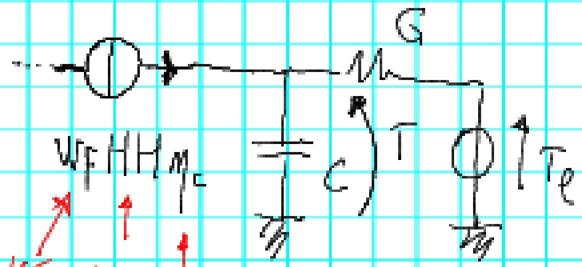
22/06/2016

1

E1) 10/09/2014, E2

a)



$\frac{\cancel{kg}}{s} \quad \frac{MJ}{\cancel{kg}} \quad \#$

$\rightarrow \frac{MJ}{s} = MW$

$HH = 50\ MJ/Kg$

$\eta_c = 0.8$

$G = 30\ W/°C$

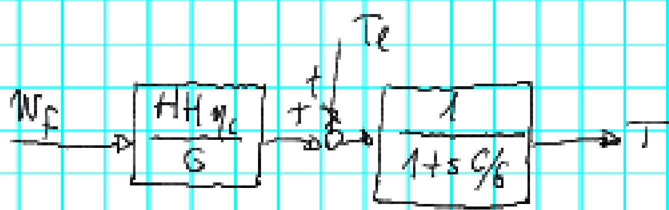
$C = 12\ KJ/°C$

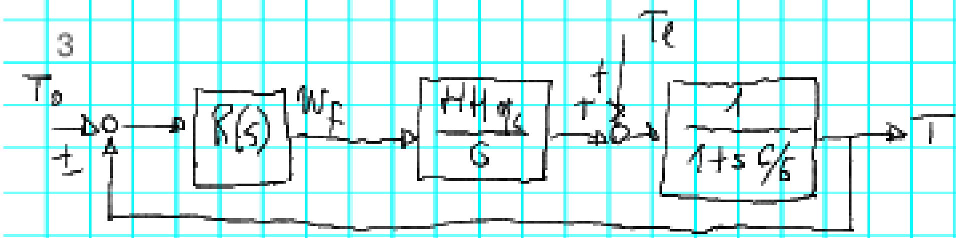
b) $$C\dot{T} = HH\eta_c w_f - G(T - T_e)$$

STATE
INPUTS
PARAMETERS

$$(sC+G)T = HH\eta_c w_f + GT_e$$

$$\left(1+s\frac{C}{G}\right)T = \frac{HH\eta_c}{G} w_f + T_e$$





Natural choice: PI tuned by cancellation

$$P(s) := \frac{T(s)}{W_F(s)} = \frac{HH\eta_c/G}{1+sC/G} \quad , \quad L(s) = R(s)P(s)$$

I want $L(s) = \frac{\omega_c}{s} \Rightarrow R(s) = \frac{\omega_c}{s} \, \frac{1+sC/G}{HH\eta_c/G}$

In the worst-case case

settling time 5 min $\Rightarrow \omega_c = \frac{1}{t_{set}/5} = \frac{1}{60}$ r/s

$\underset{t_{set}}{\wedge}$

$$\Rightarrow R(s) = \frac{1/60}{s} = \frac{1 + s\ 12\cdot 10^3/30}{5\cdot 10^7 \cdot 0{,}8/30} = \frac{1+400s}{8\cdot 10^8\, s}$$

$C = 12$ KJ/°C $= 12000$ J/°C

$G = 30$ W/°C

$HH = 50$ MJ/Kg $= 5\cdot 10^7$ J/Kg

(5) $HH = HH_n \cdot \alpha$ "$_n$" stands for "nominal"

$M_c = M_{cn} \cdot \beta$ $\alpha, \beta \approx 1$

$$L(s) = \underbrace{\frac{\omega_c}{s} \frac{\cancel{1+sC/S}}{\cancel{HH_n} \cancel{M_{cn}}/M}}_{\text{R tuned on nominal values}} \cdot \underbrace{\frac{\cancel{HH_n}\,\alpha\, \cancel{M_{cn}}\,\beta}{\cancel{s}} \frac{1}{\cancel{1+sC/S}}}_{\text{P, functioning with real values}} = \frac{\omega_c \alpha\beta}{s}$$

