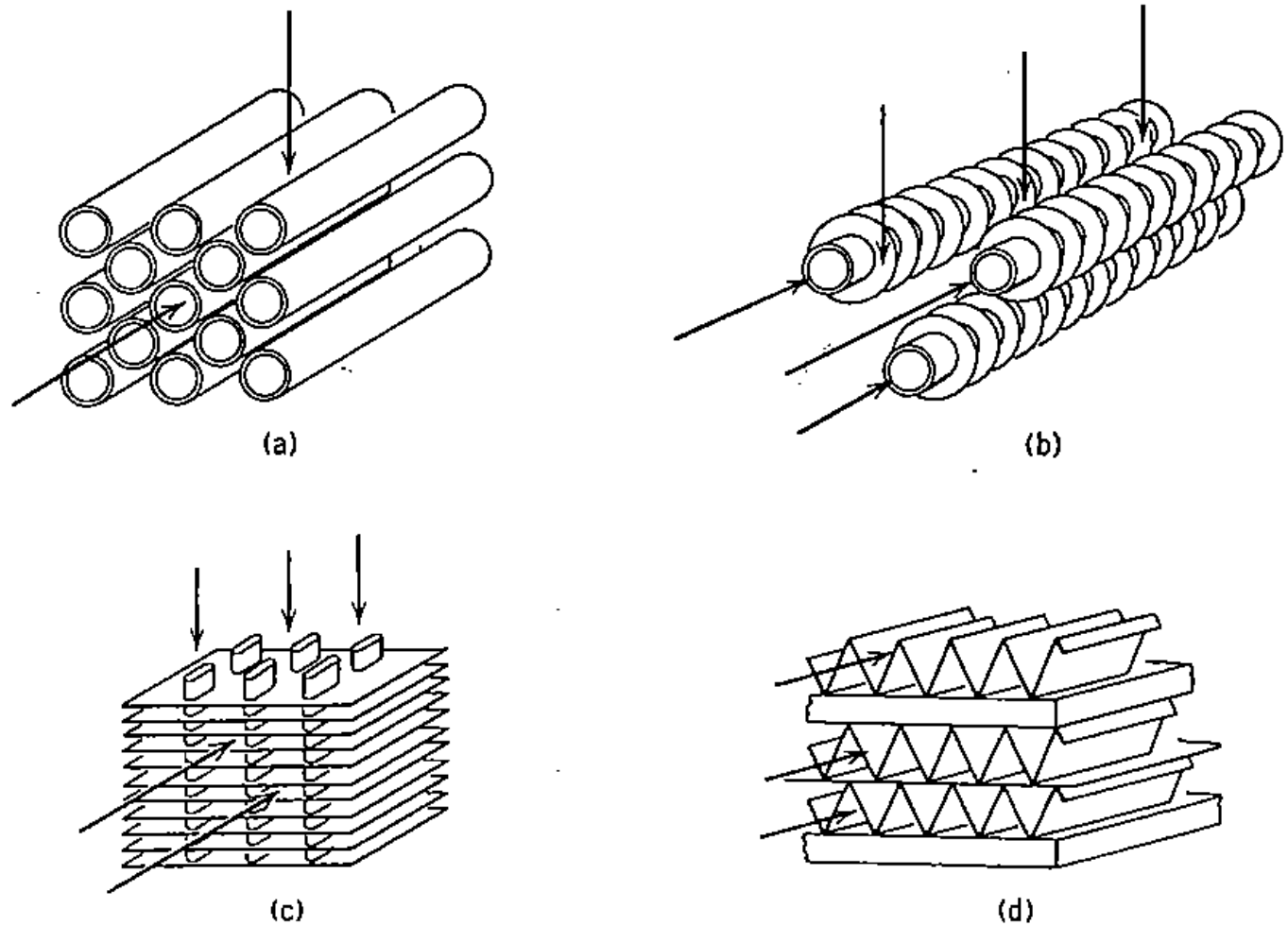
