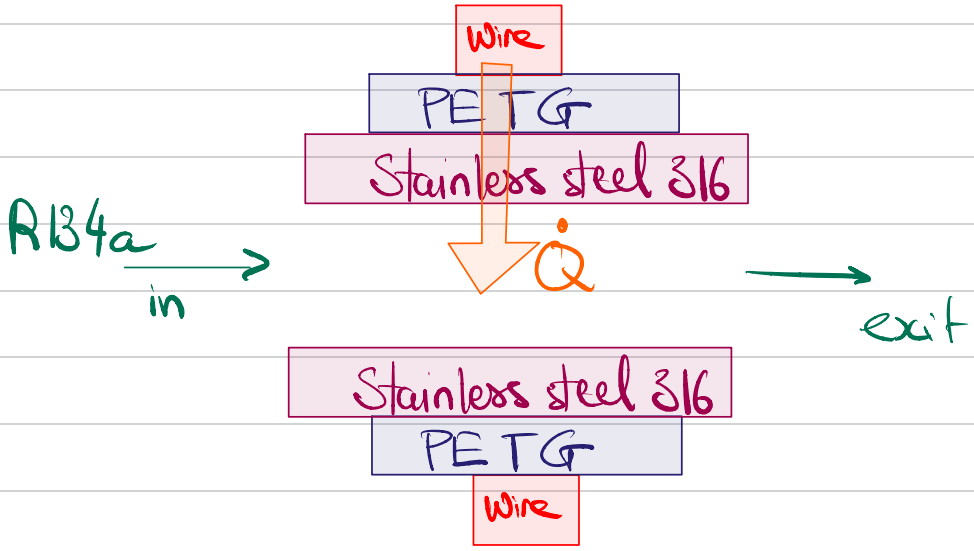
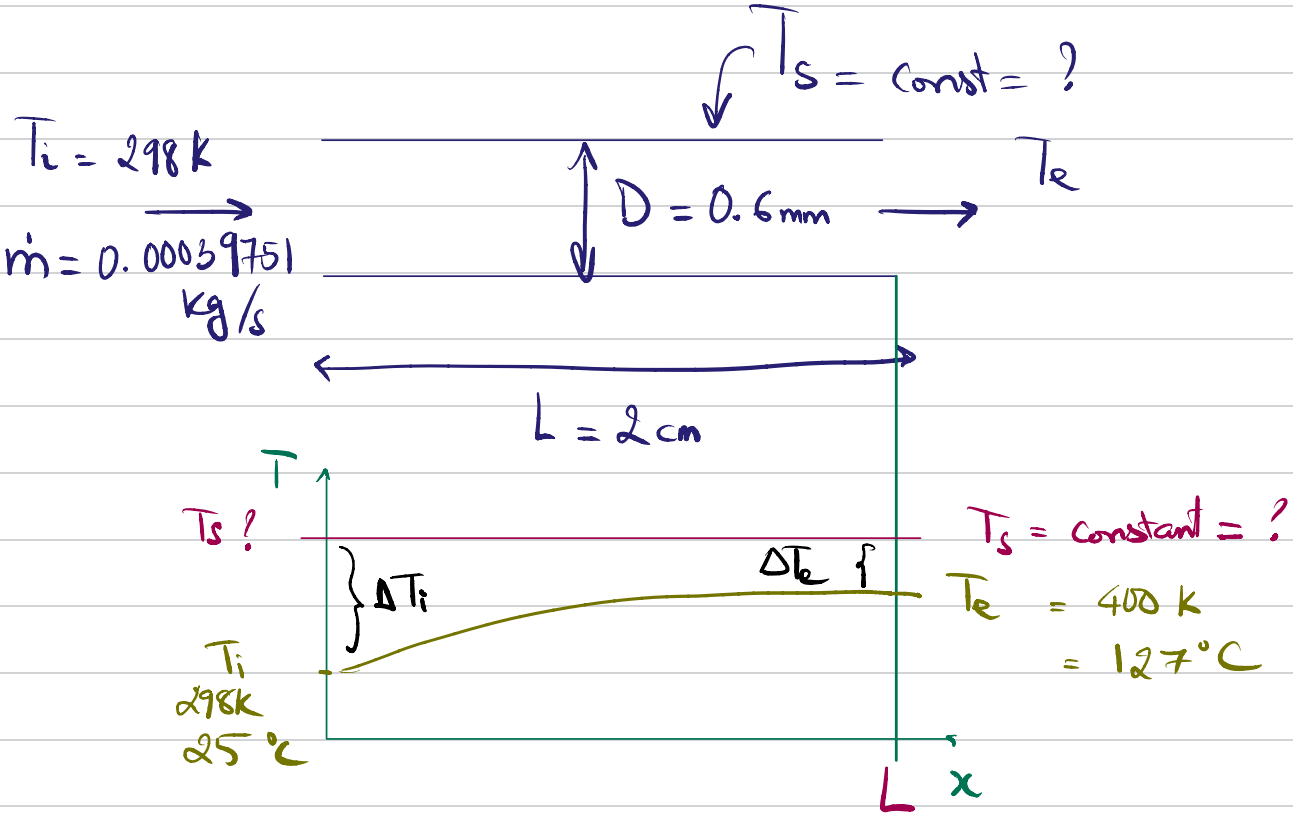



