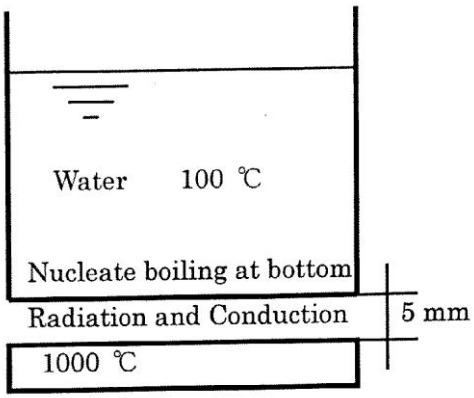
Boiling Heat Transfer Exercise



Task: Finding temperature under boiling heat transfer condition. Calculate the bottom surface temperature of the pan, neglecting resistance of the pan.

Parameters

Thermal conductivity of air $k_a = 0.057$ W/mK
Specific heat of water $c_l = 4.215$ kJ/kgK
Latent heat of water $h_{fg} = 2{,}256$ kJ/kg
Water Prandtl number Pr = 1.76
Viscosity ow water $\mu_l = 282.7 \times 10^{-6}$ Pas
Surface tension of water $\sigma = 58.917 \times 10^{-3}$ N/m
Gravitational acceleration g = 9.807 m/s²
Density of water $\rho_l = 958.0$ kg/m³
Density of vapor $\rho_g = 0.6037$ kg/m³
$C_{sf} = 0.013$
Stefan-Boltzmann constant $\sigma = 5.6697 \times 10^{-8}$ W/m²K⁴

Emissivity of hot plate $\varepsilon_1 = 0.7$,

Emissivity of bottom surface of pan $\varepsilon_2 = 0.9$

Taking T1 = hot plate temperature, T2 = bottom surface of pan temperature, Tw = surface temperature of pan on water side, Ts = boiling water temperature.

Between hot plate and pan, both conduction and radiation modes of heat transfer occur in parallel.

For conduction,

$$q_{cond} = -\mathrm{k}\frac{dT}{dx} = -k\frac{(T_1 - T_2)}{\delta}$$

For radiation,

$$q_{rad} = \sigma(T_1^4 - T_2^4)\frac{1}{\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1}$$