Heat Exchangers
Classification, Selection and Design

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Introduction

Heat exchangers are devices that facilitate the exchange of heat between two fluids that are at different temperatures while keeping them from mixing with each other.

or

A heat exchanger is a heat transfer device that is used for transfer of internal thermal energy between two or more fluids available at different temperatures. In most heat exchangers, the fluids are separated by a heat transfer surface, and ideally they do not mix.

Industrial use of Heat exchangers are

Process,
Power,
Petroleum,
Heat recovery,
Other industries.
Transportation
Air-conditioning
Refrigeration
Cryogenic, Alternate fuels

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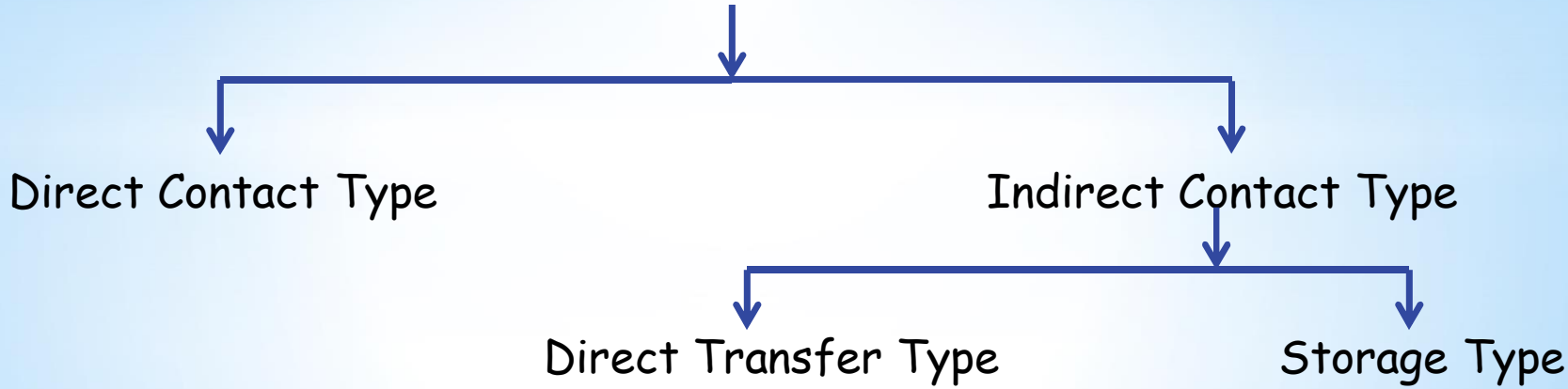
Common examples of heat exchangers familiar to us in day-to-day use are

Automobile radiators, Condensers, Evaporators, Air preheaters, and Oil coolers.

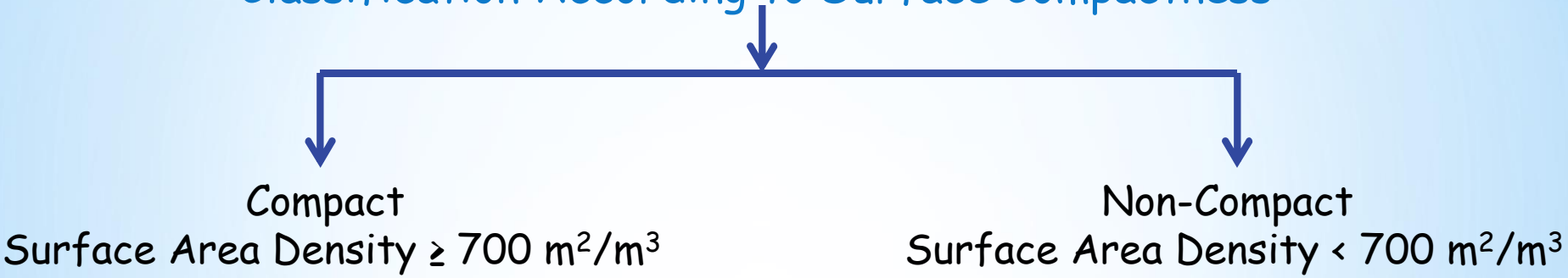
Classification of Heat Exchangers

(1) Construction (2) Transfer processes,
(3) Degrees of surface compactness,
(4) Flow arrangements, (5) Pass arrangements,
(6) Phase of the process fluids, (7) Heat transfer mechanisms.

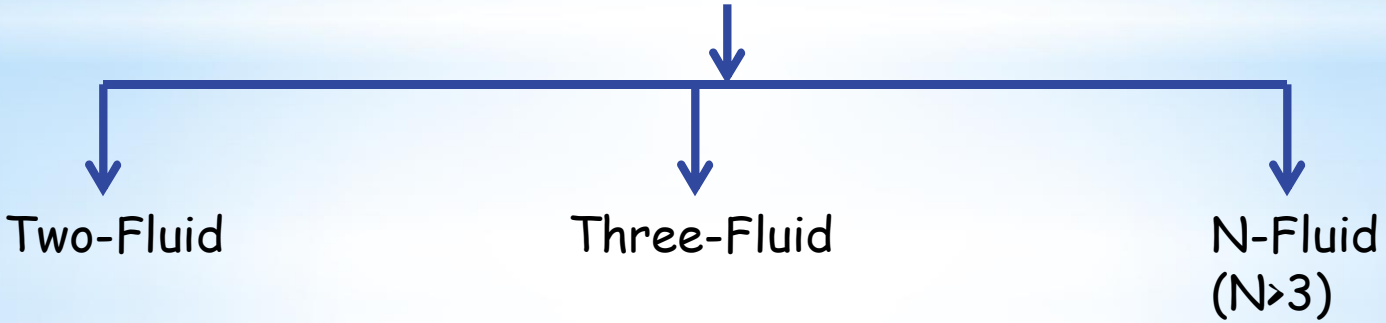
Classification According to Transfer Process



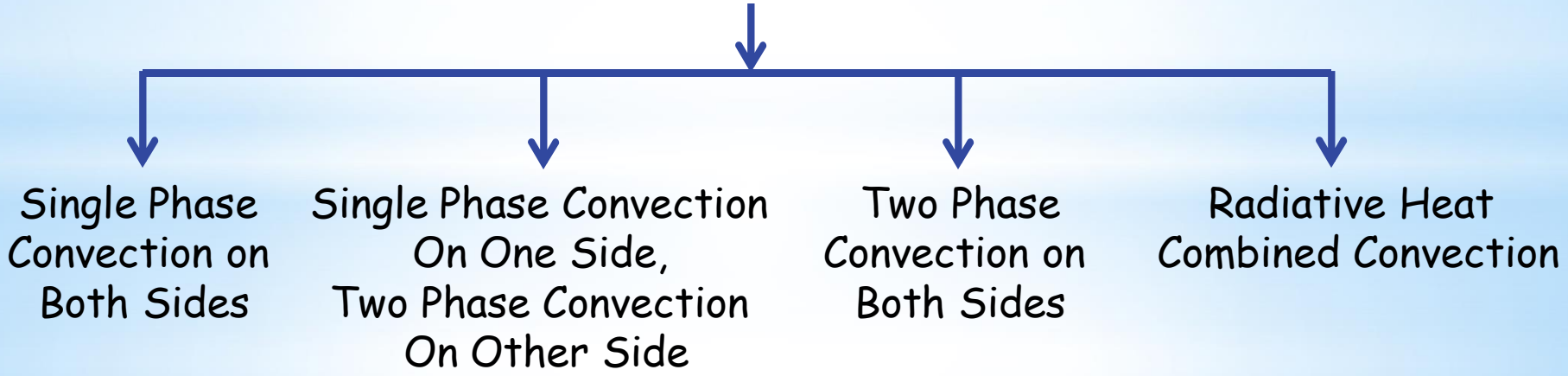
Classification According to Surface Compactness

