Lecture 6

ME756A

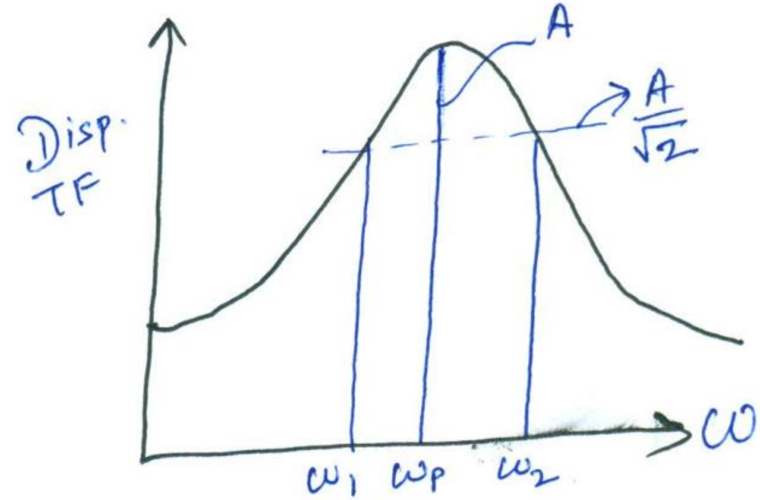
Principles of Vibration Control

Instructor : ***Prof. Bishakh Bhattacharya***
Department of Mechanical Engineering
IIT Kanpur
E-mail: *bishakh@iitk.ac.in*

