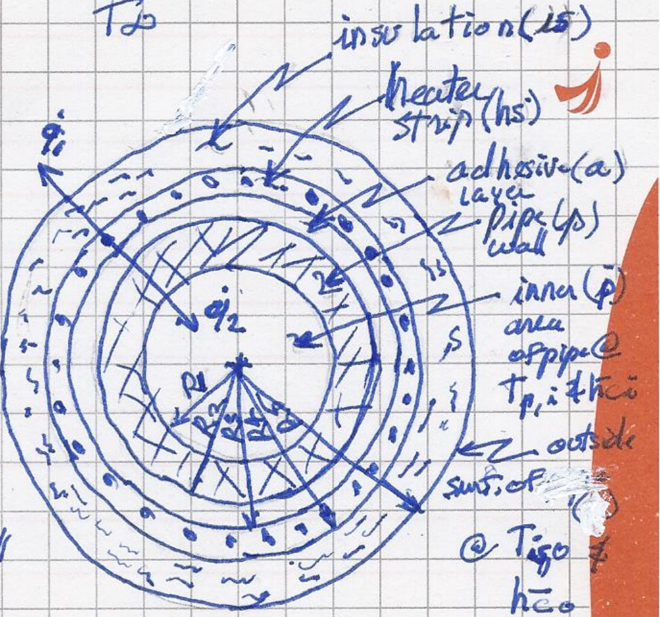
Reply to thread 391-359418



$\dot{q}_G$ – heat generated by heating element

$\dot{q}_1$ – heat transfer thru insulation

$\dot{q}_2$ – heat transfer thru adhesive layer & pipe wall

k_{is}, k_a, k_p : thermal conductivities of insulation, adhesive layer & pipe wall

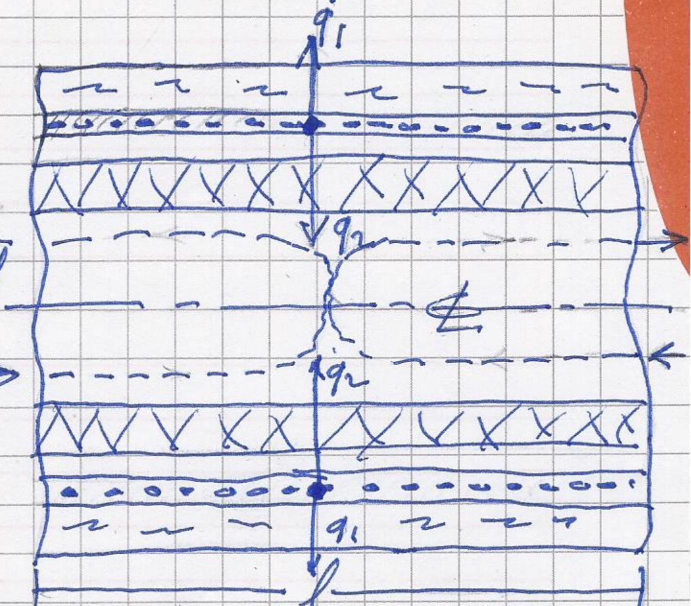
$\bar{h}_{co}, \bar{h}_{ci}$: convective heat transfer coefficient on outside surface of insulation and on the inside surface of pipe wall

$T_{is,o}$ – Temp. of outside surface of insulation

T_b – bulk temperature of air movement inside of pipe.

T_∞ – ambient temperature

T_h – temperature of heating element



Kent "Power" must estimate $T_{is,o}$ → $\bar{h}_{co} \cong 0.27\left[(T_{is,o} - T_\infty)/2R_5\right]^{0.25}$

Kreith "Heat transfer" graph on fig 8-2 → $\bar{h}_{ci} \cong 0.48\,(k/2R_1)(VD\rho/\mu)^{0.3}$

$Nu \propto Re^{0.3}$

$Nu \approx .48 Re^{0.3}$

Conditions: Steady state; heat flow outwardly & inwardly from heating element. Discount end heat loss; use bulk air temperature (T_b); units in B.T.U. (British Thermal units)

$$\dot{q}_G = \dot{q}_1 + \dot{q}_2$$

$$\dot{q}_G = \frac{T_h - T_\infty}{\dfrac{\ln(R_5/R_4)}{2\pi k_i l} + \dfrac{1}{2\pi R_5 \bar{h}_{co} l}} + \frac{T_h - T_b}{\dfrac{\ln(R_3/R_2)}{2\pi k_a l} + \dfrac{\ln(R_2/R_1)}{2\pi k_p l} + \dfrac{1}{2\pi R_1 \bar{h}_{ci} l}}$$

Solution is trial & error tempered w/ engineering judgement.

$\bar{h}_{co}$ & $\bar{h}_{ci}$ are surface temperature dependent under free air movement (convection).

$\bar{h}_c$'s would range between .6 – 5 Btu/hr ft² °F.

Known values: k_i, k_a, k_p; R_1, R_2, R_3, R_4, R_5; T_∞

Unknown values: T_b, $\bar{h}_{co}$, $\bar{h}_{ci}$. We can estimate two reasonable temperature extremes for $T_{is,o}$ & $T_{p,i}$ to calculate two extreme values for $\bar{h}_{co}$ & $\bar{h}_{ci}$ and these should not change much, so average the extreme $\bar{h}$'s. $\bar{h}_{co}$ is straight forward but $\bar{h}_{ci}$ will be determined from $Nu \simeq .48 Re^{0.3}$; $Nu = \bar{h}_c D/k$ for air at T_s; $Re = VD\rho/\mu = VD/\nu$ where μ, ρ, ν are dependent on T_s. Velocity (V) values will be low and must be judged