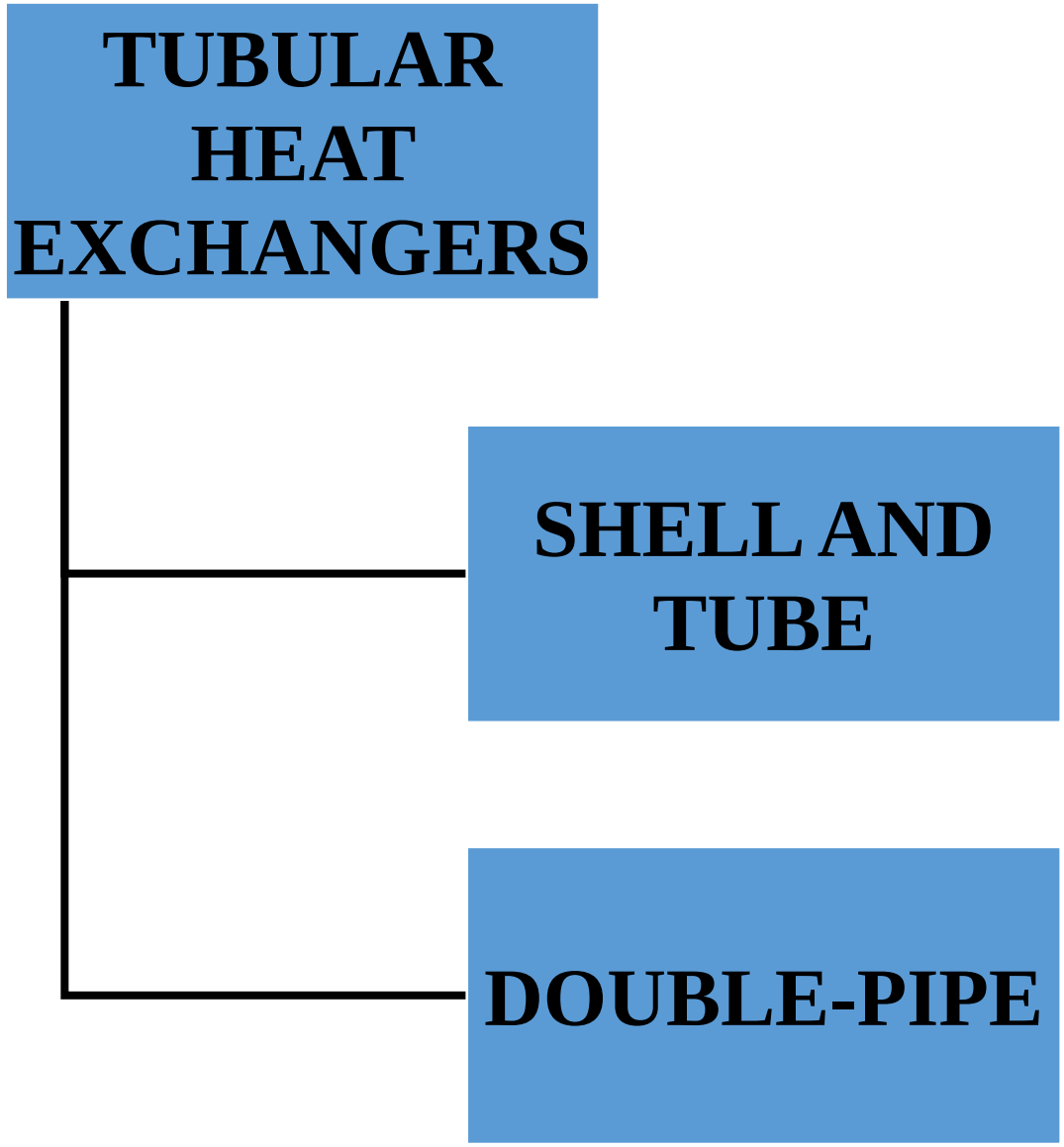


