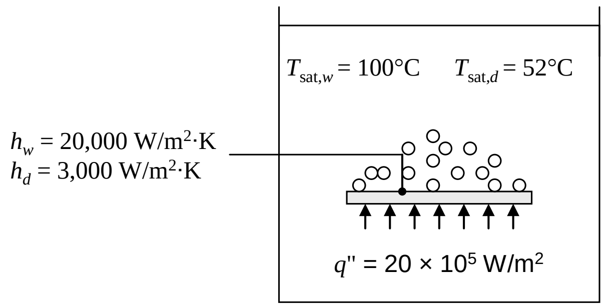
PROBLEM 1.20

KNOWN: Heat flux and convection heat transfer coefficient for boiling water. Saturation temperature and convection heat transfer coefficient for boiling dielectric fluid.

FIND: Upper surface temperature of plate when water is boiling. Whether plan for minimizing surface temperature by using dielectric fluid will work.

SCHEMATIC:



ASSUMPTIONS: Steady-state conditions.

PROPERTIES: $T_{sat,w}$ = 100°C at p = 1 atm.

ANALYSIS: According to the problem statement, Newton's law of cooling can be expressed for a boiling process as

$$q'' = h(T_s - T_{sat})$$

Thus,

$$T_s = T_{sat} + q''/h$$

When the fluid is water,

$$T_{s,w} = T_{sat,w} + q''/h_w = 100°C + \frac{20\times10^5 \text{ W/m}^2}{20\times10^3 \text{ W/m}^2\cdot\text{K}} = 200°C$$

When the dielectric fluid is used,

$$T_{s,d} = T_{sat,d} + q''/h_d = 52°C + \frac{20\times10^5 \text{ W/m}^2}{3\times10^3 \text{ W/m}^2\cdot\text{K}} = 719°C$$

Thus, the technician's proposed approach will not reduce the surface temperature. <

COMMENTS: (1) Even though the dielectric fluid has a lower saturation temperature, this is more than offset by the lower heat transfer coefficient associated with the dielectric fluid. The surface temperature with the dielectric coolant exceeds the melting temperature of many metals such as aluminum and aluminum alloys. (2) Dielectric fluids are, however, employed in applications such as *immersion cooling* of electronic components, where an electrically-conducting fluid such as water could not be used.