$$\Delta T_e = \Delta T_i e^{-\frac{hA_s}{\dot{m}c_p}}$$

$$\dot{Q}_{conv.} = \dot{m} C_p (T_e - T_i) = 34.14\ W$$

↳ for R134a; $C_p$ = 842 J/kg·°C
Super-heated vapor at 25°C

$$\dot{Q} = hA_s \Delta T_{lm} = 34.14\,W$$

$$\Delta T_{lm} = \frac{\overset{?}{\Delta T_e} - \overset{?}{\Delta T_i}}{\ln(\Delta T_e/\Delta T_i)} = \frac{\dot{Q}}{hA_s}$$

$$A_s = \pi D L = 3.77 \times 10^{-5}\ m^2$$

Find $h = ?$ $\rightarrow$ $Nu = \frac{hD}{k}$

$$T_b = \frac{T_i + T_e}{2} = \frac{25 + 127}{2} = 76\,^\circ C$$

↳ $C_p \approx 925\ J/kg\cdot{}^\circ C$ ; $k = 0.014\ W/mk$
$Pr \approx 0.91$ ; $\nu \simeq 1.44 \times 10^{-6}\ m^2/s$

- $A_c = \frac{\pi D^2}{4} = \frac{\pi (0.0006\,m)^2}{4} = 2.83 \times 10^{-7}\ m^2$
- $\rho = 10.55\ kg/m^3$

↳ $V = \frac{\dot{m}}{\rho A_c} \approx 133\ m/s$

① Geometry → circular pipe
② BC's → $T_s$ = Const.
③ Re

$$Re = \frac{VD}{\nu} = \frac{(133)(0.0006)}{1.44 \times 10^{-6}} = 55,416.67 > Re_{cr} = 2300$$

$\Rightarrow$ Turbulent

④ Flow Region → thermal entrance length, $L_t$
Turbulent flow → $L_t \simeq 10\,D = (10)(0.0006) = 0.006\ m$
$L_t = 0.006m < L_{pipe} = 0.02\,m$
$\Rightarrow$ Fully Developed Region

$$\rightarrow \quad Nu = \frac{hD}{k} = \frac{(f/8)(Re - 1000)\,Pr}{1 + 12.7(f/8)^{0.5}(Pr^{2/3} - 1)} = 128.78$$

Where $f$ is friction factor.

$f = f^{n}(Re, \varepsilon/D)$

for smooth tube, $\frac{\varepsilon}{D} = 0$

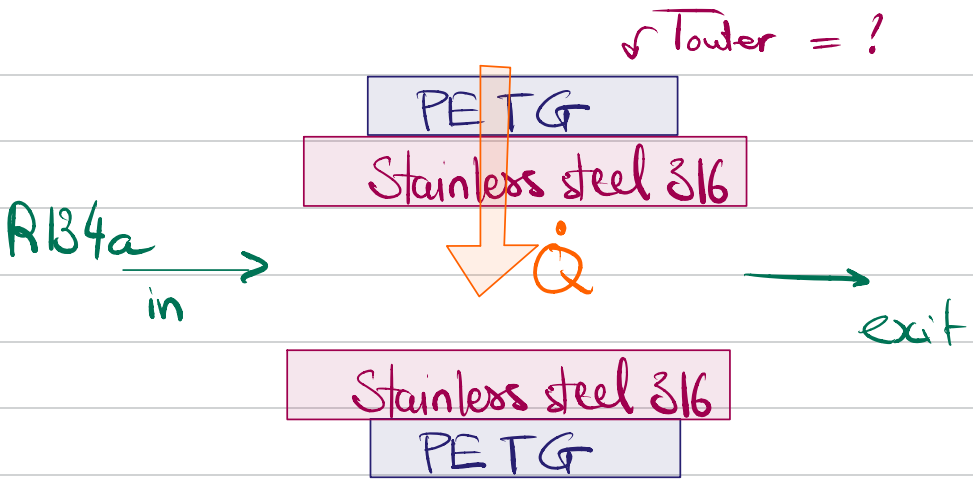
$$f = (0.79 \ln(Re) - 1.64)^{-2} \approx 0.02$$

$$\hookrightarrow \quad h = Nu \frac{k}{D} = (128.78)\frac{0.014}{0.0006} = 3004.8667 \ \frac{W}{m^2}$$

$$\Rightarrow \quad \Delta T_{Lm} = \frac{\dot{Q}}{hA_s} = \frac{34.14}{(3004.8667)(3.77 \times 10^{-5})} = 301.367\,^{\circ}C$$

$$\hookrightarrow \quad 301.367\,^{\circ}C = \frac{(T_s - T_e) - (T_s - T_i)}{\ln\left(\frac{T_s - T_e}{T_s - T_i}\right)}$$

$$\rightarrow \quad T_s = 380\ ^{\circ}C$$




$$T_{outer\ PETG} = T_\infty + \dot{Q} R_{tot}$$

## Geometry:

| Layer | Inner Radius ($r_1$) (m) | Outer Radius ($r_2$) (m) | Length (m) |
|---|---|---|---|
| Stainless | 0.00032 | 0.00082 | 0.05 |
| PETG | 0.00082 | 0.0021 | 0.05 |

- **Steel:** $R_{steel} = \dfrac{\ln(r_2/r_1)}{2\pi K L} = 0.224\ K/W$

$$K = 13.4\ W/mK$$

- **PETG:** $R_{PETG} = 10.322\ K/W$

$$\rightarrow R_{tot} = R_{steel} + R_{PETG} = 10.546\ K/W$$

$$T_{outer\ PETG} = 25 + (34.14)(10.546) = \underline{385\ ^\circ C}$$