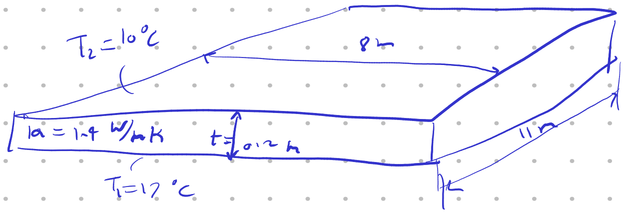
2. The concrete slab of a basement is 11m long, 8m wide and 0.2m thick. During the winter temperatures are nominally 17°C and 10°C at the top and bottom surfaces respectively. If the concrete has a thermal conductivity of 1.4 W/m.K. what is the rate of heat loss through the slab. If the basement is heated by a gas furnace operating at an efficiency of $\eta = 0.9$ and natural gas is priced at 10 P.T. per MJ, what is the daily cost of the heat loss.

$$\dot{Q}_{cond} = kA\frac{(T_1 - T_2)}{t} = 4312\ W$$

$A = 11 \times 8\ m^2$



$$Q = \frac{\dot{Q}_{cond}}{\eta} = 4791.11\ W$$

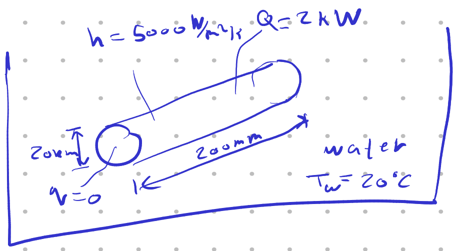
$$E = 4791.11 \times 24 \times 60 \times 60 = 413.95\ MJ/day$$

Cost = 10E = 4139 P.T.

7. A cartridge electrical heater is shaped as a cylinder of length 200 mm and outer diameter 20mm. Under normal operating conditions the heater dissipates 2kW, while submerged in a water flow that is at 20°C and provides a convection heat transfer coefficient h=5000 W/m².K. Neglecting heat transfer from the ends of the heater, determine its surface temperature T_s. If the water flow is stopped while the heater continues to operate and the heater surface is exposed to air at 20°C with h= 50 W/m².K, what is the corresponding surface temperature and what will be the consequences of that.

water: $\dot{Q}_{conv} = h_w A (T_s - T_w) = 2kW$

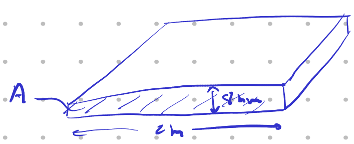
$A = \pi D L = 0.012566\ m^2$

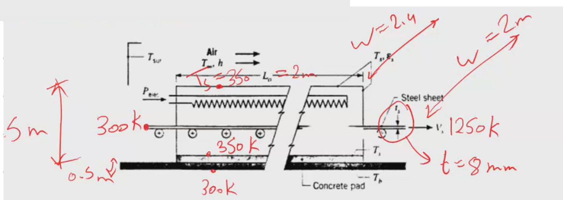


$\rightarrow T_s = 51.83\ °C$

Air: $\dot{Q}_{conv} = h_{Air} A (T_s - T_w) = 3203.19\ °C$

12. In one stage of an annealing process 304 stainless steel sheet is taken from 300K (T_1) to 1250 K (T_2) as it passes through an electrically heated oven at a speed of V=10 mm/s. The sheet thickness and width are 8mm and 2m respectively while the height, width and length of the oven are 2m,2.4m and 25m respectively. The top and four sides of the oven are exposed to ambient air and large surroundings each 300 K and the corresponding surface temperature, convection coefficient and emmisivity are 350K, 10W/m².K and 0.8. The bottom surface of the oven is also at 350K and rests on a 0.5 m thick concrete pad whose base is at 300K. Estimate the required electrical power input to the oven.





$$\dot{Q}_{absorbed} = \frac{mC\Delta T}{t} = \frac{\rho A L}{t}(T_2 - T_1) = \rho A V (T_2 - T_1) =$$

$\rho =$

$A = 2 \times 8 \times 10^{-3} = 1.6 \times 10^{-3}$

$T_\infty = 300K$

$h = 10\ W/m^2.K$

$\varepsilon = 0.8$

$$\dot{Q}_{cond} = kA\frac{(T_{oven} - T_{pad})}{t} = ✓$$

$T_6 = 350K$, $T_{pad} = 300K$

$t = 0.5m$

$A = 2.4 \times 25$

$k = 1.4$

$$P = \sum \dot{Q}$$

$\dot{Q}_{conv} = hA(T_{oven} - T_1)$

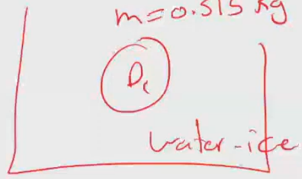
$2 \times (2 \times 2.4) + 2 \times (2 \times 25) + (25 \times 2.4) = A$ ✓

$\dot{Q}_{rad} = A \varepsilon \sigma (T_{oven}^4 - T_1^4) =$ ✓

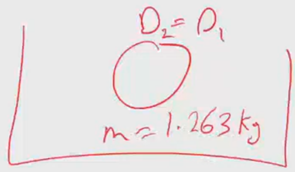
13. A small sphere of reference grade iron with specific heat of 447 J/kg.K and a mass of 0.515 kg is suddenly immersed in a water-ice mixture. Fine thermocouple wires suspend the sphere and the temperature is observed to change from 15 to 14°C in 6.35s. The experiment is repeated with a metallic sphere of the same diameter but of unknown composition with mass of 1.263 kg. If the same observed temperature change occurs in 4.59s what is the specific heat of the unknown material.

$c = 447$ J/kg.K
$m = 0.515$ kg

$15°C \rightarrow 14°C$
$t = 6.35$



$15°C \rightarrow 14°C$
$t = 4.59$



$$\dot{Q}_1 = \frac{m_1 c_1 \Delta T}{t_1} \qquad \dot{Q}_2 = \frac{m_2 c_2 \Delta T}{t_2}$$

$$\dot{Q}_1 = \dot{Q}_2 = hA(T_s - T_\infty) \rightarrow c_2 = ✓$$