Heat and Mass Transfer (DI05019071)

Complete Lecture Deck

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- Course: Heat and Mass Transfer (DI05019071)
- Unit 1: Conduction
- Lecture 11: Extended Surfaces (Fins) and their Types

Lecture Agenda

- 1. Limitations of Natural Convection
- 2. Concept of Extended Surfaces
- 3. Why Use Fins?
- 4. Practical Applications
- 5. Classification and Types of Fins

Limitations of Standard Convection

- Newton's Law of Cooling: Q = h A (Ts - T∞)
- To increase heat transfer rate (Q), we can:
- 1. Increase the temperature difference (Ts - T∞) -¿ Often limited by process.
- 2. Increase the convection coefficient (h) -¿ Requires forced convection, adding cost (fans, pumps).
- 3. Increase the surface area (A) -¿ Most practical approach.

Concept of Extended Surfaces

- An extended surface (fin) is a solid that experiences heat transfer by conduction within its boundaries, while heat is transferred by convection (and/or radiation) from its boundaries to the surroundings.
- It effectively increases the surface area 'A' in contact with the fluid.
- Primarily used when the convective heat transfer coefficient (h) is low, particularly for gases.

Why Use Fins?

- Enhance heat dissipation without needing active cooling mechanisms (like pumps).
- Cost-effective and reliable (no moving parts).
- Ideal for air cooling, where the heat transfer coefficient is inherently low compared to liquid cooling.
- Compact design for electronics and automotive applications.

Practical Applications of Fins

- Electronics: Heat sinks for CPUs, GPUs, and power transistors.
- Automotive: Radiators, engine blocks of air-cooled motorcycles.
- HVAC Systems: Condenser and evaporator coils in ACs and refrigerators.
- Power Generation: Cooling towers and transformer casings.

Types of Fins: Overview

- Fins come in various shapes depending on the application, manufacturing constraints, and fluid flow dynamics.
- 1. Straight Fins (Longitudinal)
- 2. Annular Fins (Radial)
- 3. Pin Fins (Spines)

Straight Fins (Longitudinal)

- Attached to a plane wall.
- Can have a uniform cross-section (rectangular) or non-uniform cross-section (triangular, parabolic).
- Rectangular: Easy to manufacture.
- Triangular: Lighter weight, uses less material for the same performance.

Annular Fins (Radial)

- Circumferentially attached to a cylinder.
- Cross-sectional area increases from base to tip.
- Commonly used in pipes transferring hot fluids, or on motorcycle engine cylinders.

Pin Fins (Spines)

- Protrude from a surface like a pin or peg.
- Can be cylindrical, conical, or square in profile.
- Promote turbulence in the fluid, enhancing the convection coefficient (h).
- Often used in compact heat exchangers and electronic heat sinks.

Summary

- Fins enhance heat transfer by increasing the effective surface area.
- They are most beneficial when convection coefficients are low (e.g., in air).
- Various shapes (straight, annular, pin) are used based on thermal and physical requirements.

Next Lecture Preview

- Topic: Heat Flow through a Rectangular Fin
- We will derive the governing differential equation for a simple straight fin.
- Be prepared with fundamental calculus and Fourier's law of conduction.