# Heat and Mass Transfer (DI05019071)

## Complete Lecture Deck

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# Heat Conduction through Composite Walls

- Course: Heat and Mass Transfer (DI05019071)
- Unit 1: Conduction
- Lecture 7: Heat Conduction through Composite Walls

# Lecture Agenda

- 1. Recap of Thermal Resistance
- 2. Introduction to Composite Walls
- 3. Series Thermal Circuit
- 4. Overall Heat Transfer Rate Equation
- 5. Temperature Drop Across Layers
- 6. Thermal Contact Resistance

# Introduction to Composite Walls

- Most practical walls are not made of a single material.
- Examples: house walls (brick, insulation, wood), furnace walls (firebrick, insulating brick, steel).
- Heat must flow sequentially through each layer.
- This is equivalent to electrical resistors in series.

# Series Thermal Circuit

- Consider a wall with 3 layers: A, B, and C.
- Thicknesses: LA, LB, LC. Conductivities: kA, kB, kC.
- The same heat (qx) flows through all layers.
- Total Resistance R_total = R_A + R_B + R_C
- R_total = (LA/kAA) + (LB/kBA) + (LC/kCA)

# Overall Heat Transfer Rate

- Using the overall temperature difference:
- qx = (T_inner - T_outer) / R_total
- qx = (T1 - T4) / [ (LA/kAA) + (LB/kBA) + (LC/kCA) ]
- This assumes perfect thermal contact between layers.

# Temperature Drop Across Layers

- Once qx is known, intermediate temperatures can be found.
- qx = (T1 - T2) / R_A =¿ T2 = T1 - qx * R_A
- qx = (T2 - T3) / R_B =¿ T3 = T2 - qx * R_B
- Larger resistance = larger temperature drop.

# Thermal Contact Resistance

- In reality, surfaces are rough.
- When two solid surfaces are pressed together, they touch only at high spots.
- Gaps are filled with air, which is a poor conductor.
- This creates an additional resistance at the interface: Contact Resistance (R_t,c).

# Accounting for Contact Resistance

- Contact resistance R_t,c = 1 / (hc * A)
- where hc is the contact conductance.
- It is simply added to the series circuit.
- R_total = R_A + R_t,c + R_B

# Reducing Contact Resistance

- How to minimize it:
- 1. Increase joint pressure.
- 2. Decrease surface roughness (polish).
- 3. Use thermal grease or conducting paste to displace air in gaps.
- 4. Insert a soft metallic foil (e.g., tin, silver).

# Example Problem Introduction

- A furnace wall consists of 200 mm firebrick (k=1.2 W/mK) and 50 mm insulating brick (k=0.15 W/mK).
- Inner temperature is 1000°C, outer is 40°C.
- Calculate the heat loss per unit area.

# Example Problem Solution

- R_firebrick = 0.2 / 1.2 = 0.167 (K $m^2$/W)
- R_insulation = 0.05 / 0.15 = 0.333 (K $m^2$/W)
- R_total = 0.167 + 0.333 = 0.500 (K $m^2$/W)
- q/A = (1000 - 40) / 0.500 = 1920 W/$m^2$

# Summary

- Composite walls are modeled as series thermal circuits.
- Total resistance is the sum of individual layer resistances.
- Intermediate temperatures depend on the resistance distribution.
- Contact resistance must be considered for rough interfaces.

# Next Lecture Preview

- Topic: Heat Conduction through Cylinders
- How does heat transfer change when the area is not constant?
- We'll explore radial heat conduction in pipes and tubes.