Figure 22.4 Compact heat-exchanger configurations.

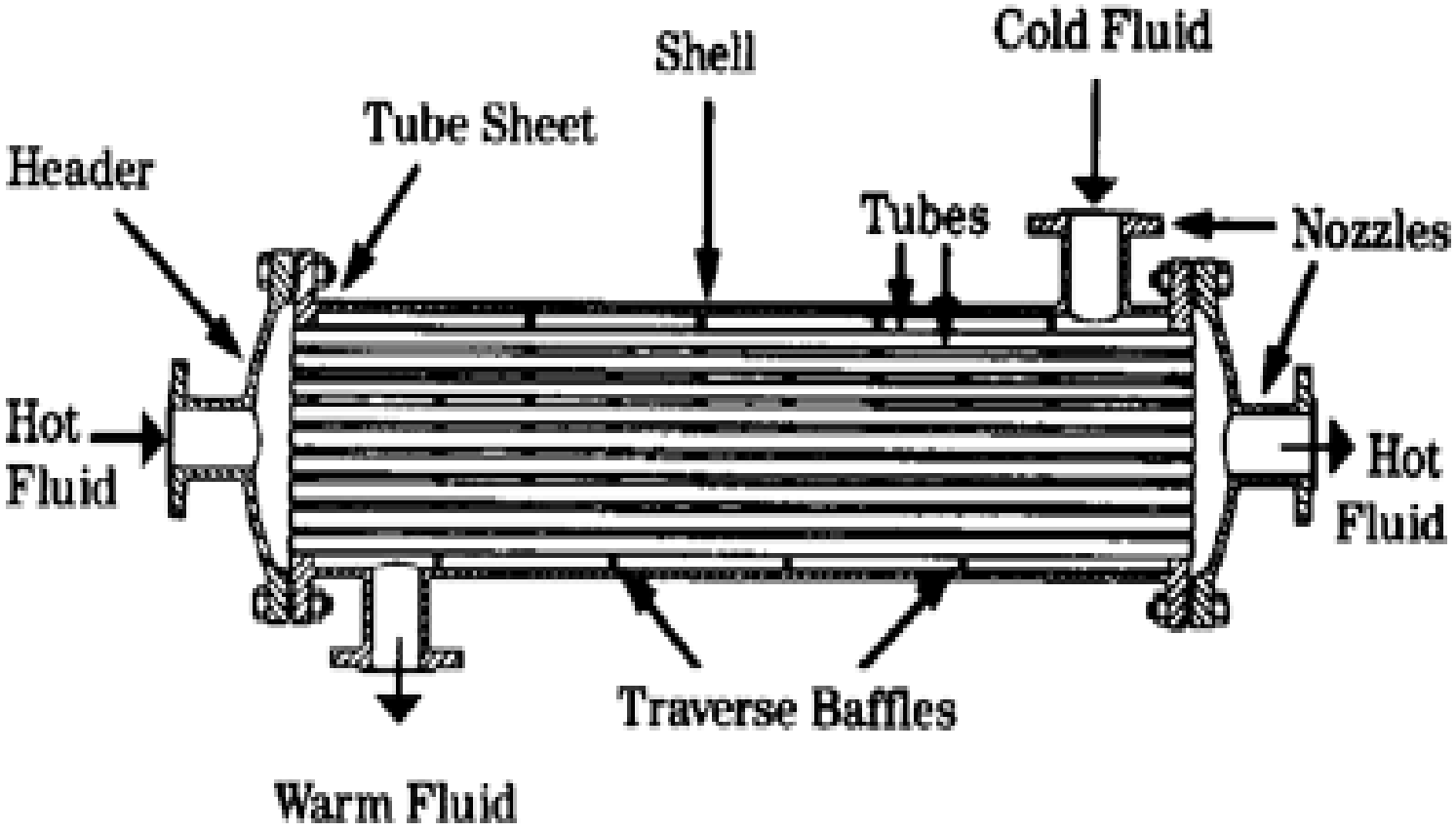
3. TUBULAR HE

- are so widely used because the technology is well established for making precision metal tubes capable of containing high pressures in a variety of materials.

➢ There is no limit to the range of pressures and temperatures that can be accommodated.


TUBULAR HEAT EXCHANGERS
SHELL AND TUBE
DOUBLE-PIPE

SHELL AND TUBE HEAT EXCHANGERS



SHELL AND TUBE HEAT EXCHANGERS

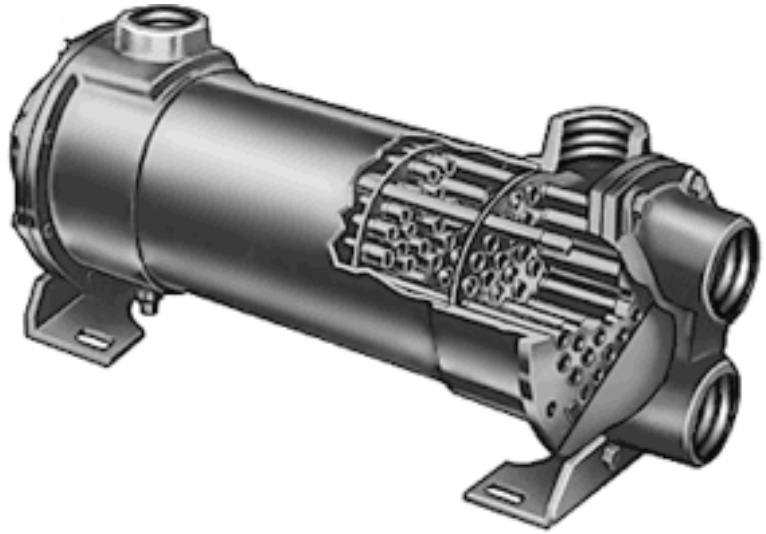
- are the most commonly used heat exchangers in oil refineries and other large chemical processes.
- are used when a process requires large amounts of fluid to be heated or cooled.
- provide transfer of heat efficiently.
- use baffles on the shell-side fluid to accomplished mixing or turbulence.

