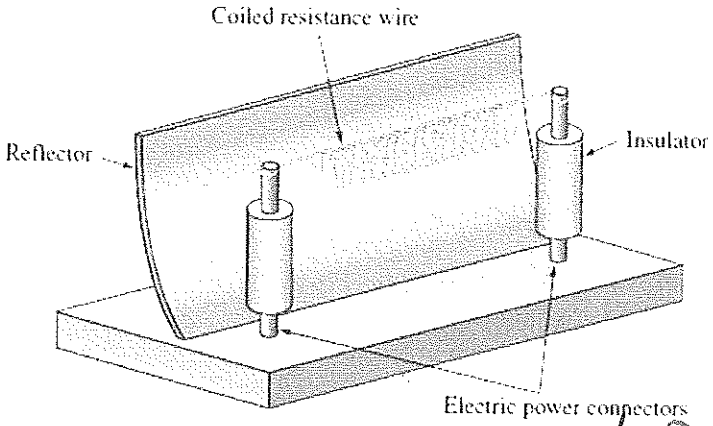
CANKAYA UNIVERSITY
FACULTY OF ENGINEERING
MECHANICAL ENGINEERING DEPARTMENT
ME 313 HEAT TRANSFER

Fall 2016

HW 9

1) An electrical room heater consists of a horizontal coil of electrical resistance wire, as shown in figure given below Such a coil is to be tested at a low power that will result in a wire temperature of . Calculate the rate of convection heat loss per unit length from the wire, which is 1 mm in diameter. For the purposes of this calculation, the wire can be approximated as being straight and horizontal. Room air is at 27 ^{0}C . Repeat the calculation for a test performed in a carbon dioxide atmosphere, also at 27°C.



$T_f = 77^\circ C$

$$Ra_D = \frac{g\beta \Delta T D^3}{\nu^2} Pr = \frac{(9.81)(\frac{1}{350})(100)(0.001)^3}{(2.12\times10^{-5})^2}(0.7)$$

$$= 4.43$$

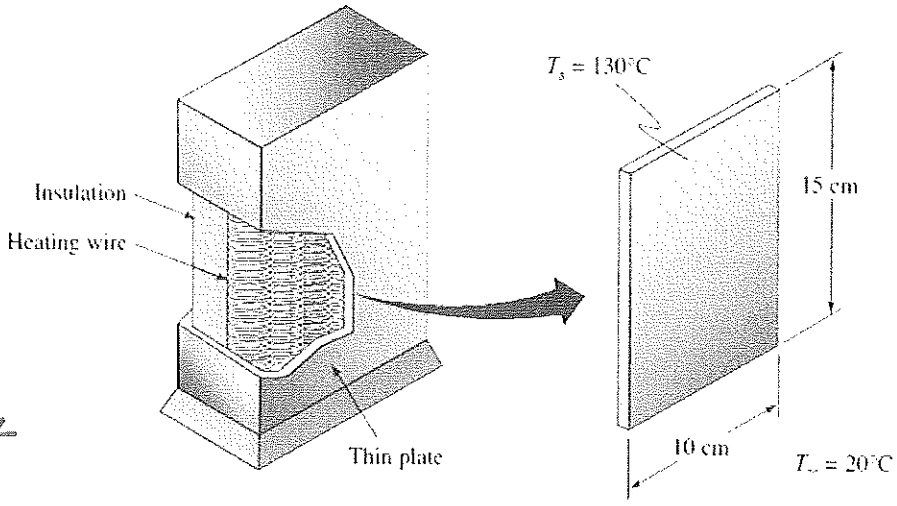
$$\overline{Nu}_D = C Ra_D^n = 1.02(4.43)^{0.148} = 1.27$$

$$\bar{h} = \frac{k}{D}\overline{Nu}_D = \left(\frac{0.0291}{0.001}\right)(1.27) = 37\ w/m^2K$$

$$q = \bar{h}\pi DL(T_w - T_\infty)$$

$$q/L = \bar{h}\pi D(T_w - T_\infty) = (37)(\pi)(0.001)(100) = 11.61\ w/m$$

2) The rating for the small vertical-plate resistance heater shown in Figure given below is to be determined. Estimate the electrical power required to maintain the vertical heater surface at 130 °C in ambient air at 20 °C . The plate is 15 cm high and 10 cm wide. Compare with results for a plate 450 cm high. The heat transfer coefficient for radiation is 8.5 W/m² K for the specified surface temperature.



$T_f = 75\,^\circ C$

$Gr_L \cong 2.41 \times 10^7$

$Pr = 0.71$ for air

$Gr_L Pr \cong 1.17 \times 10^7$

$\overline{Nu}_L = C Ra_L^n$ $\quad C = 0.59$ $\quad n = 1/3$

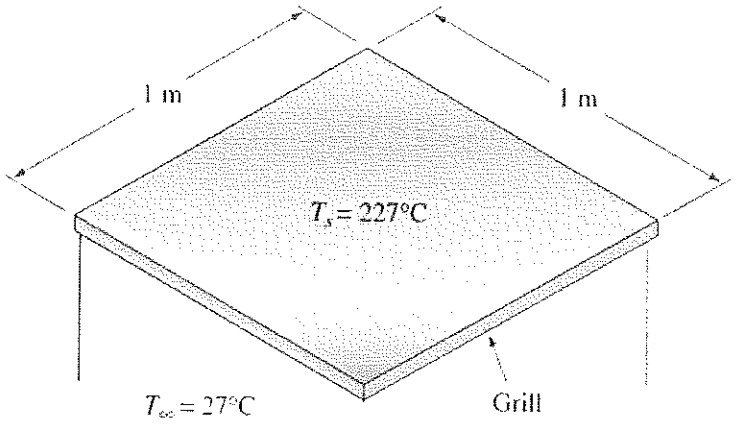
$\overline{Nu}_L = 0.59(1.17 \times 10^7)^{1/4} \cong 58$

$\bar{h} = \overline{Nu}_L \frac{k}{L} = (58)\left(\frac{0.029}{0.15}\right) = 11.3\ W/m^2K$

$q = A(\bar{h}_c + \bar{h}_r)(T_w - T_\infty)$

$= (2)(0.5)(0.1)(11.3 + 8.5)(110) = 1960\ W$

3)
Calculate the rate of convection heat loss from the top and bottom of a flat, 1-m square, horizontal restaurant grill heated to 227 ^{0}C in ambient air at (see Figure)



use air properties at T_f

$$L = \frac{A}{P} = \frac{L^2}{4L} = L/4 = 0.25m$$

$$Ra_L = \frac{(9,8)(200)(0,25)^3(0,71)}{(396)(2,7\times10^{-5})} = 7,55\times10^7$$

$$\overline{Nu_L} = 0.27(7.55\times10^7)^{0,25} = 25,2$$ for heat transfer from bottom of plate

$$\overline{Nu_L} = 0.15(7.55\times10^7)^{0,33} = 63,4$$ from top surface.

$\overline{h_1} = 3,23\ W/m^2K$

$\overline{h} = 8,11\ W/m^2K$

$q = (1)(3,23+8,11)(200) = 2268\ W$