Process Dynamics & Control

For GATE-2019

Chemical Engineering

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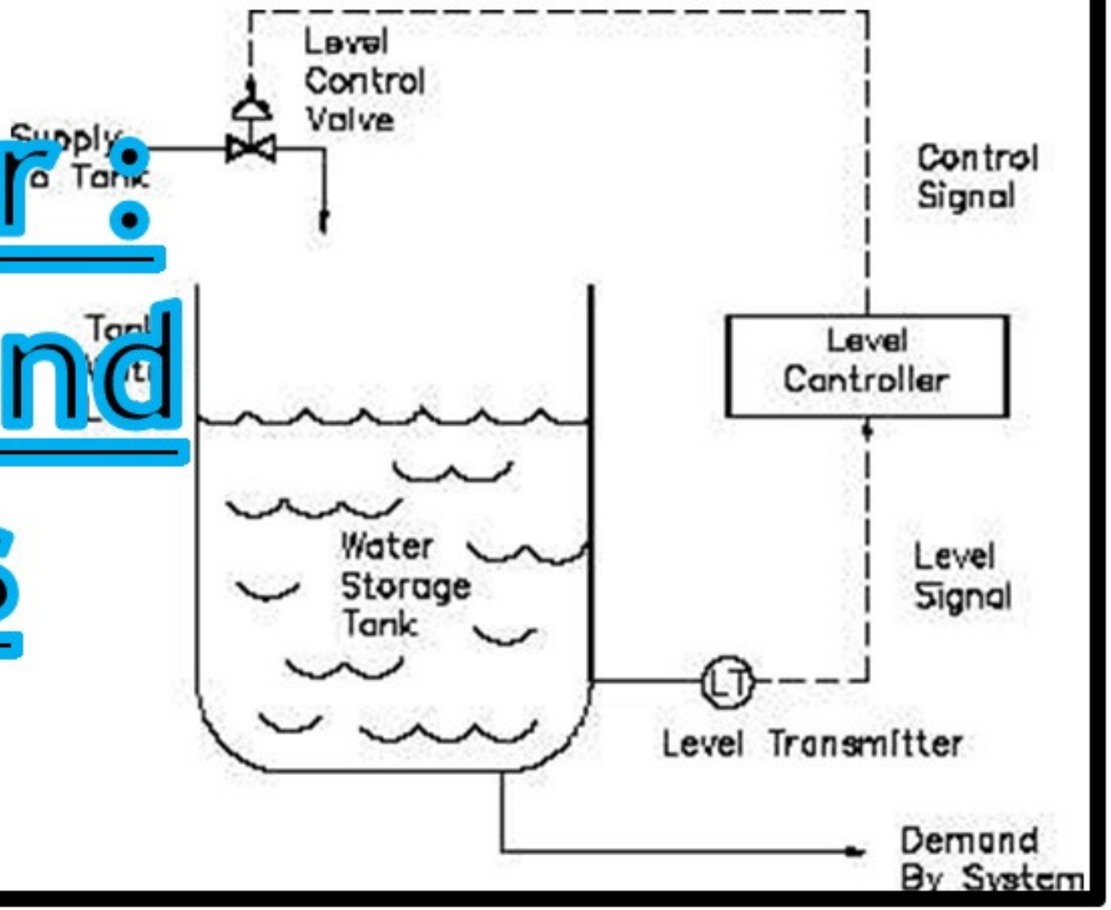
Process Dynamics & Control

Lesson 18

Damped Vibrator: Example of Second Order Systems



#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

Step Response of a 2nd order system

① $\zeta > 1$ ⇒ (Exponential Nature) ⇒ Overdamped.

→ Roots (poles) are real but unequal.