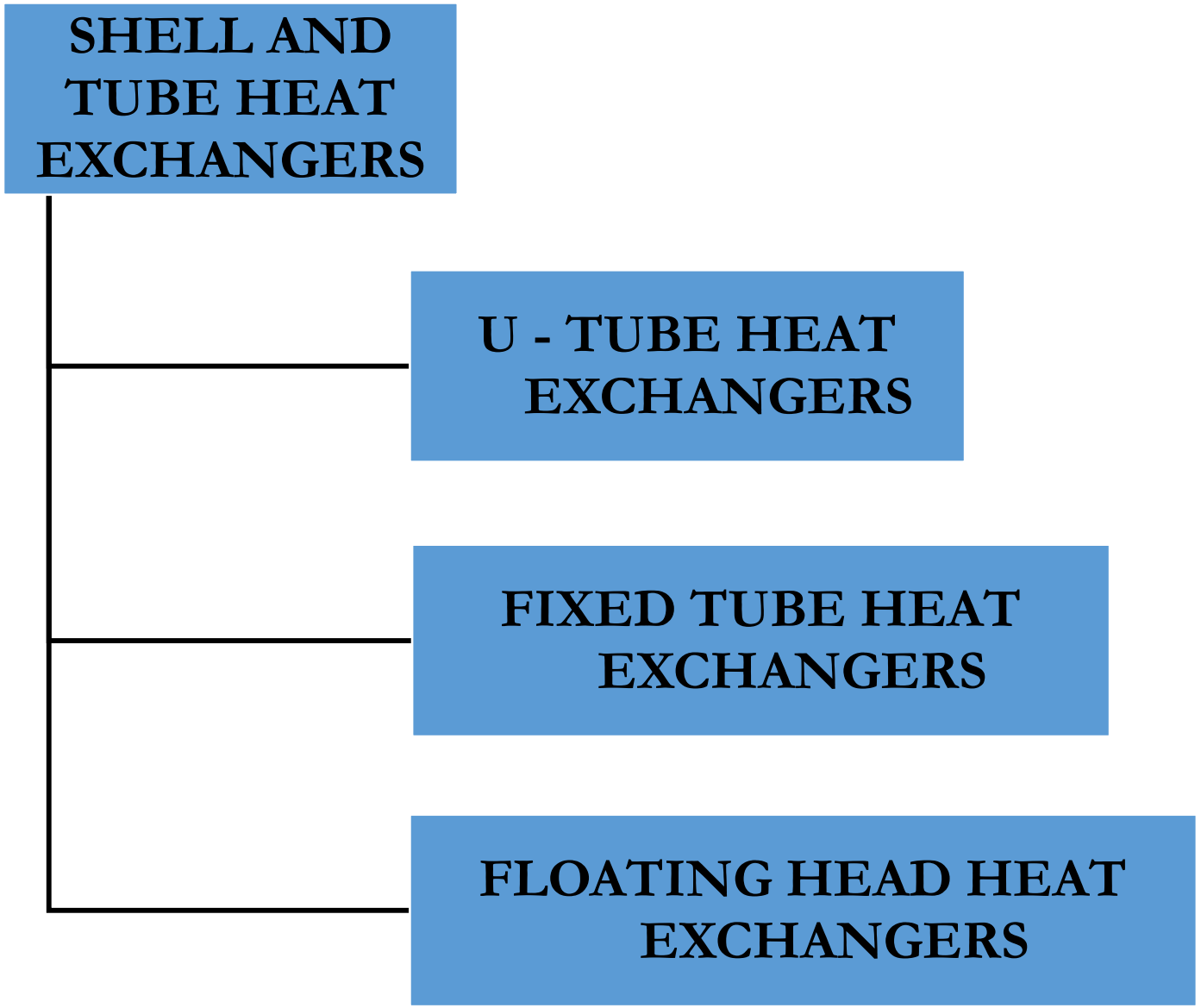
SHELL AND TUBE HEAT EXCHANGERS

- **tube** : strong, thermally conductive, corrosion resistant, high quality
- **outer shell** : durable, highly strong
- **inner tube** : having effective combination of durability, corrosion resistant and thermally conductive

APPLICATIONS:

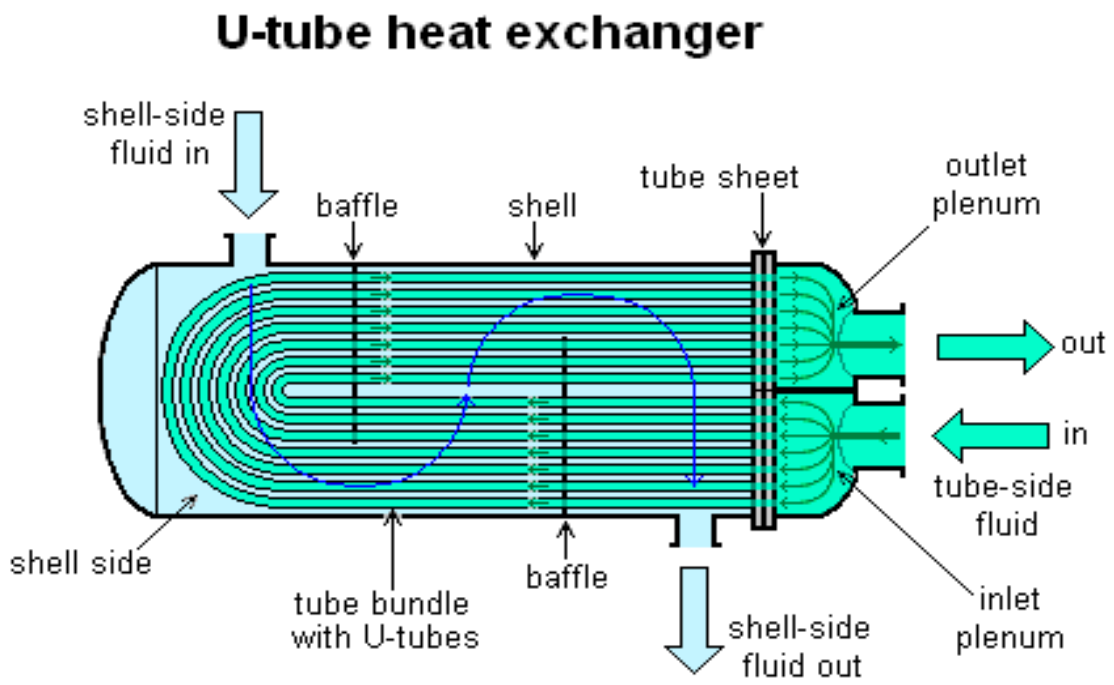
- Oil refining,
- Vapor recovery systems,
- Permanent engines,
- Industrial paint systems.




SHELL AND TUBE HEAT EXCHANGERS
U - TUBE HEAT EXCHANGERS
FIXED TUBE HEAT EXCHANGERS
FLOATING HEAD HEAT EXCHANGERS

U - TUBE HEAT EXCHANGERS

heat exchanger systems consisting of straight length tubes bent into a U-shape surrounded by a shell.