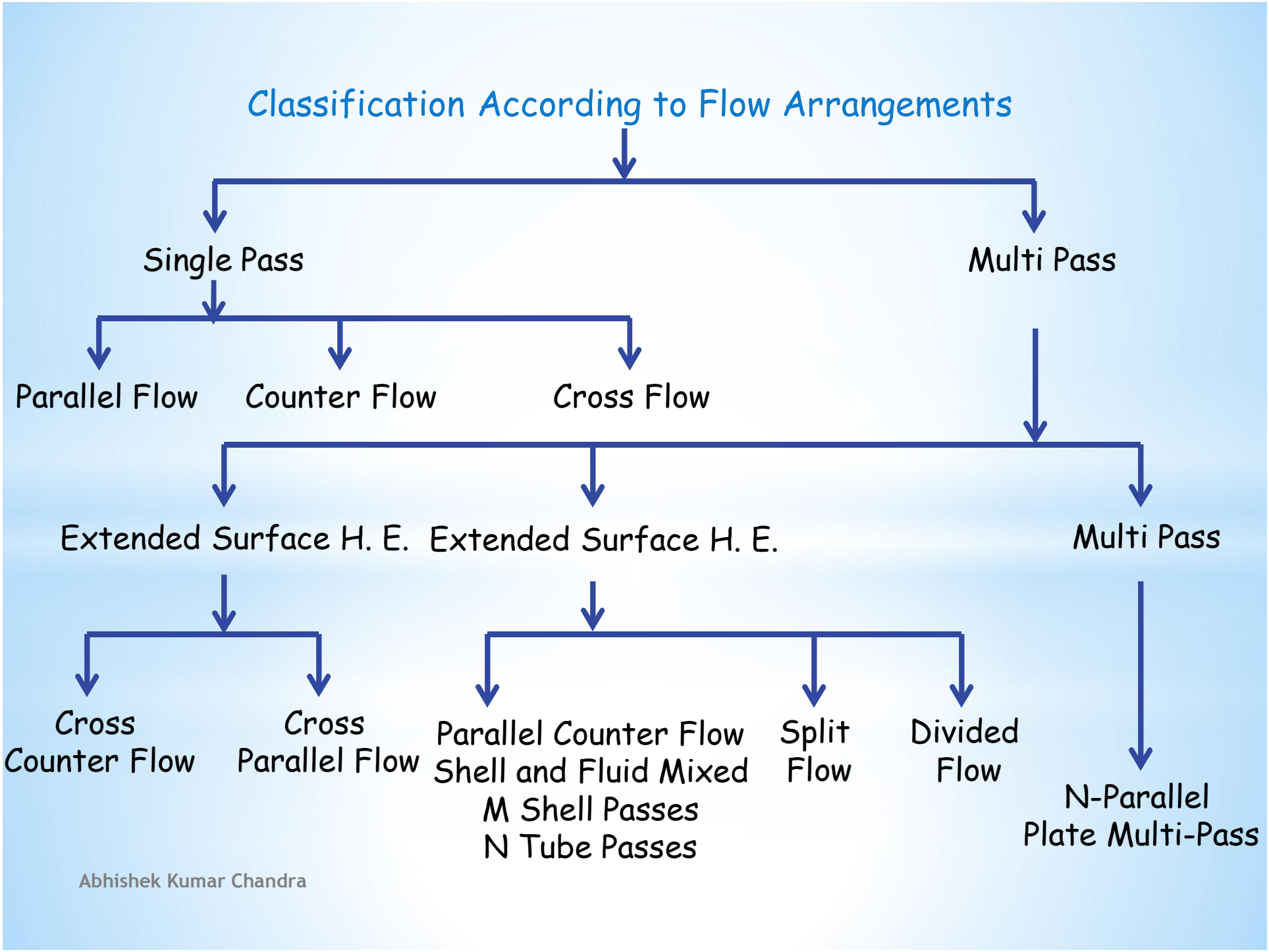


Classification According to Number of Fluids



Classification According to Heat Transfer Mechanism Flow Arrangements




Classification According to Flow Arrangements
Single Pass
Multi Pass
Parallel Flow
Counter Flow
Cross Flow
Extended Surface H. E.
Extended Surface H. E.
Multi Pass
Cross Counter Flow
Cross Parallel Flow
Parallel Counter Flow
Shell and Fluid Mixed
M Shell Passes
N Tube Passes
Split Flow
Divided Flow
N-Parallel Plate Multi-Pass
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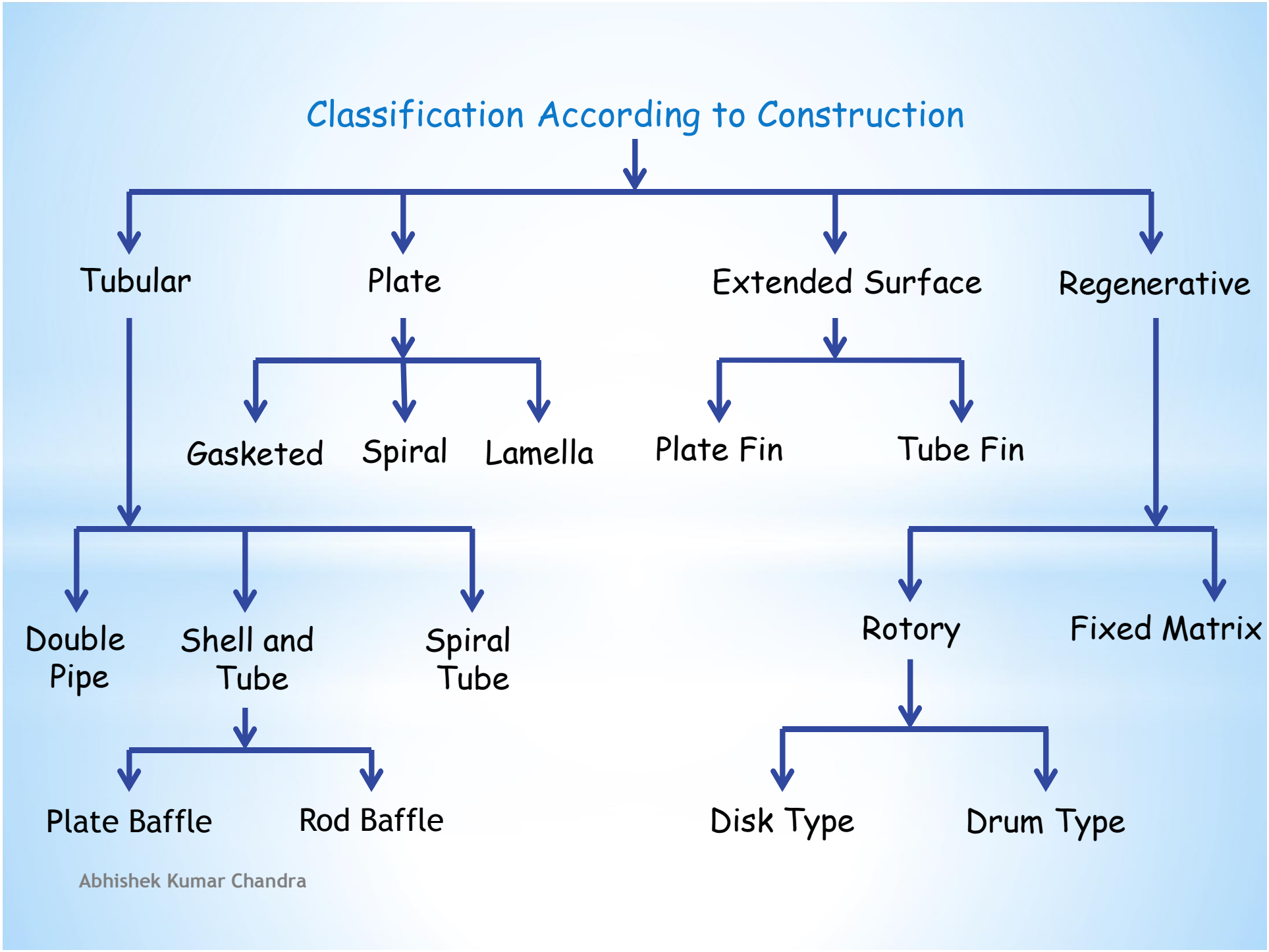

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Double Pipe Heat Exchanger

A double pipe heat exchanger has two concentric pipes, usually in the form of a U-bend design.

U-bend design is known as hairpin heat exchangers. The flow arrangement is pure countercurrent.

The surface area ranges from 300 to 6000 ft^2 (finned tubes).

Pressure capabilities are full vacuum to over 14,000 psi (limited by size, material, and design condition) and temperature from –100°C to 600°C (–150°F to 1100°F).

Applicable services:

