Process Dynamics & Control

For GATE-2019

Chemical Engineering

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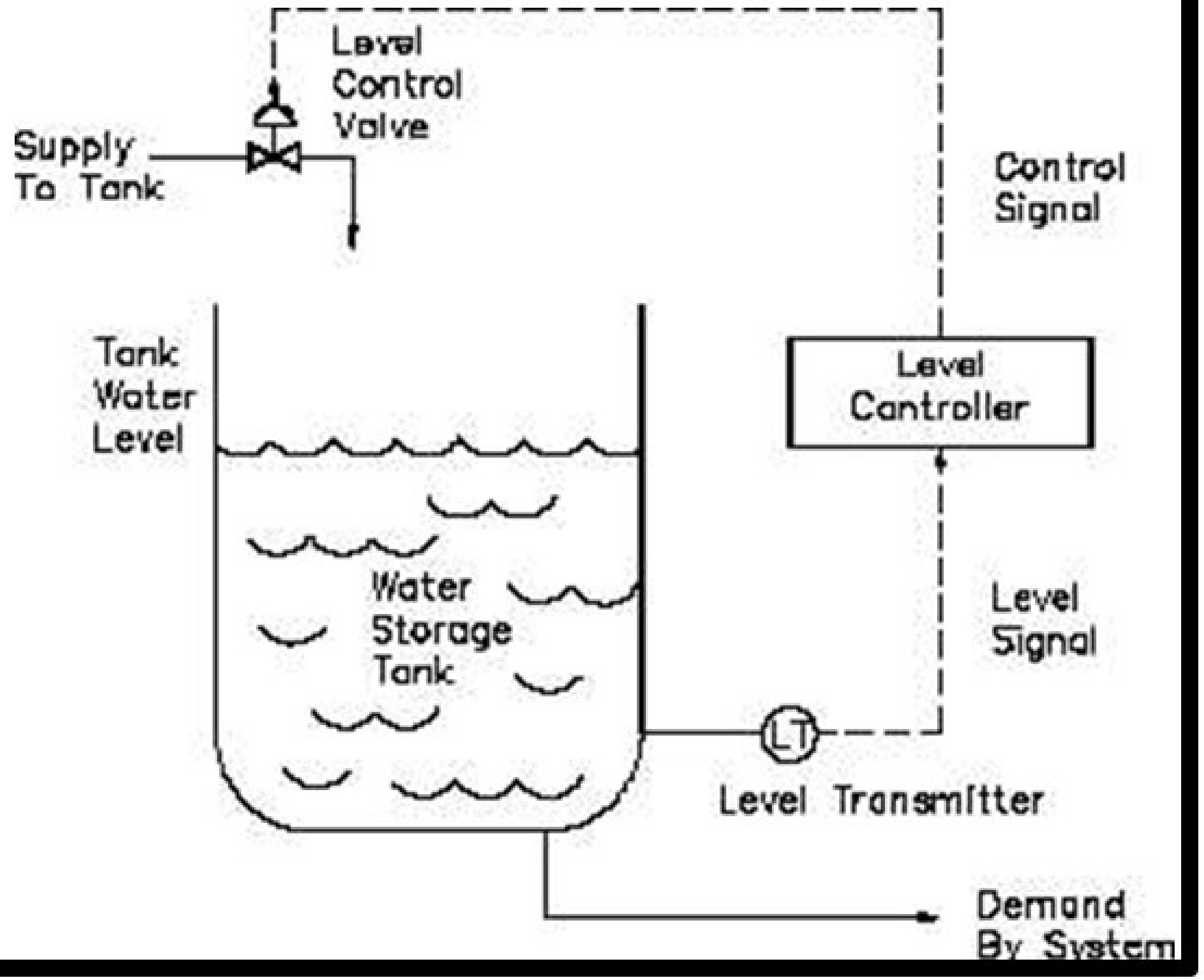
Process Dynamics & Control

Lesson 22

Multi-capacity System- Part 2



#My Courses on Unacademy

- Process Calculations for GATE (Chemical Engineering)-2019
- Preparation Strategy for GATE (Chemical Engineering)-2019 with most important topics.
- Heat Exchangers
- Radiation Heat Transfer for GATE-2019 exam.
- Transportation and Metering of Fluids for PSU Interviews -2018.
- Non-Ideal Reactors for GATE-2019.
- Mass Transfer Equipment for PSU Interviews -2018.
- Chemical Reaction Engineering- Part 1
- How to get Best Rank in GATE 2019 Chemical Engineering

