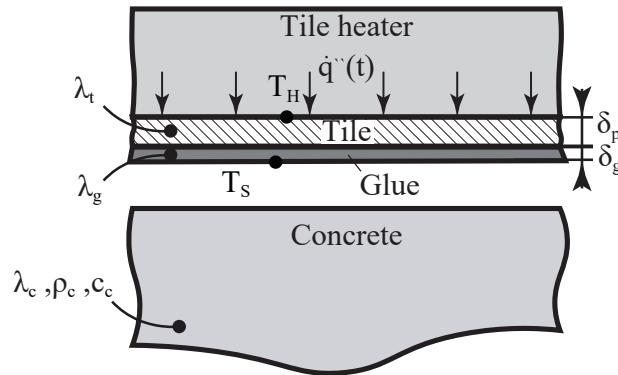


Exercise II.15 (Tile setting ★★):

A tile setter employs a modern technique for tile installation, involving preheating the tile and glue before affixing them to the concrete. The tile and glue are heated until they reach a steady-state condition, achieving a uniform heating temperature T_H and a constant heat flux \dot{q}''_0 . Once these conditions are met, the tile setter places the heated tile and glue on the concrete, maintaining a constant temperature T_S throughout the process. After reaching a critical temperature T_{crit} at a distance δ_{crit} within the concrete, the heater is removed. Initially, the concrete used to be at a homogeneous temperature T_0

**Given parameters:**

- Steady-state heat flux: $\dot{q}''_0 = 7.5 \text{ kW/m}^2$
- Thickness of the pile: $\delta_p = 10 \text{ mm}$
- Thickness of the glue: $\delta_g = 2 \text{ mm}$
- Conductivity of the pile: $\lambda_p = 1.0 \text{ W/mK}$
- Conductivity of the glue: $\lambda_g = 0.35 \text{ W/mK}$
- Conductivity of the concrete: $\lambda_c = 2.3 \text{ W/mK}$
- Heat capacity of the concrete: $c_c = 1,000 \text{ J/kgK}$
- Density of the concrete: $\rho_c = 2,400 \text{ kg/m}^3$
- Initial temperature of the concrete: $T_0 = 20 \text{ }^\circ\text{C}$
- Heating temperature of the tile heater: $T_H = 200 \text{ }^\circ\text{C}$
- Critical temperature: $T_{\text{crit}} = 35 \text{ }^\circ\text{C}$
- Critical distance: $\delta_{\text{crit}} = 10 \text{ mm}$

Hints:

- Heat will never penetrate entirely through the concrete.

Tasks:

- Derive the differential equation and establish the boundary and/or initial conditions to determine the temperature profile of the concrete. Based on your findings, identify the method that can be employed to determine the temperature at a particular position and time.
- Determine the time t_{crit} at which the heater can be removed.
- Illustrate the concrete's temperature profile that depicts both temporal and spatial variations.

Exercise II.16 (Heating and quenching of a sphere ★★★):

A sphere, initially at a homogeneous temperature of T_0 , is put into an oven. The oven temperature remains constant at a homogeneous temperature of T_o .

Given parameters:

- Initial temperature of the sphere: $T_0 = 25 \text{ } ^\circ\text{C}$
- Intermediate temperature of the sphere: $T_h = 150 \text{ } ^\circ\text{C}$
- Oven temperature: $T_o = 200 \text{ } ^\circ\text{C}$
- Quenching temperature: $T_q = 30 \text{ } ^\circ\text{C}$
- Heat transfer coefficient: $\alpha = 110 \text{ W/m}^2\text{K}$
- Radius of the sphere: $r_1 = 1.5 \text{ cm}$
- Thermal conductivity of the sphere: $\lambda = 1.52 \text{ W/mK}$
- Density the sphere: $\rho = 1.45 \cdot 10^3 \text{ kg/m}^3$
- Specific heat capacity the sphere: $c_p = 0.88 \text{ kJ/kg} \cdot \text{K}$

Hints:

- Heat radiation can be neglected.
- It always remains that $Fo > 0.2$

Tasks:

- a) Derive the differential equation and establish the boundary and/or initial conditions to determine the temperature profile of the sphere. Based on your findings, identify the method that can be employed to determine the temperature at a particular position and time.
- b) Determine the temperature of the center of the sphere after 3 minutes.

After some time the sphere has a hot homogeneous temperature T_h and is being quenched. During this process, the quenching temperature is constant at T_q . Further, in time, the center of the sphere has a temperature of $54 \text{ } ^\circ\text{C}$ and the surface has a temperature of $44.4 \text{ } ^\circ\text{C}$.

- c) Determine the time instant when the center of the sphere has a temperature of $54 \text{ } ^\circ\text{C}$ and the surface has a temperature of $44.4 \text{ } ^\circ\text{C}$.
- d) Determine the amount of heat dissipated at this time instant.