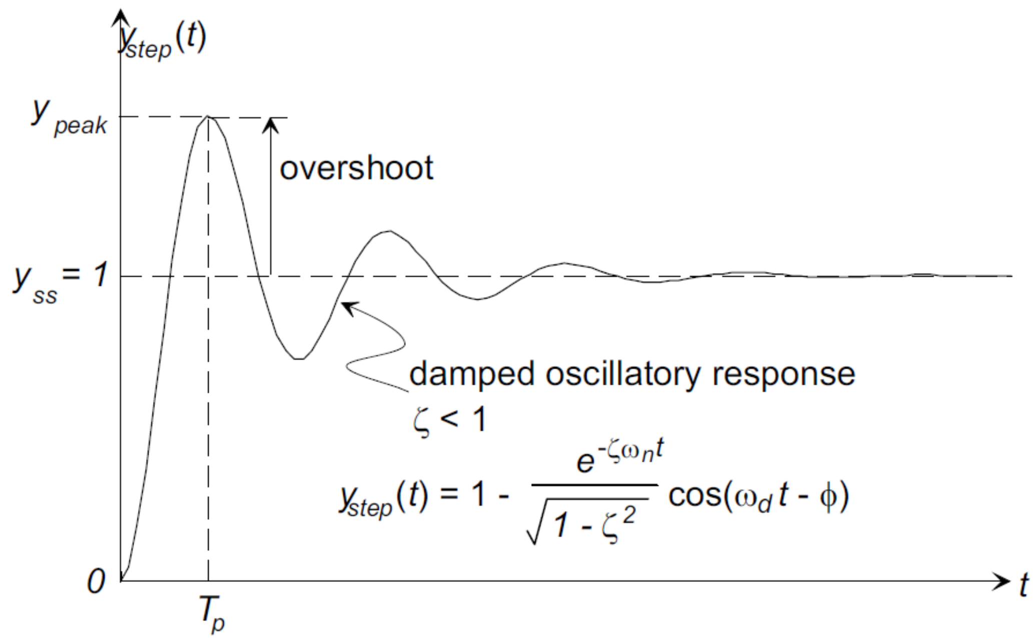
Half-power bandwidth method

$$\eta = \frac{\omega_2 - \omega_1}{\omega_p}$$

$$\xi = \frac{\eta}{2}$$



Damping using Percentage Overshoot

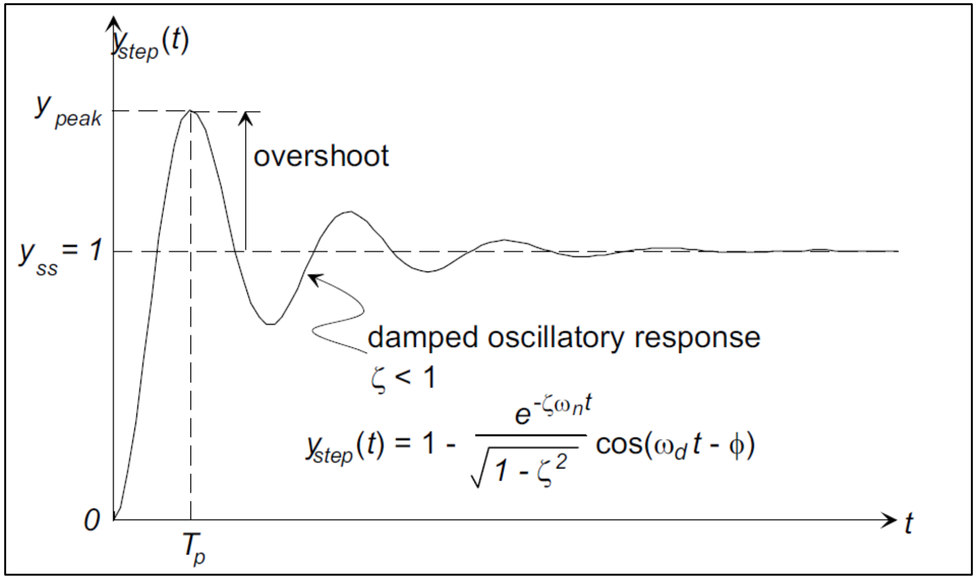


The height of the first peak of the response, expressed as a percentage of the steady-state(ss) response.

$$\% \, OS = \frac{y_{peak} - y_{ss}}{y_{ss}} \text{ x } 100$$

At the time of the peak y (T_p)

$$y_{peak} = y(T_p) = 1 + e^{\frac{-\zeta\pi}{\sqrt{1-\zeta^2}}}$$



And since y_{ss} = 1

$$\% \, OS = e^{\frac{-\zeta\pi}{\sqrt{1-\zeta^2}}} \text{ x } 100$$

Conversely we can find damping ratio, ζ to give a specific percent overshoot from the above

$$\zeta = \frac{-\ln(\% \frac{OS}{100})}{\sqrt{\pi^2 + ln^2(\% \frac{OS}{100})}}$$

Balancing of Rigid Rotors

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- Balancing of Rigid Rotors
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Vibration due to Unbalanced Inertia Forces/Moments

Unbalanced inertia force generated in a machine is a common source of excitation. The machine foundations are subjected to dynamic forces/moments generated due to such unbalanced forces.

The effect of unbalanced forces

● Reduction of the life of the supports ● Vibrations causing noisy operation

Control Remedies

● Balancing of the inertia forces. The first step towards balancing is to analyze the inertia forces (and moments) present in a machine. In

what follows, we shall discuss some practical methods of balancing different kinds of rotors

Balancing of Rigid Rotors

- When the operating speed of a rotor coincides with any of the natural frequencies of its transverse vibration, then the rotor undergoes a significant transverse deflection. This speed is referred to as **Critical Speed**.
- For operating speed far below the first critical speed, the rotor deflection is negligible. In such cases, the rotor is assumed to be rigid and the complete balancing of its inertia (centrifugal) forces can be achieved by attaching two masses at any two arbitrarily chosen axial planes called the balancing planes.
- If, for practical reasons, the masses cannot be attached, the balancing can then still be done by removing the rotor material from the positions diametrically opposite to those positions, the balancing masses would have occupied.

