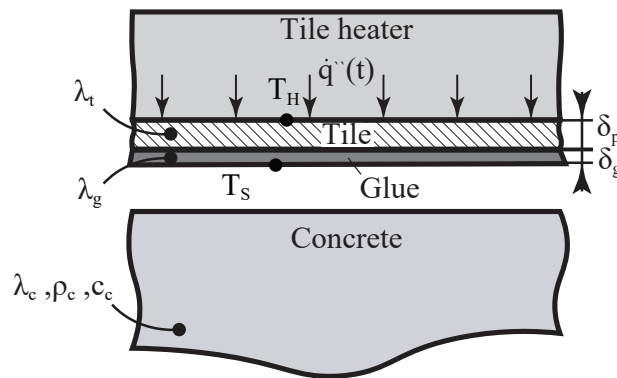


Exercise II.15 (Tile setting **):

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: | $T_{crit} = 35 \text{ }^\circ\text{C}$ |
| • Critical distance: | $\delta_{crit} = 10 \text{ mm}$ |

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:

- 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.
- 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 $44.4\text{ }^{\circ}\text{C}$.

- 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 $44.4\text{ }^{\circ}\text{C}$.
- Determine the amount of heat dissipated at this time instant.