$\Rightarrow$ decreasing HH and/or M_c decreases response speed

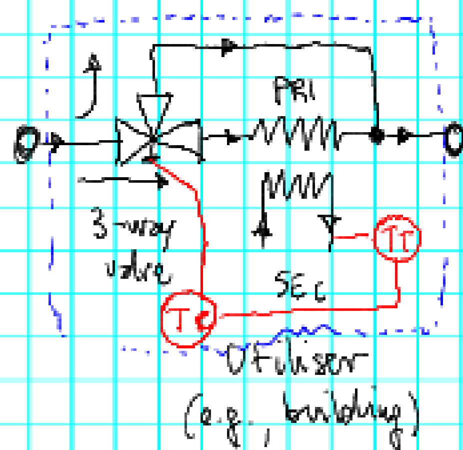
$\Rightarrow$ the two effects multiply

$\Rightarrow$ if HH and/or M_c decrease, ω_p increases

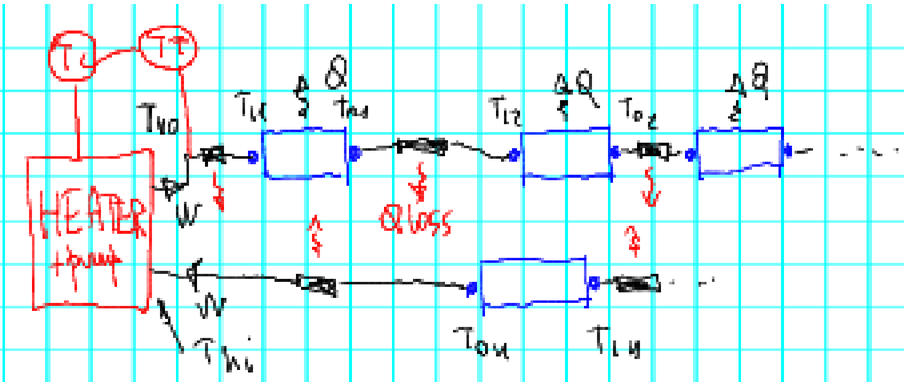
- Control of simple heat networks (just a few words)

Two basic topologies (simplified)

(1)



plus some logic to bypass if no secondary flow



PROS

- min piping length
- ⇒ min Q_{loss}

CONS

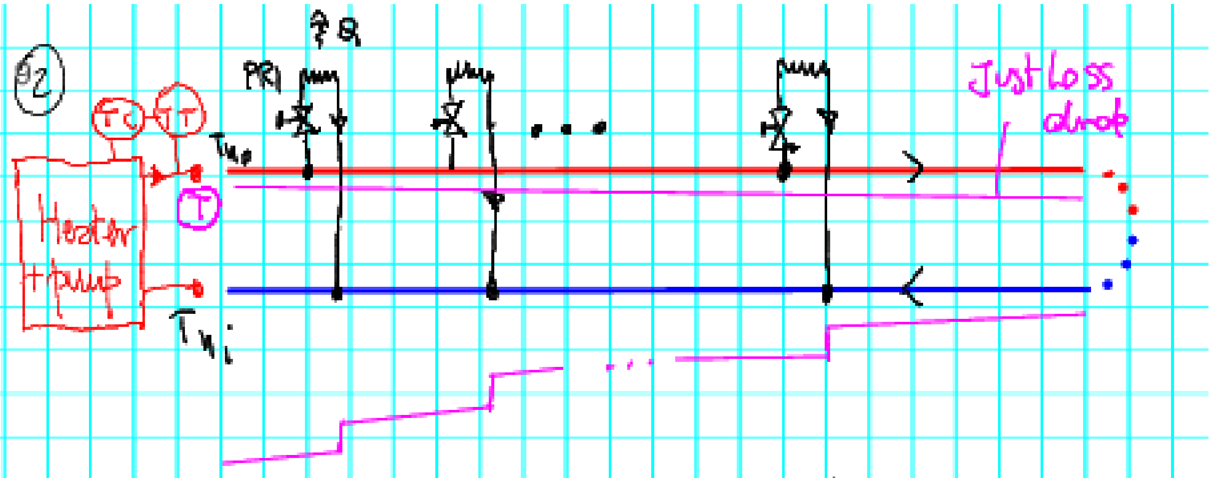
- Each utiliser disturbs those downstream
- ⇒ some central control useful

Requirement: control T_{ho} so that T_{on} is high enough for the last user to get heat

Typically one privileges HIGH flow rates in the ring and low difference between Tho & Thi

$\Rightarrow$ pumping power may be significant

Advisable for small installations, like a compound of residential buildings.



Cons: in general more piping

Pros: no disturbance for downstream users in the hot pipe
No need for centralised control

objectives for the central heater: keep T_{ho} having T_{hi} as a disturbance
ADVISABLE for large networks

□