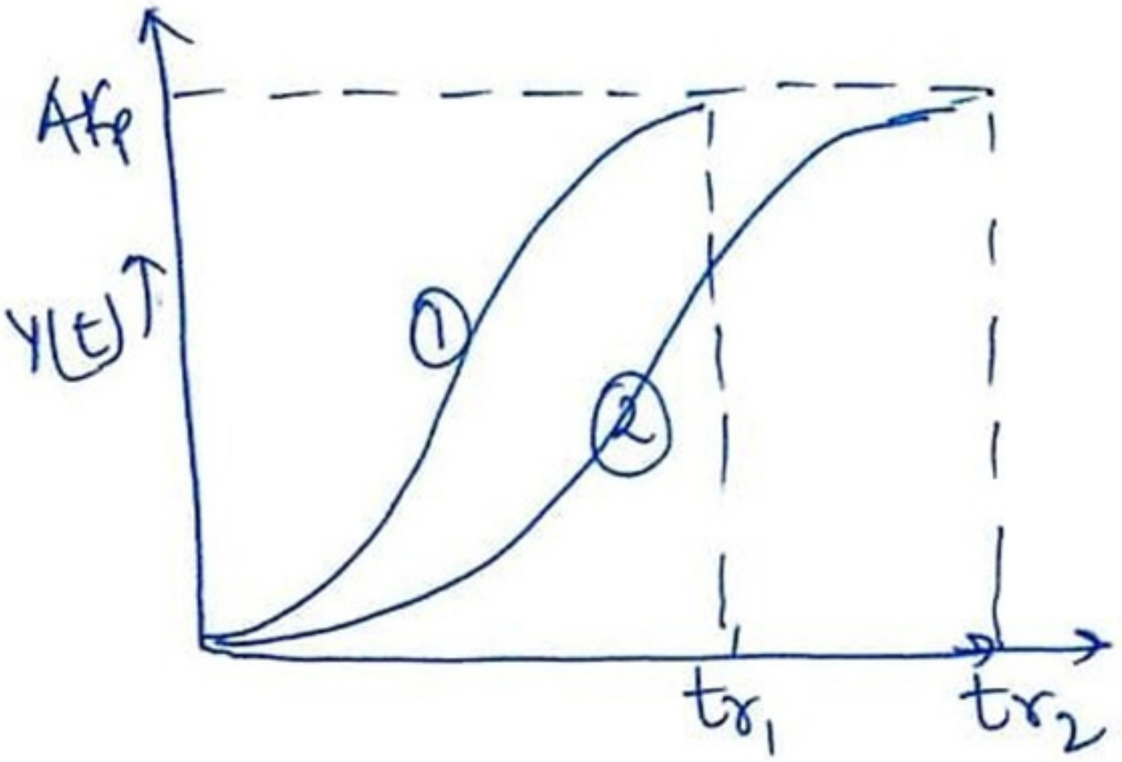
② $\zeta = 1$ ⇒ (exponential + time) ⇒ Critically damped.

→ Roots (poles) are real and equal.

③ $\zeta < 1$ ⇒ (sinusoid) ⇒ Underdamped

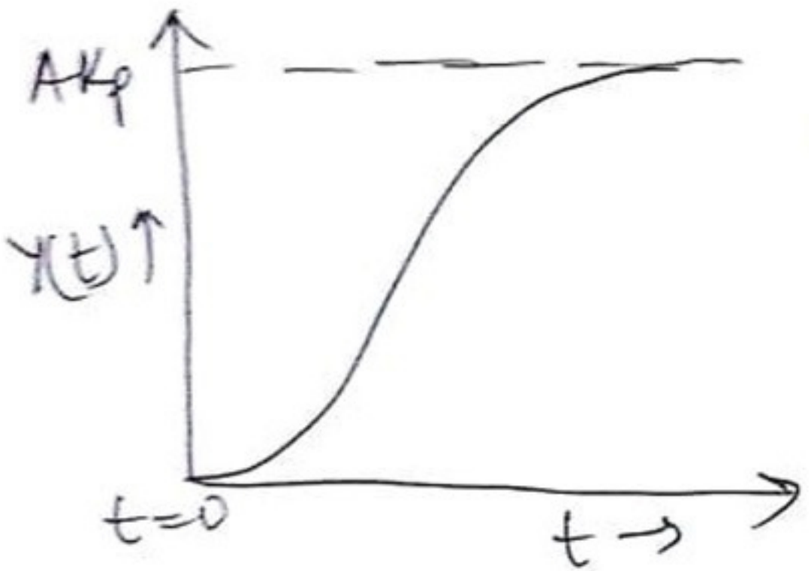
⇒ Roots are complex conjugate.

Overdamped System :- ($\zeta > 1$)



- Sluggish response for increase in the value of 'y'.