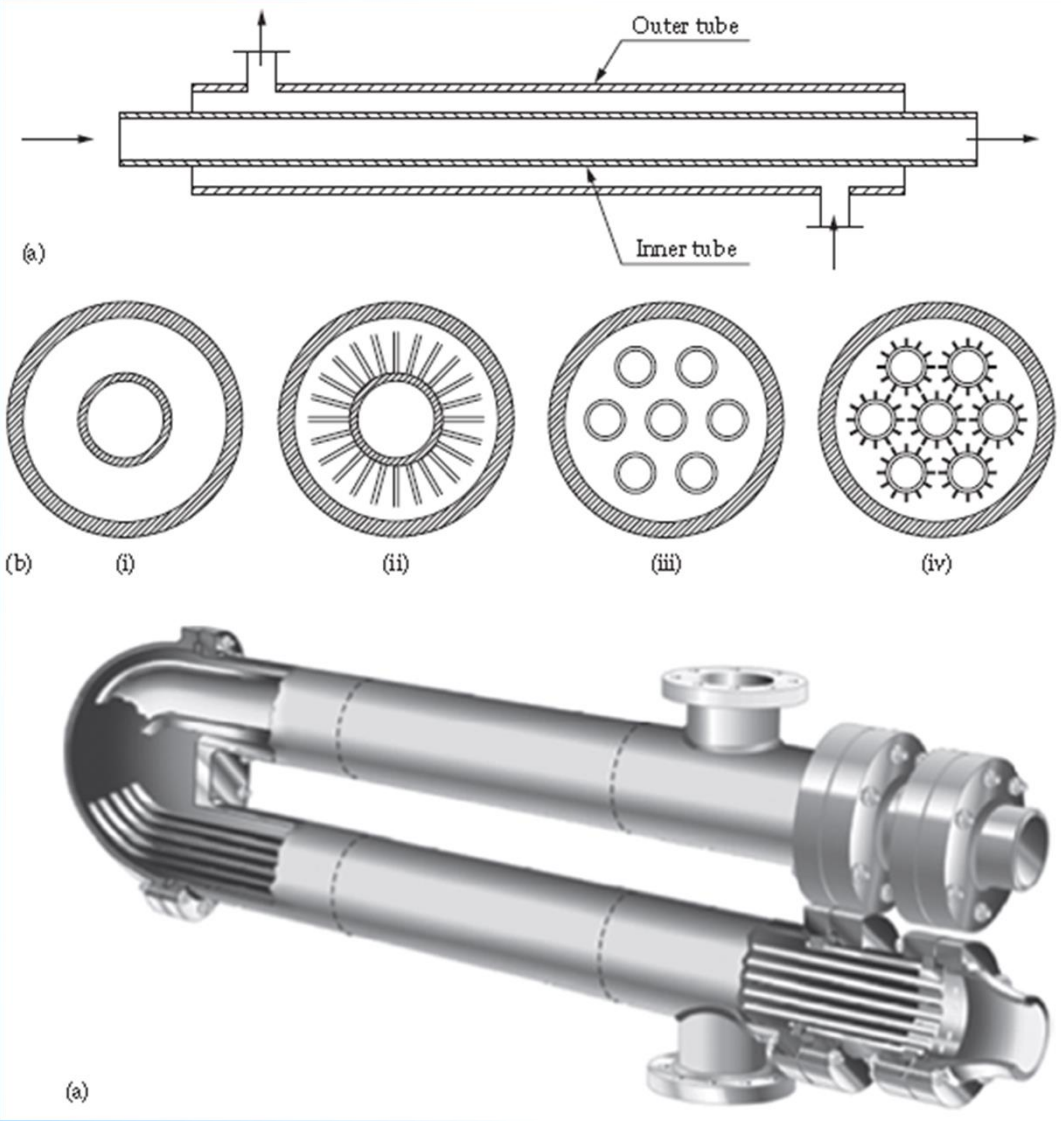
Temperature cross in a process,

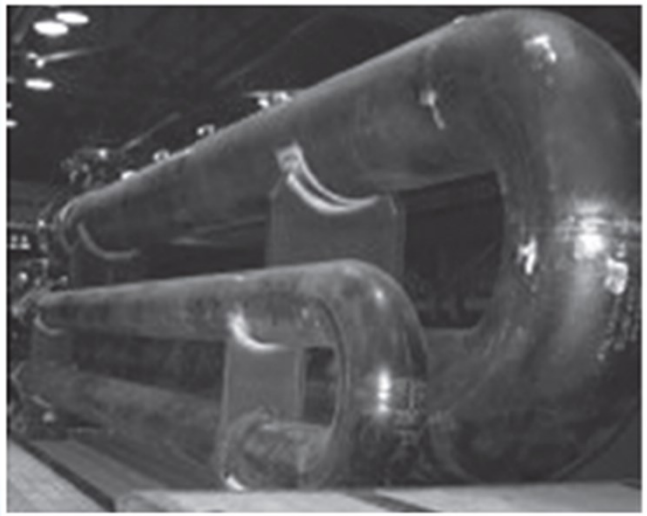
High-pressure stream on tube side,

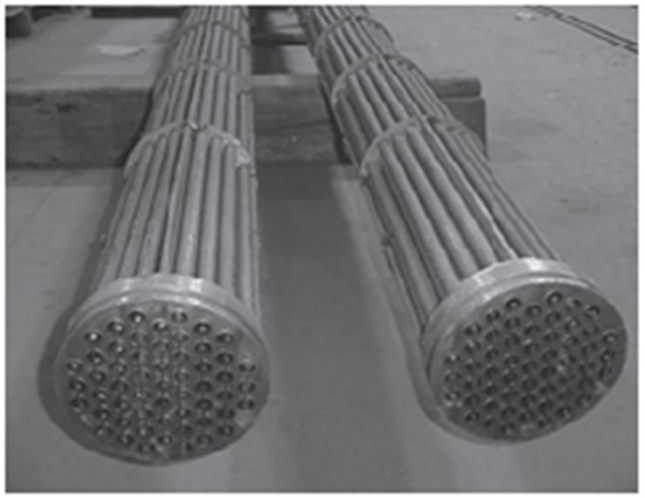
A low allowable pressure drop is required on one side,

When the exchanger is subject to thermal shocks,

When flow-induced vibration may be a problem.







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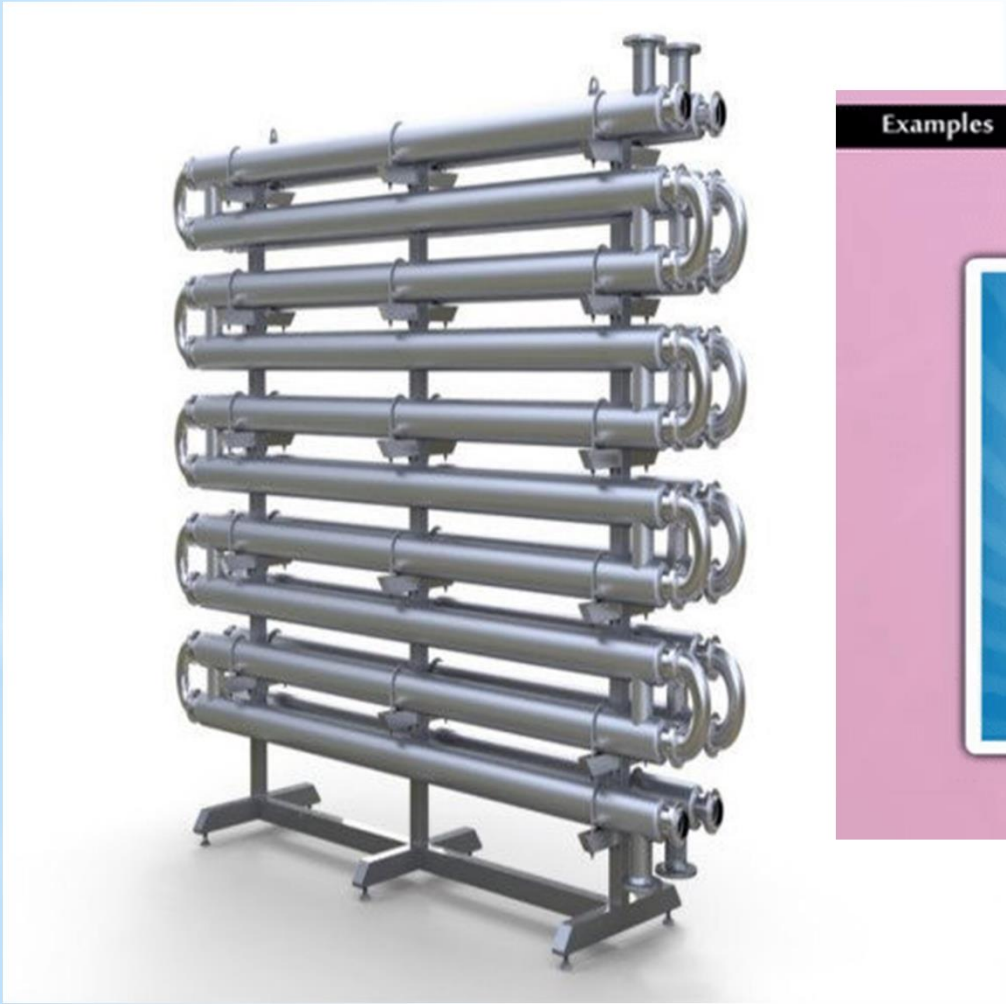


Examples

Double pipe heat exchanger

