

1.15 Heating and quenching of a sphere

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A sphere, initially at a homogeneous temperature of 25 °C, is put into an oven. The oven temperature remainst constant at a homogeneous temperature of 200 °C. The heat transfer coefficient for this process is 110 W/m²K.

- a) Determine the temperature of the center T_m after 3 minutes.

After some time the sphere has a homogeneous temperature of 150 °C and is being quenched. During this process, the ambient temperature remains constant at 30 °C. It was found that after time t_1 the center of the sphere has a temperature of 54 °C and the surface has a temperature of 44.4 °C.

- b) Determine the time t_1 it takes for the center of the sphere to have a temperature of 54 °C and the surface to have a temperature of 44.4 °C.
- c) Determine the amount of heat dissipated Q at time instant t_1 .

Hints

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

Given parameter

- Radius of the sphere: $r_1 = 1.5 \text{ cm}$
- Thermal diffusivity of the sphere: $a = 9.5 \cdot 10^{-7} \text{ m}^2/\text{s}$
- 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: $c_p = 0.88 \text{ kJ/kg} \cdot \text{K}$