Basic Principles of Balancing Machines

- total unbalance of a rigid rotor can be completely expressed in terms of the unbalances in any two conveniently chosen balancing planes.
- a rigid rotor balanced at one speed can be considered as balanced for any other speed well below the first critical speed.
- the inertia force of the rotor depends on the product of the mass and eccentricity. The amount of a balancing mass may be adjusted depending on its convenient radial position to result in the requisite value of the product.

Balancing Machines

Various types of balancing machines are commercially available. These are commonly used in the production line of rotors. There are two common balancing machines.

- for low-speed, rough rotors which do not require a very high degree of balancing - **Pivoted- Carriage** machines are used**.**
- for intermediate-speed, smooth rotors which need a comparatively more accurate balancing - **Gisholt-type** balancing machines are used

Pivoted-Carriage Balancing Machine

The rotor to be balanced is mounted on half-bearings in a light but stiff carriage. This carriage is pivoted near one end and rests on a spring at the other.

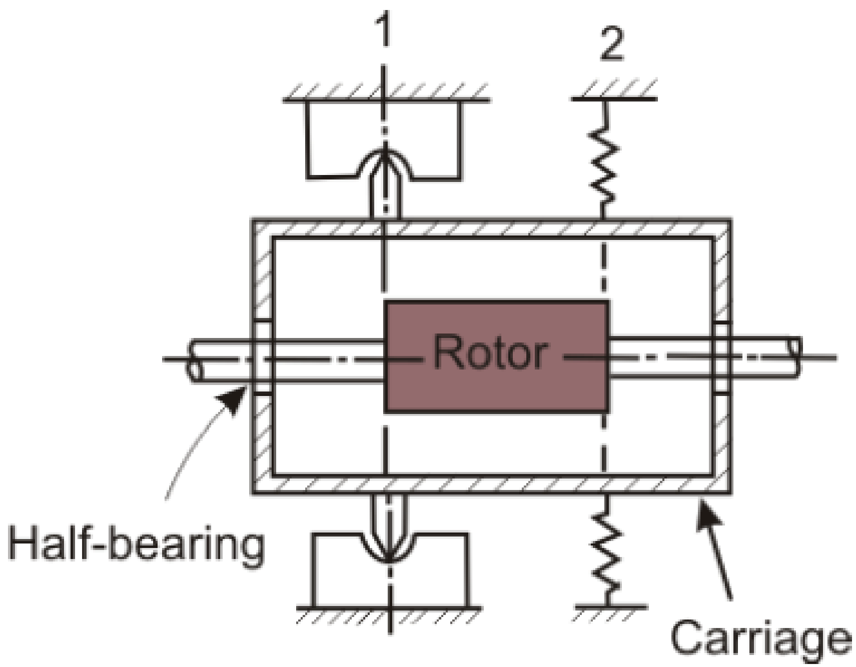
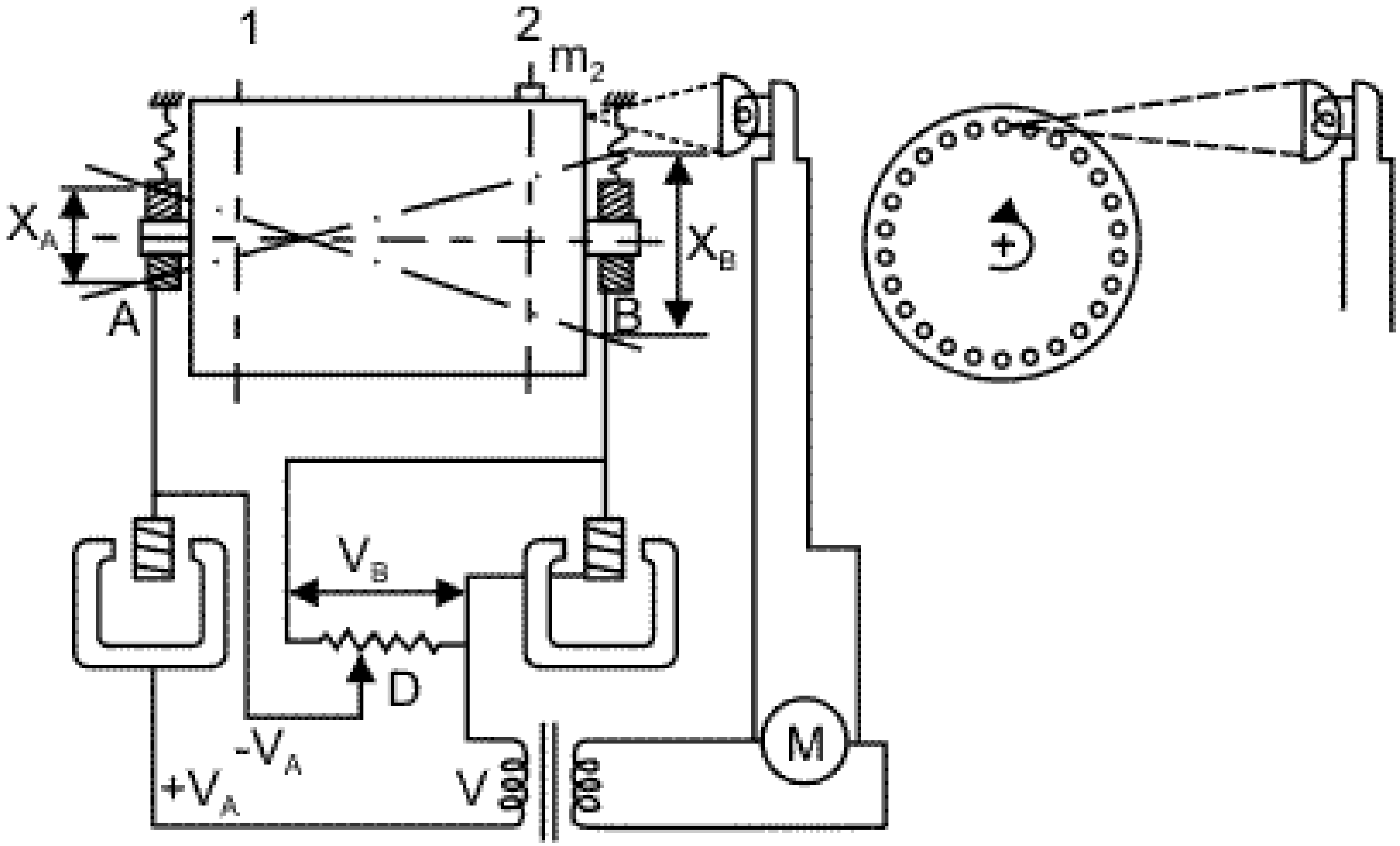


Fig. 5.1

- The rotor is mounted with plane 1 coinciding with the pivot axis so that the unbalance in this plane has no effect on the carriage motion. When the rotor is rotated in this position, the carriage oscillates due only to the unbalance in plane 2.
- A trial mass is then placed (at a known radius) in plane 2 and the amplitude of carriage oscillation is noted.
- The procedure is repeated with the same trial mass (at the same radius) at different angular positions. A plot of the observed amplitude of carriage motion against the angular position of the trial mass indicates the best angular position for which the amplitude is minimum.
- The magnitude of the trial mass is varied at this angular position, and the exact amount of balance mass, which reduces the amplitude to almost zero, is determined by trial and error.
- A similar procedure is followed to determine the required balancing mass in plane 1, the rotor being mounted with plane 2 coinciding with the pivot axis.

Gisholt-type Balancing Machine



More Accurate.

Better for Rotors with Higher Inertia

Characteristics of Gisholt type Balancing

- The rotor is mounted on spring supported half bearings eliminating the inertia of the carriage
- Bearing Vibrations are monitored with the help of accelerometers/LVDTs
- Trial mass placed in Plane 2 generates more voltage to the bearing closer to the mass.
- A part of this is used to nullify the effect of vibration in the further bearing by using a Voltage divider.