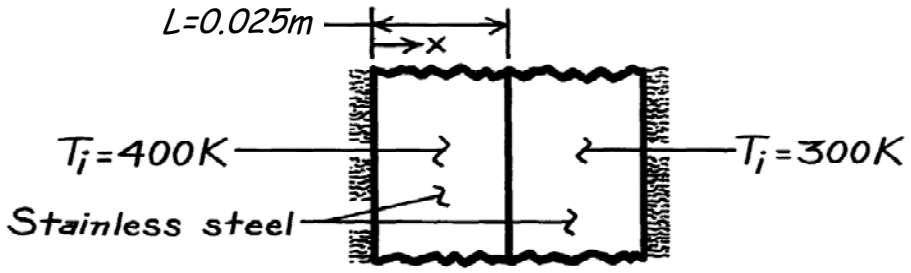
PROBLEM 5.95

KNOWN: Initial temperatures, properties, and thickness of two plates, each insulated on one surface.

FIND: Temperature on insulated surface of one plate at a prescribed time after they are pressed together.

SCHEMATIC:



ASSUMPTIONS: (1) One-dimensional conduction, (2) Constant properties, (3) Negligible contact resistance.

PROPERTIES: Stainless steel (given): $\rho = 8000$ kg/m^3, c = 500 J/kg·K, k = 15 W/m·K.

ANALYSIS: At the instant that contact is made, the plates behave as semi-infinite slabs and, since the (ρkc) product is the same for the two plates, Equation 5.66 yields a surface temperature of

$$T_S = 350\text{K}.$$

The interface will remain at this temperature, even after thermal effects penetrate to the insulated surfaces. The transient response of the hot wall may therefore be calculated from Equations 5.43 and 5.44. At the insulated surface (x* = 0), Equation 5.43 yields

$$\frac{T_o - T_s}{T_i - T_s} = C_1 \exp\left(-\zeta_1^2 \text{Fo}\right)$$

where, in principle, $h \to \infty$ and $T_\infty \to T_s$. From Table 5.1, $\zeta_1 = 1.5708$, $C_1 = 1.2733$.

Also,
$$\text{Fo} = \frac{\alpha t}{L^2} = \frac{3.75\times10^{-6}\,\text{m}^2/\text{s}\,(60\text{s})}{(0.025\ \text{m})^2} = 0.360.$$

Hence,
$$\frac{T_o - 350}{400 - 350} = 1.2733\exp\left(-1.5708^2 \times 0.360\right) = 0.524$$

$$T_o = 376.2\ \text{K}.$$ <

COMMENTS: Since Fo > 0.2, the one-term approximation is appropriate.