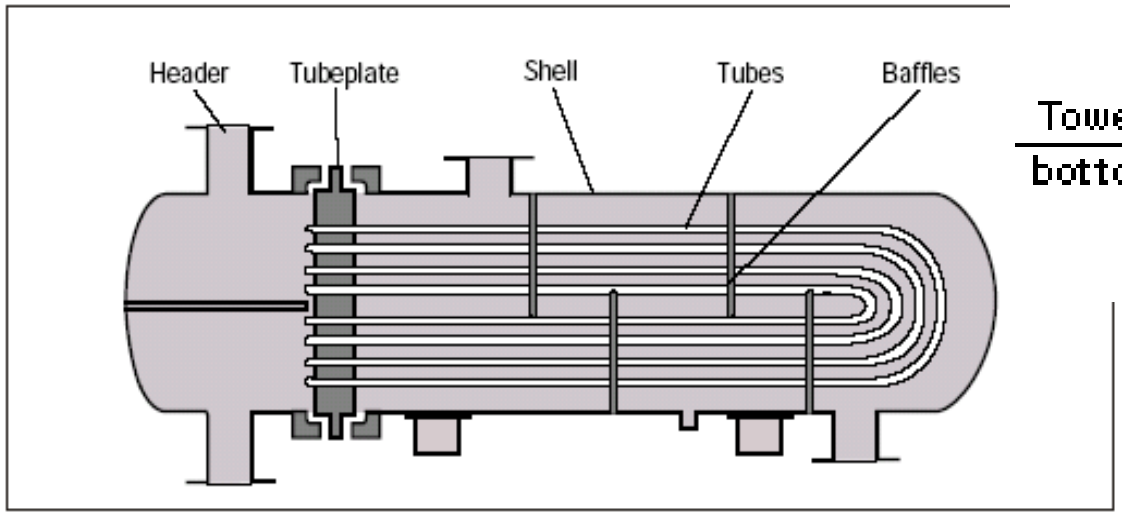
U - TUBE HEAT EXCHANGERS

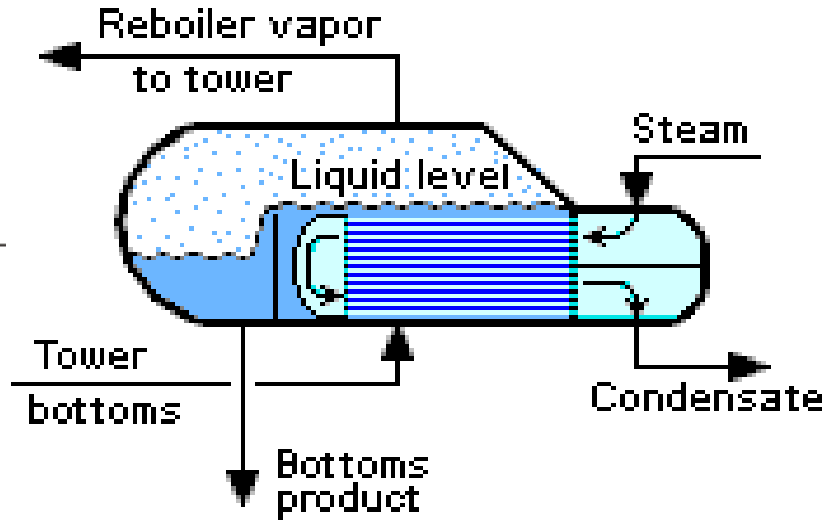
- Both initial and maintenance costs are reduced by reducing the number of joints.

- They have drawbacks like inability to replace individual tubes except in the outer row and inability to clean around the bend.

U - TUBE HEAT EXCHANGERS

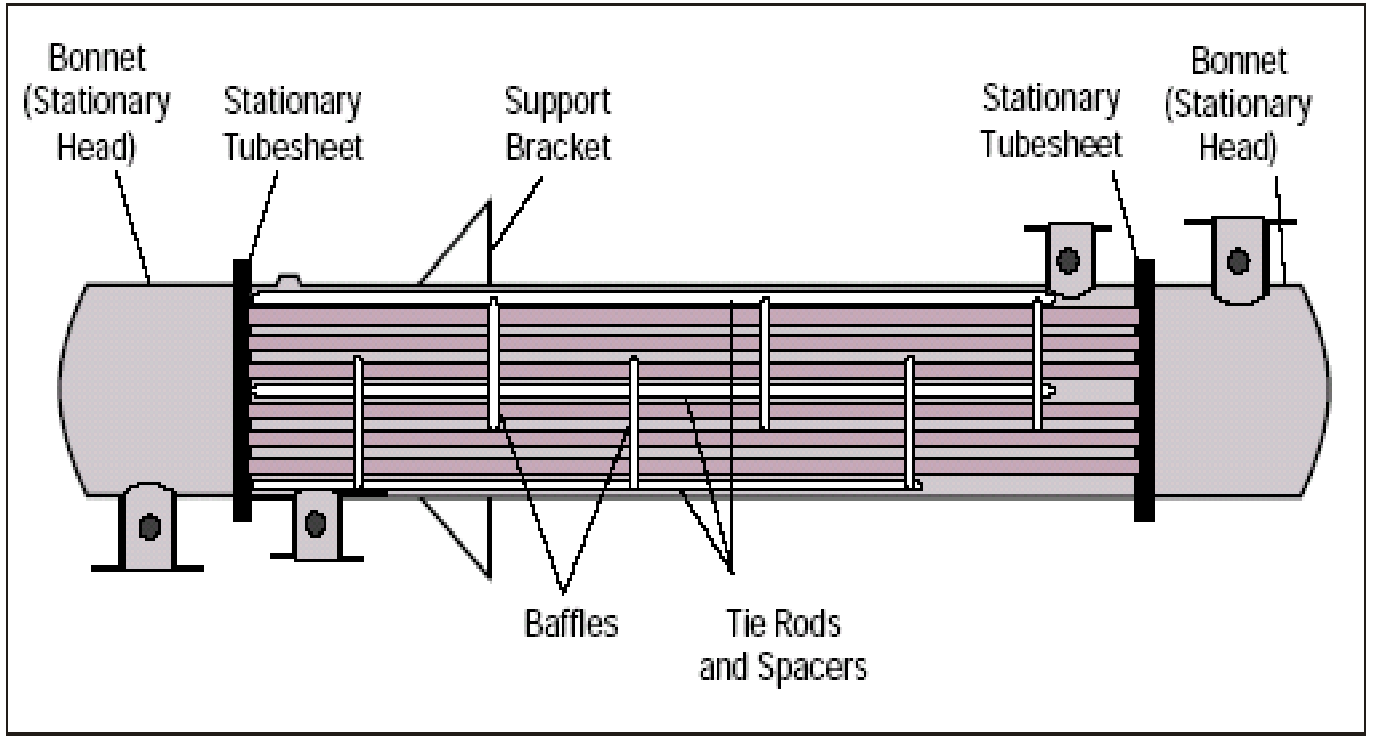
- Examples : reboilers, evaporators and Kettle type.
- They have enlarged shell sections for vapor-liquid separation.