Shell and Tube Heat Exchanger

The most commonly used heat exchanger. It is the "workhorse" of industrial process heat transfer.

They are used as oil cooler, surface condenser, feed water heater, etc.

The major components of a shell and tube exchanger are tubes, baffles, shell, front head, rear head, and nozzles.

Shell diameter: 60 up to 2000 mm.

Operating temperature: –20°C up to 500°C.

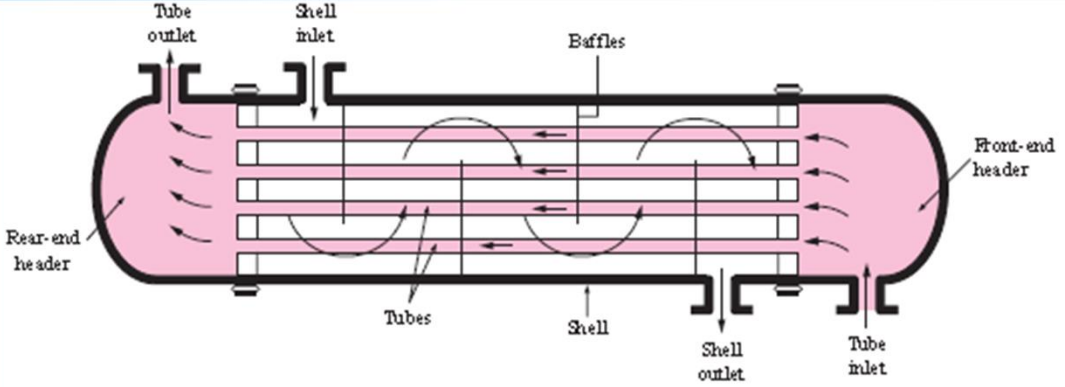
Operating pressure max. 600 bar.

