2 DEC 2019 ①
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Where were we?
(before Thanksgiving break).....

Applied Heat Transfer

DOUBLE PIPE

$Q = U A$ (Average driving "force" for heat transfer)

ΔT_{lm}

$$\Delta T_{lm} = \frac{(\Delta T)_R - (\Delta T)_L}{\ln \frac{(\Delta T)_R}{(\Delta T)_L}}$$

Shell + Tube HE

$$Q = UA\left(F_T \Delta T_{lm}\right)$$

$F_T = 1$ { double pipe, 1-1 shell + tube }

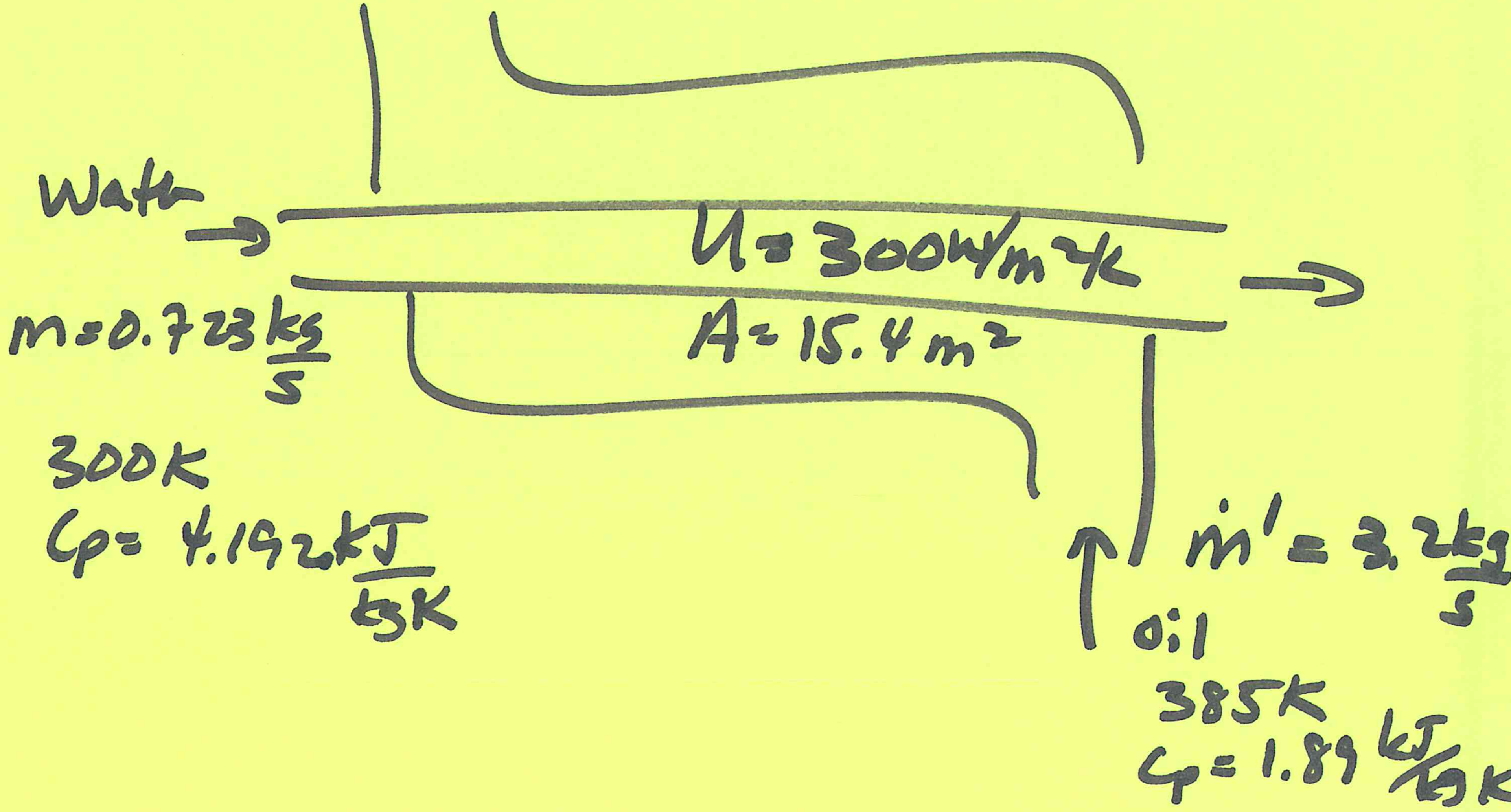
$F_T < 1$ { other types shell + tube }

(Usually we do not accept designs w/ $F_T < 0.75$)