FIXED TUBE HEAT EXCHANGERS

have straight tubes that are secured at both ends to tube sheets welded to the shell.



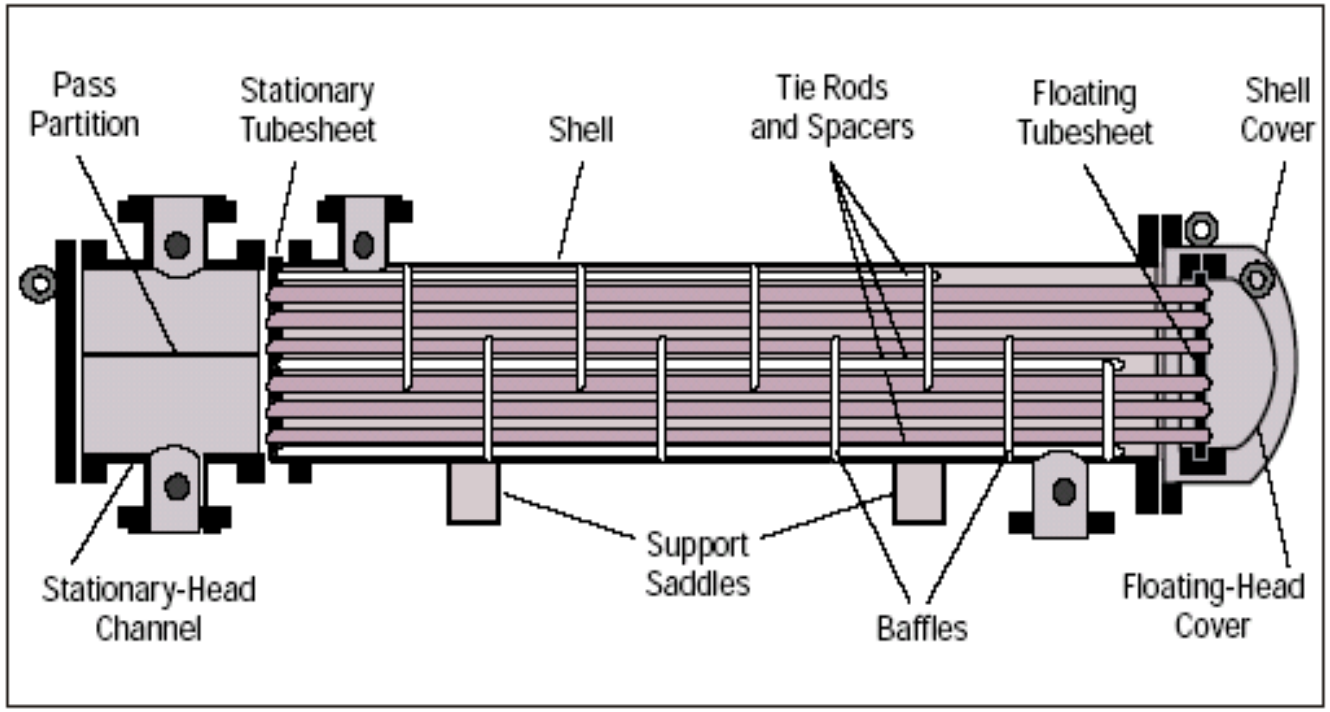
FIXED TUBE HEAT EXCHANGERS

- They are the most economical type design.
- They have very popular version as the heads can be removed to clean the inside of the tubes.

- Cleaning the outside surface of the tubes is impossible as these are inside the fixed part.
- Chemical cleaning can be used.

FLOATING HEAD HEAT EXCHANGER

one tube is free to float within the shell and the other is fixed relative to the shell.



FLOATING HEAD HEAT EXCHANGERS

- A floating head is excellent for applications

where the difference in temperature between the hot and cold fluid causes unacceptable stresses in the axial direction of the shell and tubes.

- The floating head can move, so it provides the possibility to expand in the axial direction.
- Design allows for bundle to be removed for inspection, cleaning or maintenance.

DOUBLE-PIPE HEAT EXCHANGERS

- They consist of one pipe concentrically located inside a second, larger one.
- Cold and hot liquid respectively flows in the gap of inner pipe and sleeve pipe.
- Structure is simple and heat transmission is large.