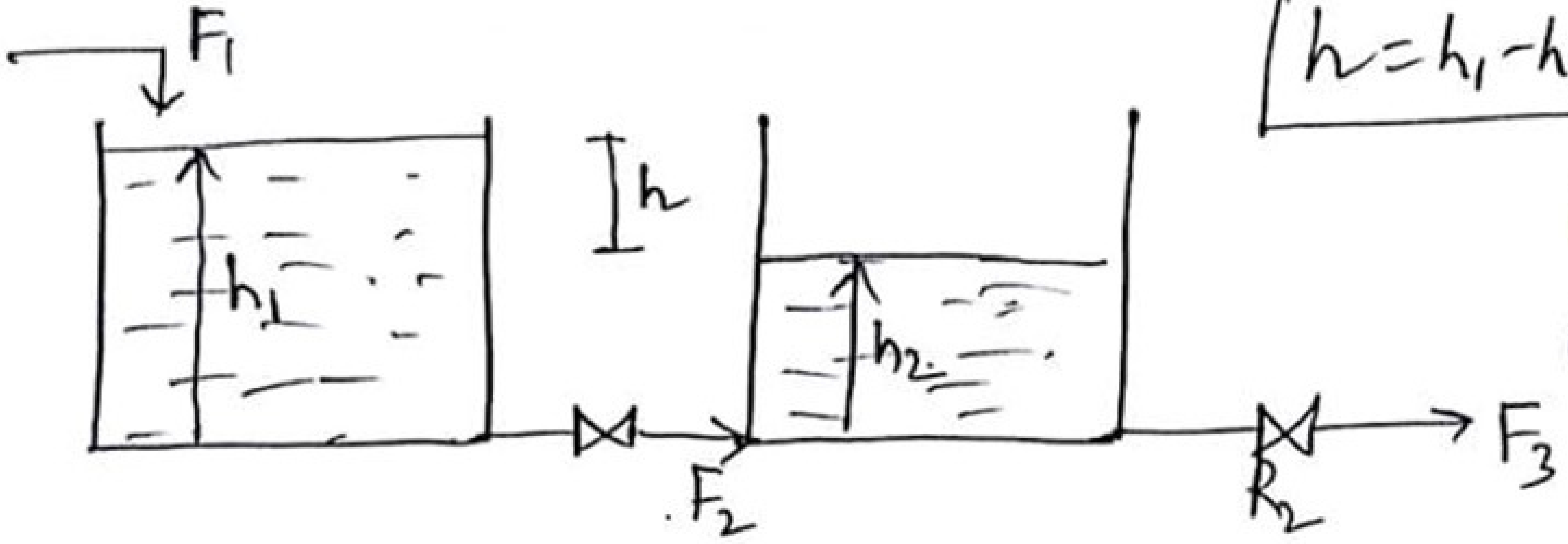
Target Audience

All undergraduate Chemical Engineering Students

GATE- (Chemical Engineering) aspirants

Interacting capacities

$\boxed{h = h_1 - h_2}$



if $h = 0$, no F_2

if $h = -ve$, back flow

if $h = +ve$, forward flow.

$$F_2 = \frac{h_1 - h_2}{R_1} \quad \& \quad F_3 = \frac{h_2}{R_2}$$

Material Balance on tanks results :-

$$F_1 - F_2 = A_1 \frac{dh_1}{dt} \quad \& \quad F_2 - F_3 = A_2 \frac{dh_2}{dt}$$

Replacing F_2 & F_3, we get,

$$A_1 R_1 \frac{dh_1}{dt} + h_1 - h_2 = R_1 F_1 \quad \text{—— (1)}$$

& $$A_2 R_2 \frac{dh_2}{dt} + \left(1 + \frac{R_2}{R_1}\right) h_2 - \frac{R_2}{R_1} h_1 = 0 \quad \text{—— (2)}$$

At s.s., we get

$$h_{1s} - h_{2s} = R_1 F_{1s} \quad \text{—— (3)}$$

$$\left(1 + \frac{R_2}{R_1}\right) h_{2s} - \frac{R_2}{R_1} h_{1s} = 0 \quad \text{—— (4)}$$

Now, subtracting the respective equations & writing in terms of deviation variables, we get,

$$A_1 R_1 \frac{dH_1}{dt} + H_1 - H_2 = R_1 F_1 \quad \text{—(5)}$$

$$A_2 R_2 \frac{dH_2}{dt} + \left(1 + \frac{R_2}{R_1}\right) H_2 - \frac{R_2}{R_1} H_1 = 0 \quad \text{—(6)}$$

Taking laplace transform of equation 5 & 6.

$$(A_1 R_1 s + 1) H_1(s) - H_2(s) = R_1 F_1(s)$$

$$-\frac{R_2}{R_1} H_1(s) + \left[A_2 R_2 s + \left(1 + \frac{R_2}{R_1}\right)\right] H_2(s) = 0.$$

Solving the above equations, we get,

$$\boxed{\frac{H_2(s)}{F_1(s)} = \frac{R_2}{\tau_{p1}\tau_{p2} s^2 + (\tau_{p1} + \tau_{p2} + A_1 R_2) s + 1}}$$

Interacting factor.

