

Heat and Mass Transfer (DI05019071)

Complete Lecture Deck

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July 23, 2026

Classification of Heat Exchangers

- Course: Heat and Mass Transfer (DI05019071)
- Unit 4: Heat Exchanger
- Lecture 27: Classification

Lecture Agenda

- 1. What is a Heat Exchanger?
- 2. Applications
- 3. Classification by Flow Arrangement
- 4. Classification by Construction
- 5. Regenerators vs. Recuperators

What is a Heat Exchanger?

- A heat exchanger is a device that facilitates the exchange of heat between two fluids that are at different temperatures.
- The fluids may be separated by a solid wall to prevent mixing or they may be in direct contact.
- Primary goal: Heating or cooling of a fluid, or changing its state (condensation or evaporation).

Applications

- 1. Power plants (Boilers, Condensers, Cooling towers)
- 2. HVAC systems (Heating, Ventilation, and Air Conditioning)
- 3. Automotive industry (Radiators, Oil coolers)
- 4. Chemical and food processing industries
- 5. Refrigeration systems (Evaporators, Condensers)

Classification by Flow Arrangement

- Heat exchangers can be classified based on the relative direction of fluid motion:
 - 1. Parallel Flow: Both fluids move in the same direction.
 - 2. Counter Flow: Fluids move in opposite directions.
 - 3. Cross Flow: Fluids move perpendicular to each other.

Parallel Flow Heat Exchangers

- Hot and cold fluids enter at the same end, flow in the same direction, and leave at the same end.
- Large temperature difference at the inlet, which rapidly decreases along the length.
- Outlet temperature of cold fluid can never exceed the outlet temperature of the hot fluid.

Counter Flow Heat Exchangers

- Hot and cold fluids enter at opposite ends and flow in opposite directions.
- More uniform temperature difference along the length.
- Highly efficient: Cold fluid outlet temperature can exceed the hot fluid outlet temperature.

Cross Flow Heat Exchangers

- Fluids move perpendicular to each other.
- Commonly used when one of the fluids is a gas (like air).
- Sub-classified into Mixed and Unmixed flow depending on whether the fluid is allowed to mix in the transverse direction.

Classification by Construction

- Based on how they are built, heat exchangers fall into several categories:
- 1. Tubular (e.g., Shell and Tube, Double pipe)
- 2. Plate (e.g., Plate and frame)
- 3. Extended Surface (e.g., Finned tube)
- 4. Regenerative vs Recuperative

Shell and Tube Heat Exchangers

- Consists of a large shell with a bundle of tubes inside.
- One fluid flows inside the tubes, the other flows outside over the tubes (in the shell).
- Baffles are used in the shell to direct flow and increase turbulence and heat transfer.
- Very common in industrial processes due to robustness.

Compact Heat Exchangers

- Designed to realize a large heat transfer surface area per unit volume.
- Typically area density greater than $700 \text{ m}^2/\text{m}^3$.
- Often use closely spaced fins or plates.
- Ideal for applications where weight and volume are restricted (e.g., aerospace, automotive).

Summary

- Heat exchangers transfer thermal energy between fluids.
- Flow arrangements include parallel, counter, and cross flow.
- Counter flow is generally the most thermally efficient.
- Construction types include shell and tube, plate, and compact designs depending on application needs.

Next Lecture Preview

- Topic: Heat Exchanger Analysis
- - Overall energy balance
- - Heat transfer rate equations
- - Assumptions used in thermal analysis of heat exchangers