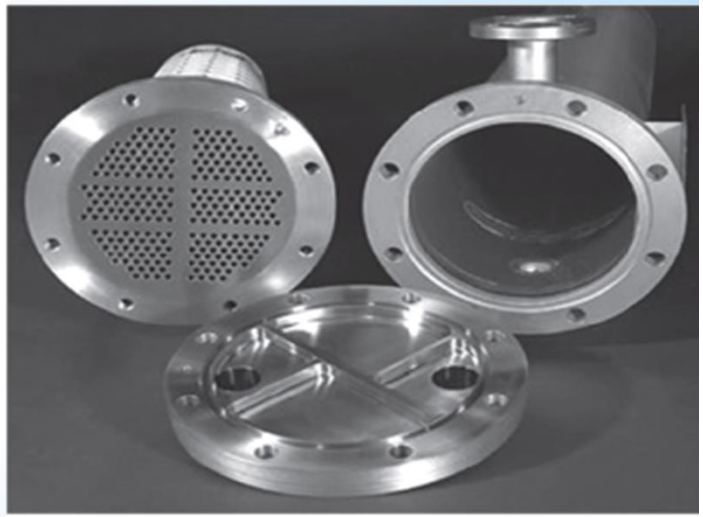
Advantages: Extremely flexible and robust design, easy to maintain and repair.

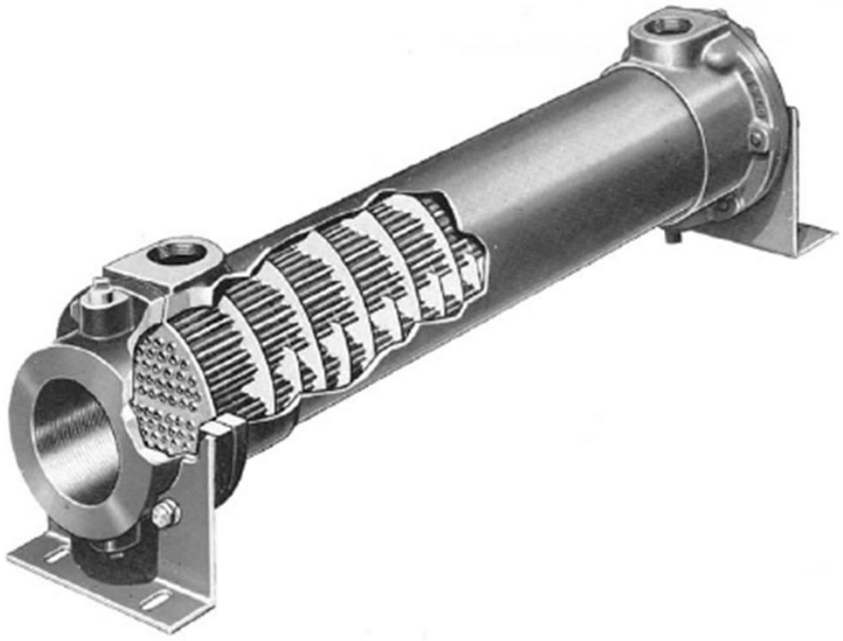
Disadvantages

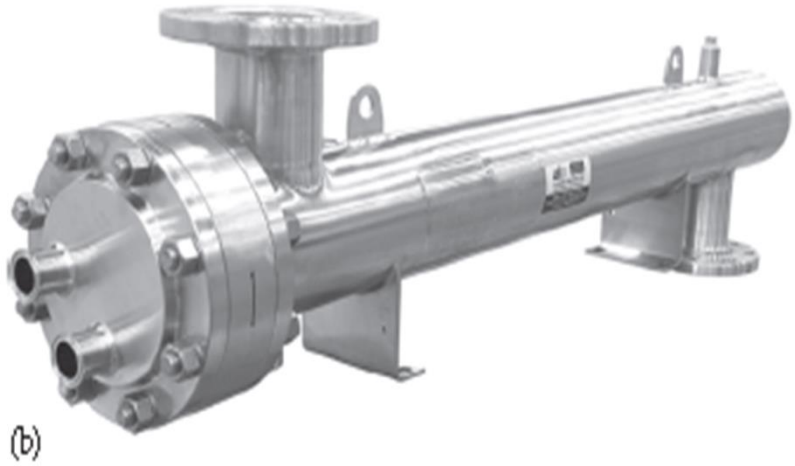
1. Require large site (footprint) area for installation and often need extra space to remove the bundle.