Comparing the equation with 2^{nd} order T.F :-

$$\tau^2 = \tau_{p_1}\tau_{p_2} \Rightarrow \boxed{\tau = \sqrt{\tau_{p_1}\tau_{p_2}}} = \text{G.M. of } \tau_{p_1} - \tau_{p_2}$$

& $2\xi\tau = \tau_{p_1} + \tau_{p_2} + A_1R_2$

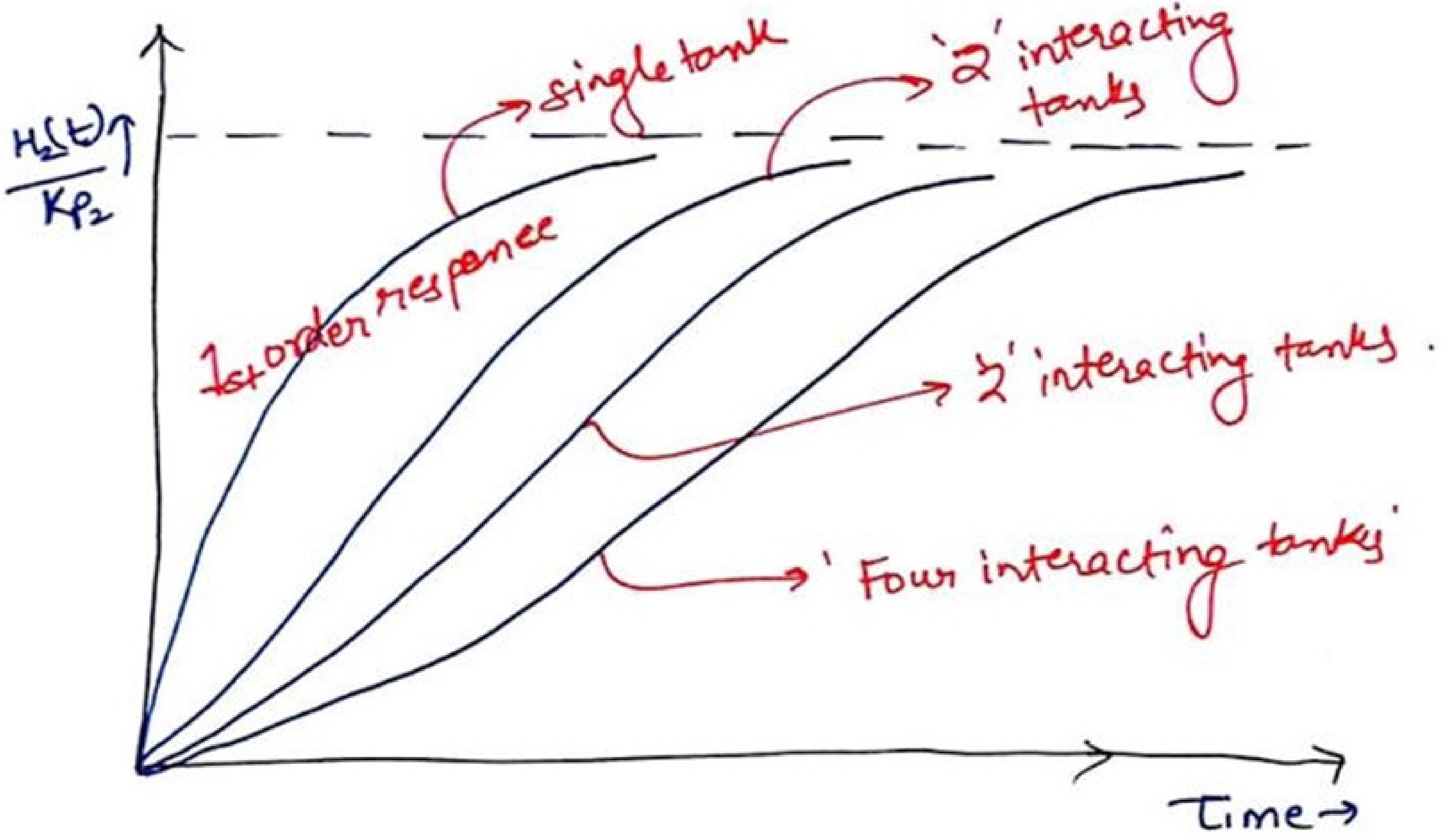
$$\Rightarrow \boxed{\xi_I} = \frac{\tau_{p_1} + \tau_{p_2} + A_1R_2}{2\sqrt{\tau_{p_1} + \tau_{p_2}}}.$$

$$\Rightarrow \boxed{\xi_I = \xi_{N.I} + \frac{A_1R_2}{2\tau}}$$

Cannot be made zero.

\# • $\gamma_I > 1$ (always) → Overdamped → difficult to reach even critical.

\# • $\gamma_{N.I.} > 1$ (always) → but could be made '1' for the case where $\tau_{p_1} = \tau_{p_2}$.



* As the number of capacities in series increases, the delay in the initial response (sluggishness) becomes more pronounded.

Thanks!

You can find me at:

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Any questions?