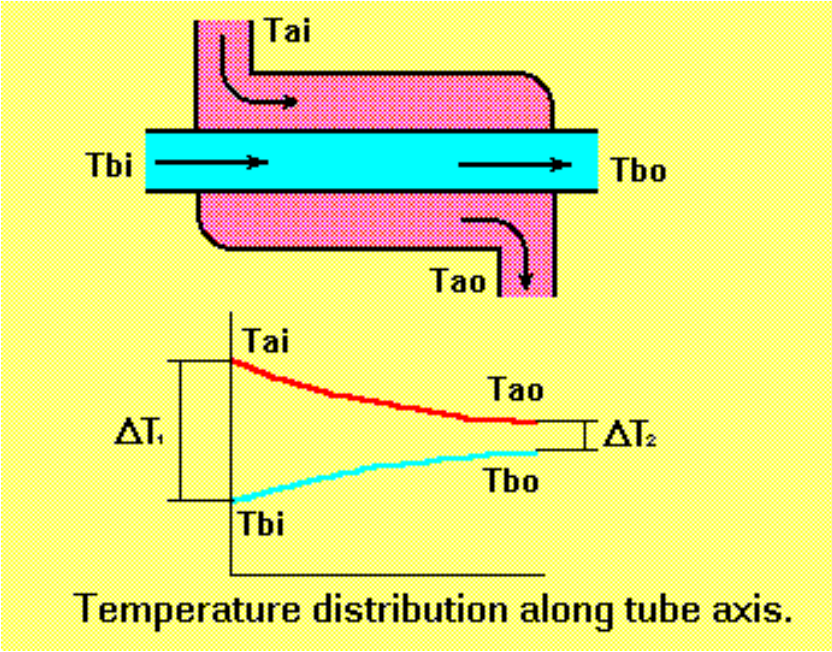
DOUBLE-PIPE HEAT EXCHANGERS

- utilize *true counter-current flow* which maximizes the temperature differences between the shell side and tube side fluids.

hairpin

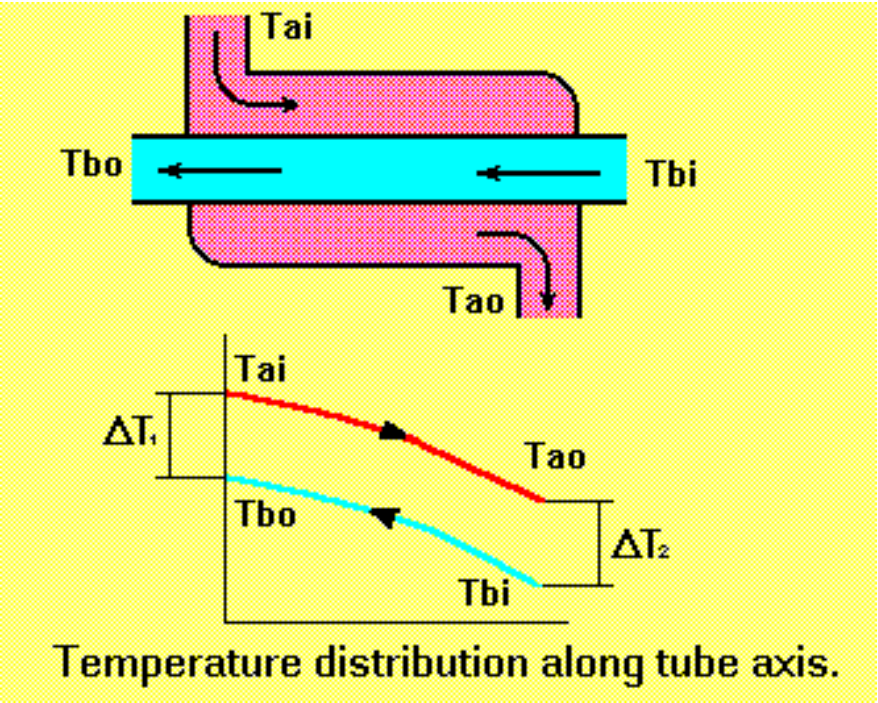
FLOW ARRANGEMENTS

1. Paralel Flow Heat Exchangers:



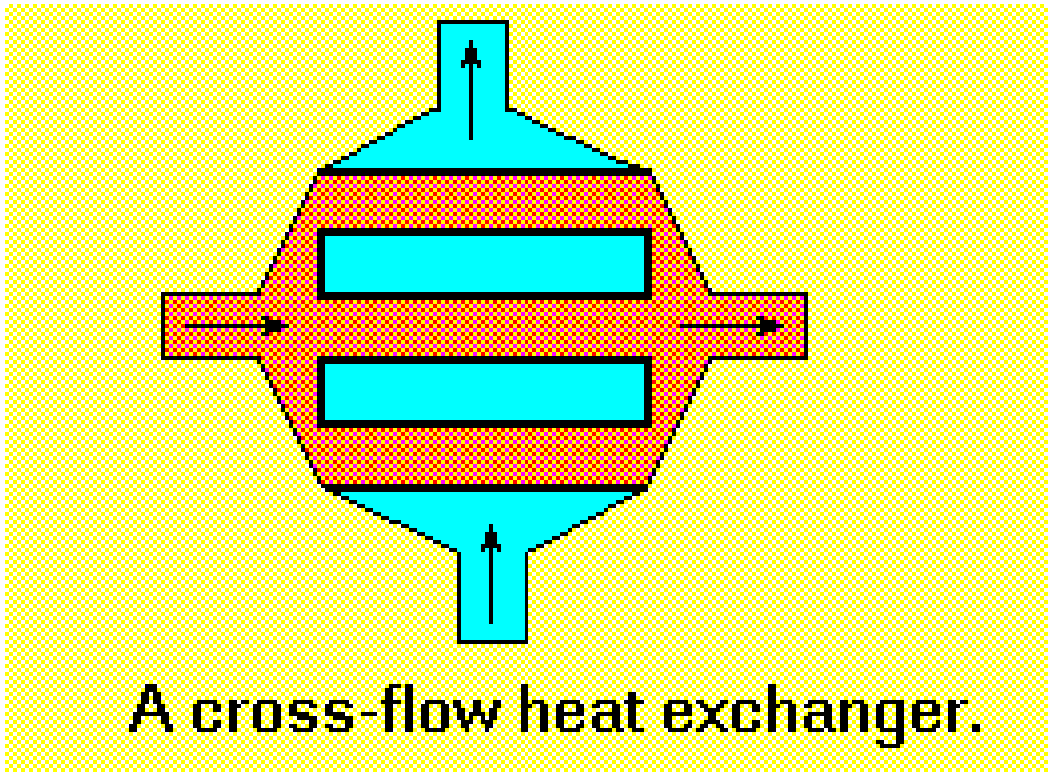
• Two fluid streams enter together at one end, flow through in the same direction, and leave through at the other end