2. Construction is heavy.
3. PHE may be cheaper for pressure below 16 bar (230 psi) and temperature below 200°C (392°F).



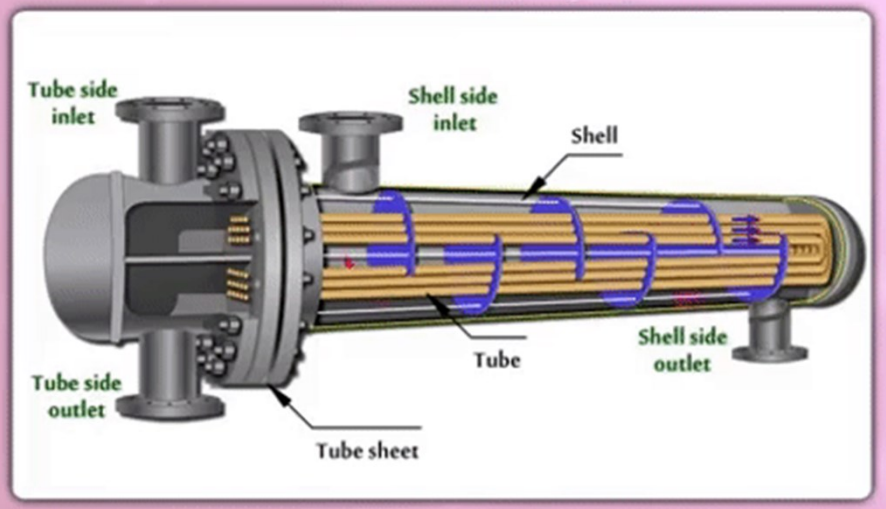


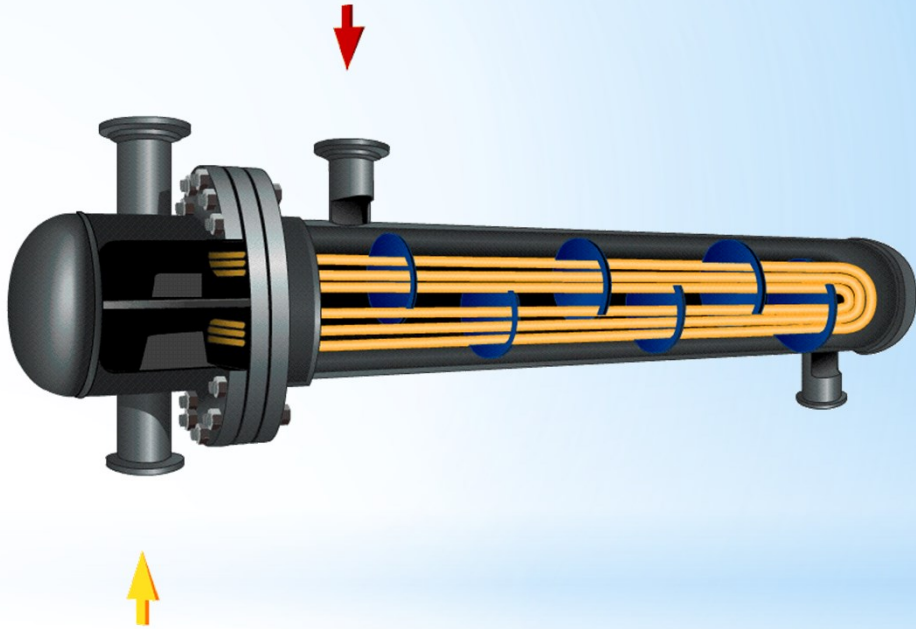


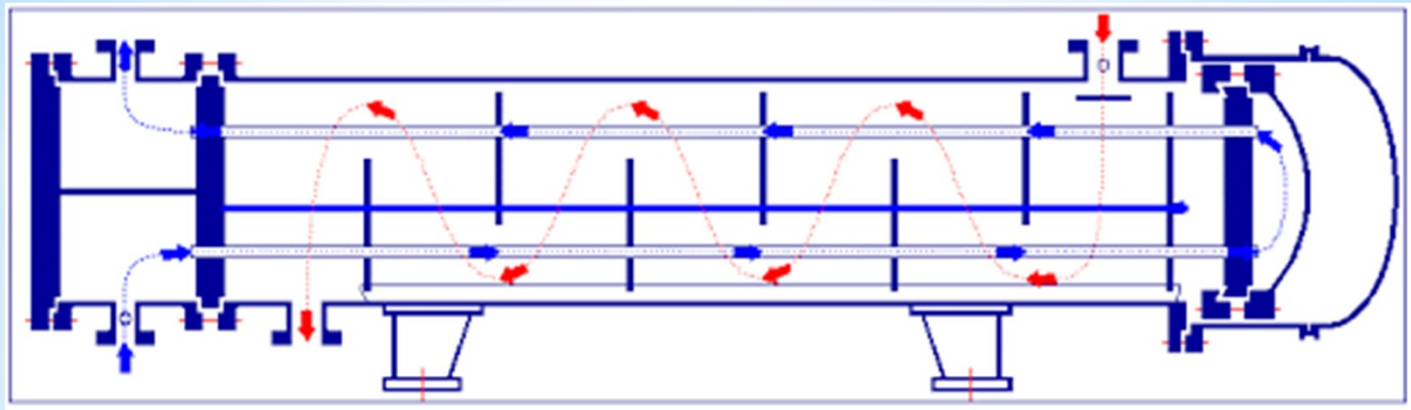


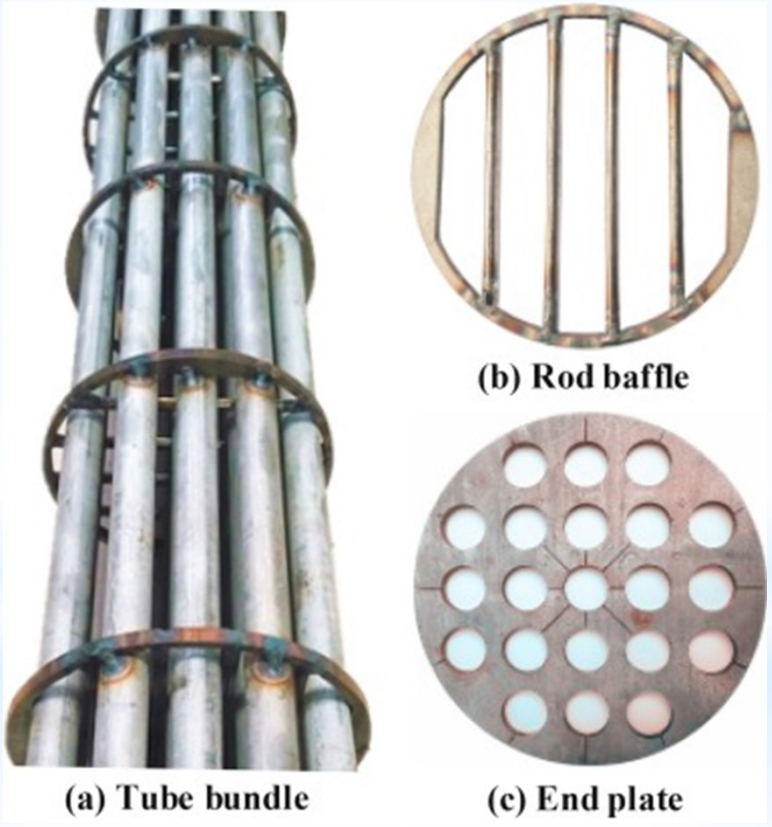
Examples

Shell and tube heat exchanger









(a) Tube bundle

(b) Rod baffle

(c) End plate

Spiral/Coil Tube Heat Exchanger

Construction of these heat exchangers involves winding a large number of small-bore ductile tubes in helix fashion around a central core tube,

Each exchanger containing many layers of tubes along both the principal and radial axes.

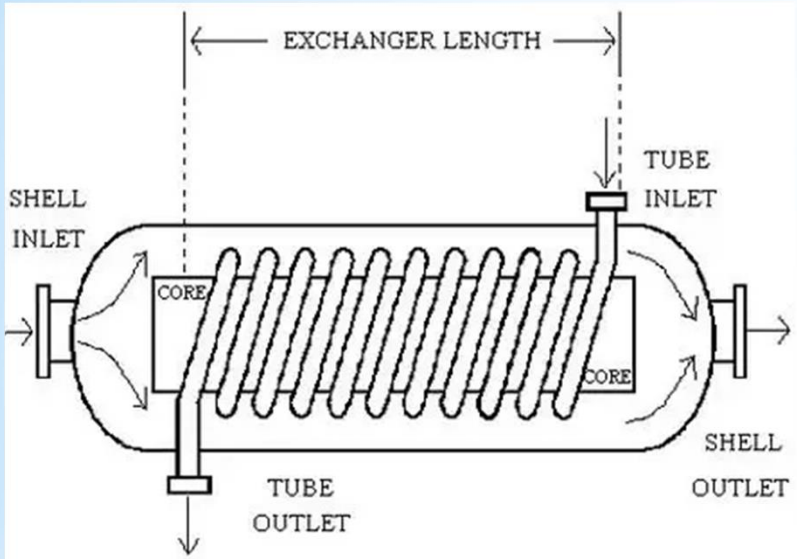
Different fluids may be passed in counter flow to the single shell side fluid.