HE Effectiveness

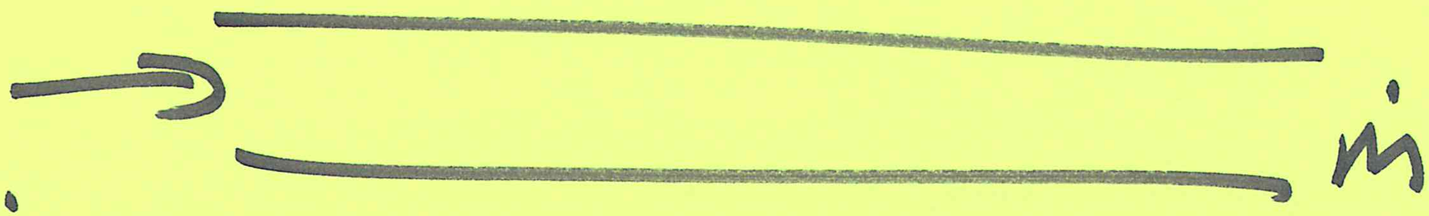
EXAMPLE

What is Q?



MACRO $\hat{E}$-BAL INSIDE

WATER



$\dot{m} = 0.723$

$$\cancel{\Delta E_p} + \cancel{\Delta E_k} + \Delta H = Q_{in} + \cancel{W_{s,in}}$$

$$Q_{in} = \Delta H$$

$$= \sum_{outs} \dot{m}_i \hat{H}_i - \sum_{ins} \dot{m}_i \hat{H}_i$$

$$= \dot{m} (\hat{H}_{out} - \hat{H}_{in}$$

$$-Q'_{in} = \grave{Q}_{in} = \grave{\dot{m}}\, \grave{C}_p (T_{out} - T_{in})$$

MACRO E BAL OUTSIDE

$$\cancel{\Delta E_p} + \cancel{\Delta E_k} + \Delta H = Q_{in} + \cancel{W_{s,on}}$$

$$Q_{in}^{(1)} = \Delta H$$

$$= \sum_{outs} \dot{m}_i \hat{H}_i - \sum_{in} \dot{m}_i \hat{H}_i$$

$$= \dot{m}' (\hat{H}'_{out} - \hat{H}'_{in})$$

$$Q'_{in} = \underset{\checkmark}{m'} \underset{\checkmark}{C_p'} (T_{out}' - \underset{\checkmark}{T_{in}'})$$

2 EQNS

3 UNKNOWNS: Q_{in}, $T_{out,w}$, $T_{out,oil}$

$$Q_{in} = U A \Delta T_{lm}$$

$$\Delta T_{lm} = \frac{\Delta T_{left} - \Delta T_{right}}{\ln \frac{\Delta T_{left}}{\Delta T_{right}}}$$

good

3 eqn s
3 unknowns

Guess: Q

Q	$T_{out,w}$	$T_{out,oil}$	ΔT_{lm}	Q	Match?

OR

We could use
Heat Exchanger
Effectiveness

. . .

$$Q = \varepsilon \, (\dot{m} C_p)_{min} \, (T_{hi} - T_{ci})$$

↑ function of:
• $NTU = \dfrac{UA}{(\dot{m} C_p)_{min}}$
• $\left(\dfrac{(\dot{m} C_p)_{max}}{(\dot{m} C_p)_{min}} \right)^{-1}$

EXAMPLE

1. Is it a HE Effectiveness plm?
   (if Temp in's known YES)

2. $$(\dot{m}C_p)_{\text{cold water}} = (0.723\ \tfrac{kg}{s})(4.192\ \tfrac{kJ}{kgK}) = 3.03\ \tfrac{kW}{K} \leftarrow C_{min}$$

   $$(\dot{m}C_p)_{\text{hot oil}} = (1.89\ \tfrac{kJ}{kgK})(3.2\ \tfrac{kg}{s}) = 6.048\ \tfrac{kW}{K}$$

$$Q = \varepsilon\,(\dot{m} c_p)_{min}\,(T_{h_i} - T_{c_i})$$

(3) $$NTU = \frac{UA}{C_{min}} = \frac{\left(300\ \frac{W}{m^2 K}\right)(15.4\ m^2)}{3.03\ \frac{kW}{K}\left(\frac{10^3\ W}{kW}\right)}$$

$$= 1.52$$

$$\frac{C_{min}}{C_{max}} = \frac{3.03}{6.048} = 0.5$$

$$\varepsilon = 0.67$$