2. Counter Flow Heat Exchangers:



- Two fluid streams flow in opposite directions.

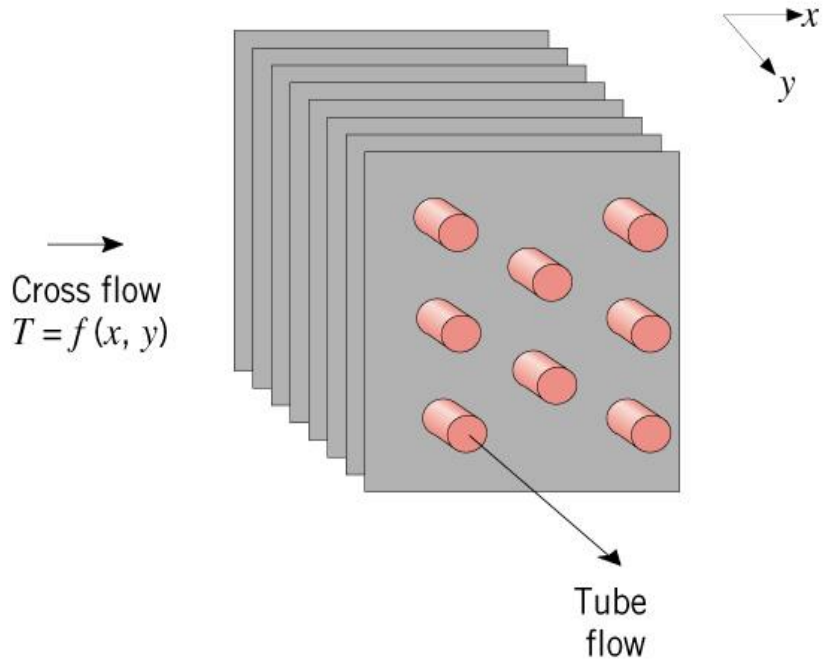
3. Cross Flow Heat Exchangers:



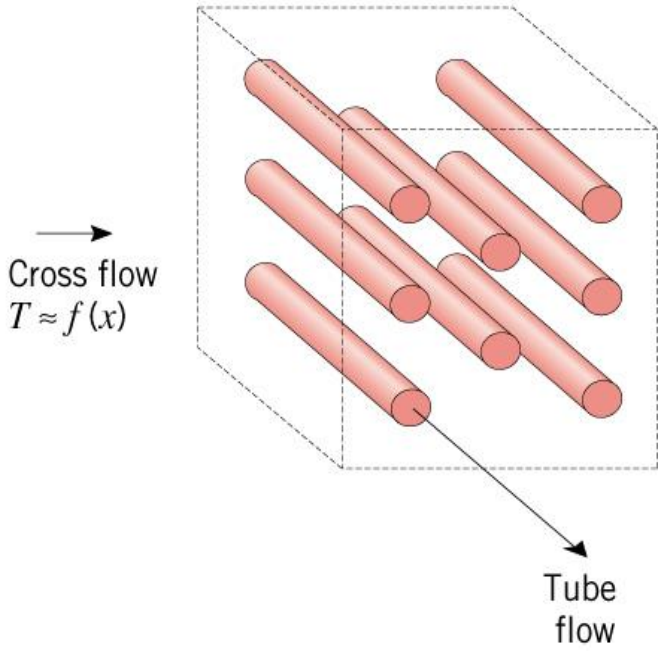
A cross-flow heat exchanger.

- The direction of fluids are perpendicular to each other.

- Cross-flow Heat Exchangers



Finned-Both Fluids
Unmixed



Unfinned-One Fluid Mixed
the Other Unmixed

- For cross-flow over the tubes, fluid motion, and hence mixing, in the transverse direction (y) is prevented for the finned tubes, but occurs for the unfinned condi

- Heat exchanger performance is influenced by mixing.

BASIC CRITERIAS FOR THE SELECTION OF HEAT EXCHANGERS

- ✓ Process specifications
- ✓ Service conditions of the plant environment, resistance to corrosion by the process
- ✓ Maintenance, permission to cleaning and replacement of components
- ✓ Cost- Effectiveness
- ✓ Site requirements, lifting, servicing,capabilities