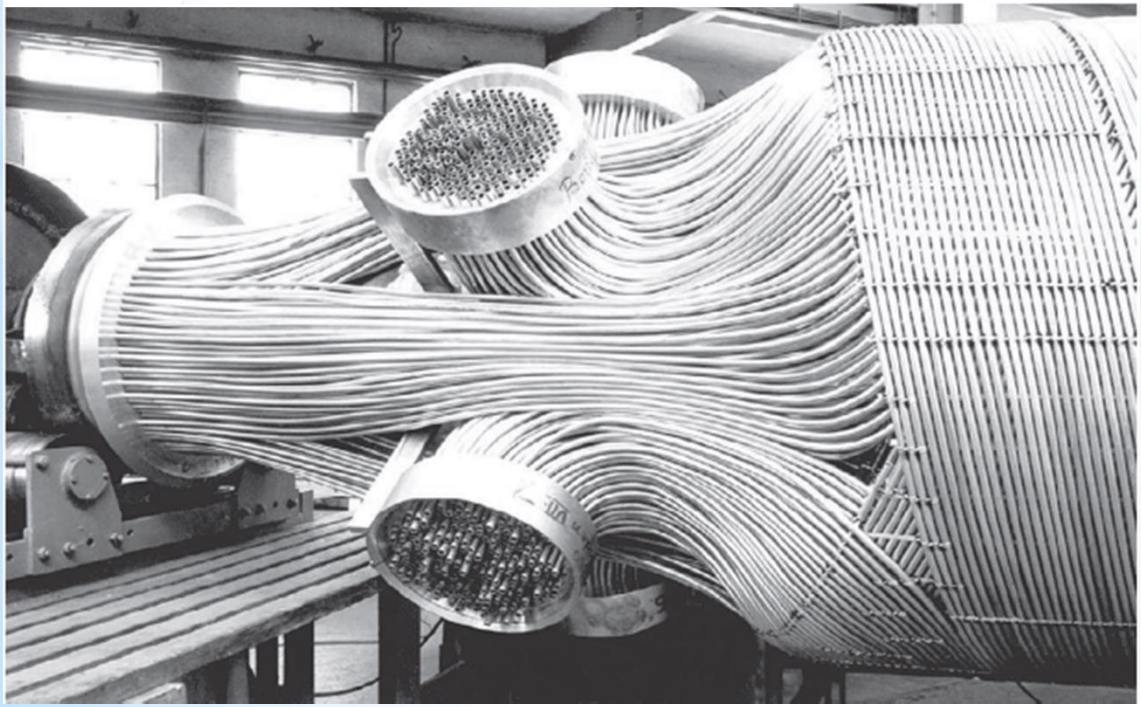
Advantages:

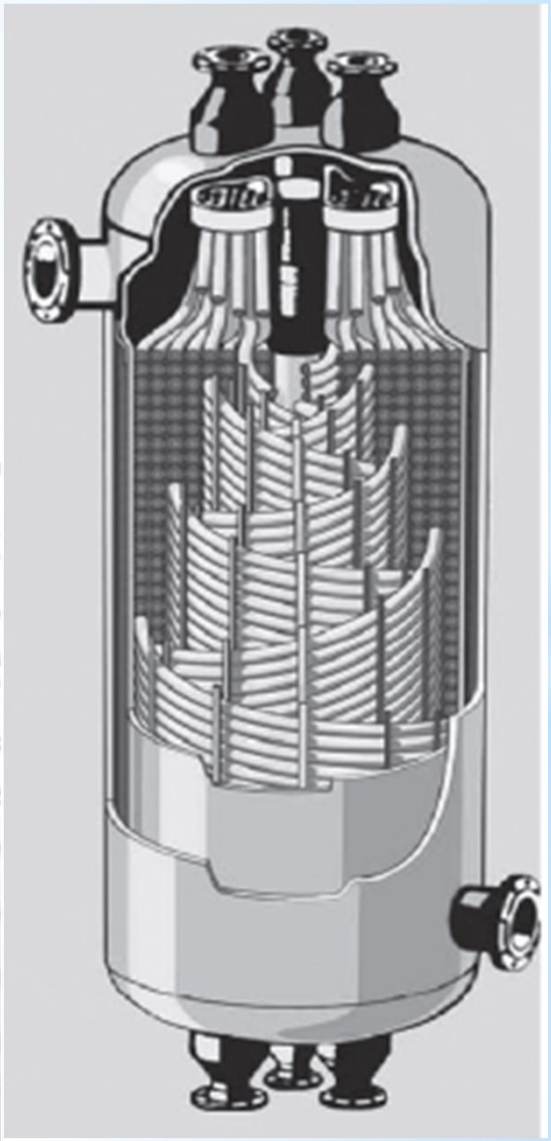
Especially when dealing with low-temperature applications where simultaneous heat transfer between more than two streams is desired.

Because of small bore tubes on both sides, CTHEs do not permit mechanical cleaning and therefore are used to handle clean, solid-free fluids or fluids whose fouling deposits can be cleaned by chemicals.

Materials are usually aluminum alloys for cryogenics, and stainless steels for high-temperature applications.


EXCHANGER LENGTH
SHELL
INLET
TUBE
INLET
CORE
CORE
SHELL
OUTLET
TUBE
OUTLET





Gasketed Plate Heat Exchanger

A plate heat exchanger is usually comprised of a stack of corrugated or embossed metal plates in mutual contact, each plate having four apertures serving as inlet and outlet ports, and seals designed so as to direct the fluids in alternate flow passages.

Standard performance limits :

Maximum operating pressure 25 bar (360 psi)

Maximum temperature 160°C (320°F)

With special gaskets 200°C (390°F)

Maximum flow rate 3600 m^3/h (950,000 USG/min)

Temperature approach as low as 1°C

Heat recovery as high as 93%

Heat transfer coefficient 3000–7000 $W/m^{2.}°C$

(water–water duties with

normal fouling resistance)

Merits:

True counter flow, high turbulence and high heat transfer performance. Close approach temperature.

Reduced fouling: Cross-contamination eliminated.

Multiple duties with a single unit. Expandable.

Easy to inspect and clean, and less maintenance.

Low liquid volume and quick process control.