Critically damped System ($\zeta = 1$)

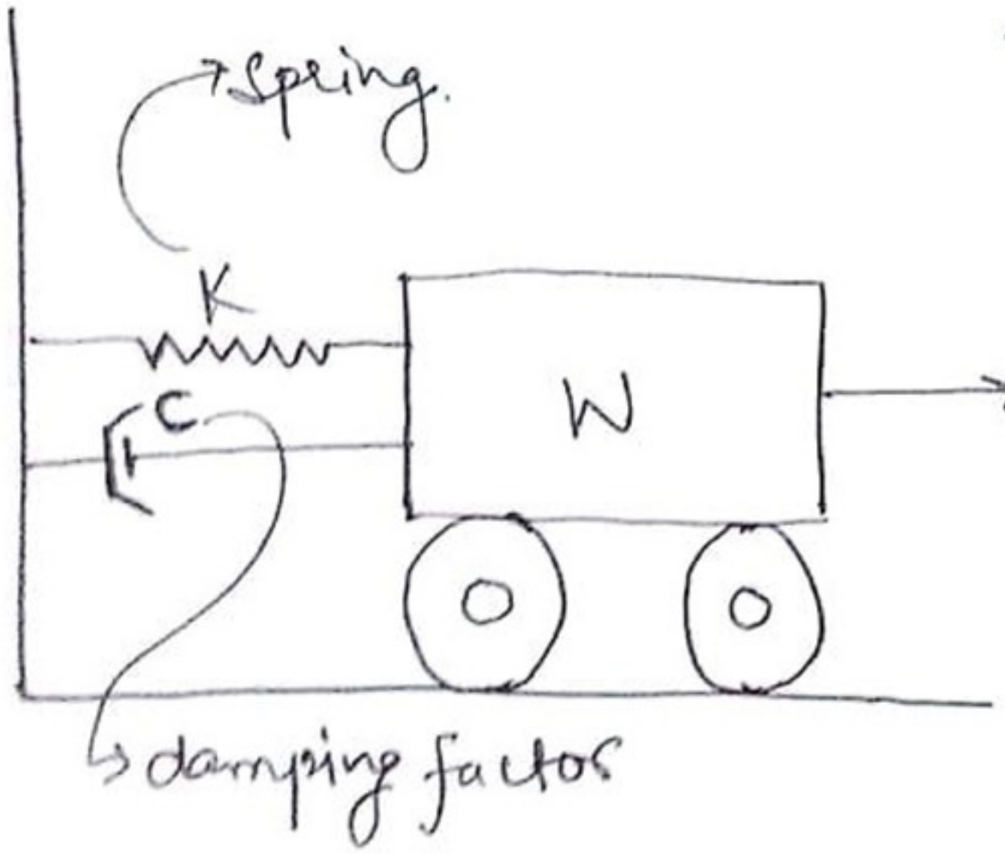


- neither sluggish nor oscillatory.
- are faster because of low ζ.

Physically

['ζ' means resistance offered by the system & as the value of 'ζ' increases, system becomes more & more sluggish.]

Damped Vibrator (An Example of a Second Order Systems)



→Let the system be free to oscillate horizontally under the influence of a forcing function. f(t).

- At a particular instant, following forces are acting on the block:

(1) Force exerted by spring (towards left) → $(-Ky)$

(2) Viscous friction force (acting to the left) → $\left(-c\frac{dy}{dt}\right)$

(3) External force $f(t)$ (acting right) → $f(t)$.

Now, according to Newton's law of motion:

→ Sum of all forces acting on the mass is equal to the rate of change of momentum (mass x acc^n)

So,

$$f(t) - Ky - c\left(\frac{dy}{dt}\right) = m\frac{d^2y}{dt^2}$$

(m: mass; $\frac{d^2y}{dt^2}$: acc^n)

Rearranging, we get

$$\frac{m}{K}\frac{d^2y}{dt^2} + \frac{C}{K} + y = \frac{1}{K} f(t)$$

* Force balance or the equation that contains inertia or torque are not important to chemical engineers & hence second order systems are not important to us.. But there are a few examples in chemical engineering that are inherently second order system.

Examples

(1) U tube manometer

(2) Pneumatic control valve.

(3) Externally mounted level indicator.

(4) Transducers.

Thanks!

You can find me at:

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Any questions?