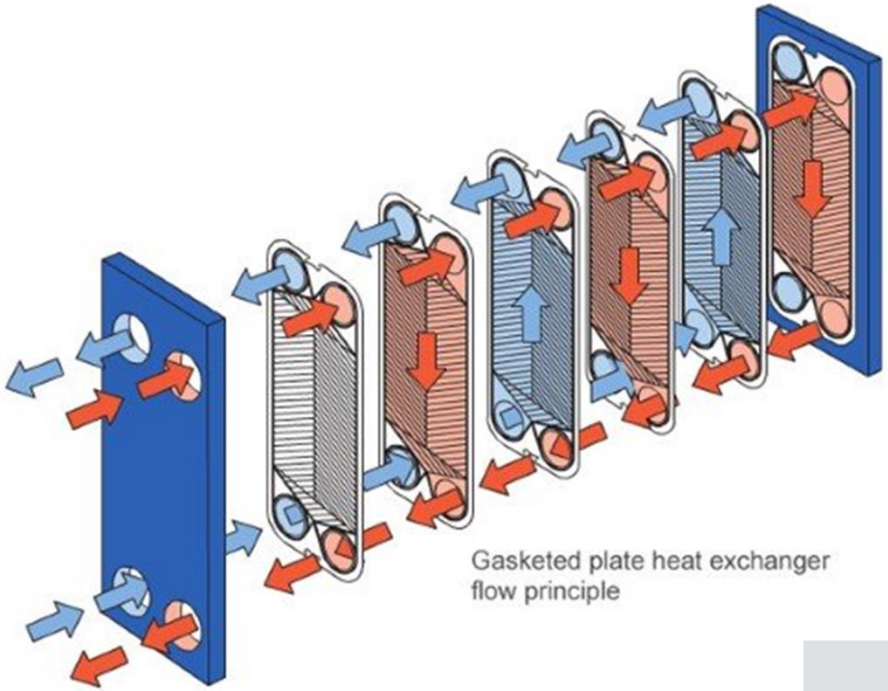
Lower cost.

Disadvantages

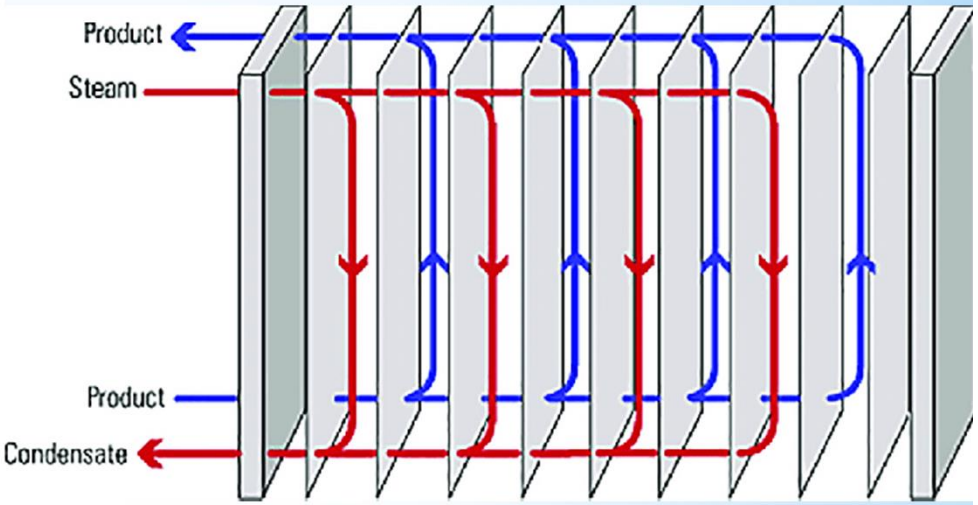
1. The maximum operating temperature and pressure are limited by gasket materials. The gaskets cannot handle corrosive or aggressive media.

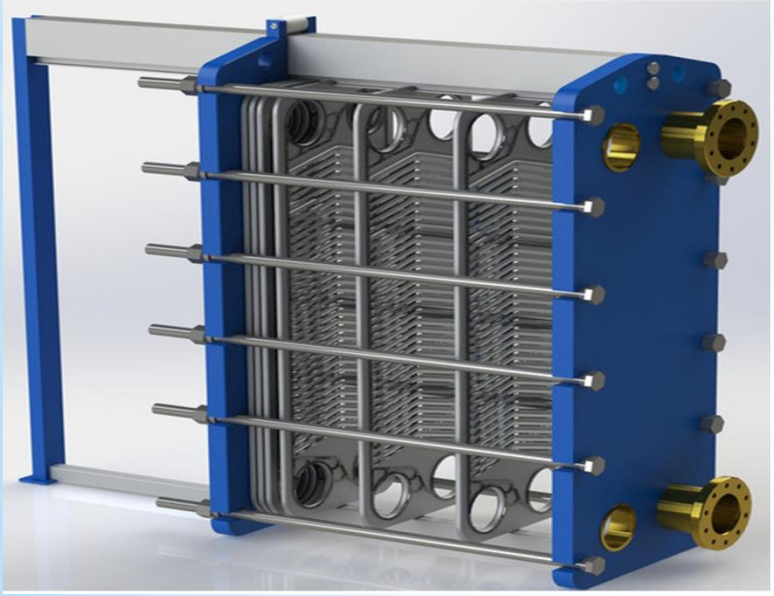
2. Gasketed plate heat exchangers cannot handle particulates that are larger than 0.5 mm.

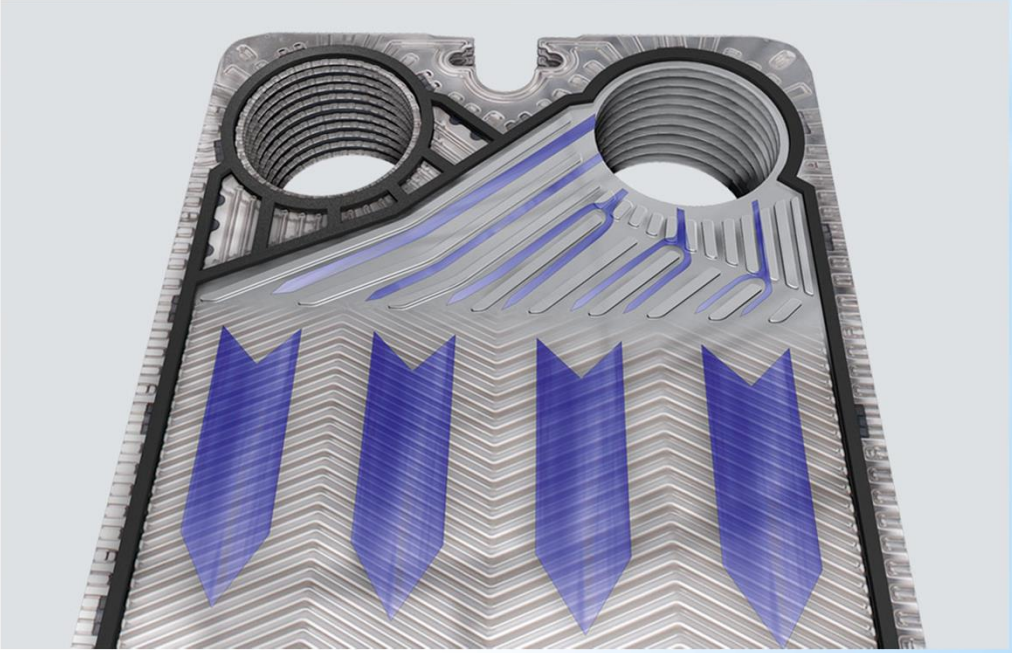
3. Gaskets always increase the leakage risk.



Gasketed plate heat exchanger
flow principle







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