Chapter 9
Vibration Control

9

Chapter Outline

9.1
Introduction

9.1

9.1 Introduction

- Vibration leads to wear of machinery and discomfort of humans, thus we want to eliminate vibration
- Designer must compromise between acceptable amount of vibration and manufacturing cost
- We shall consider various techniques of vibration control in this chapter.

9.2
Vibration Nomograph and Vibration Criteria

9.2

9.2 Vibration Nomograph and Vibration Criteria

- Vibration nomograph displays the variations of displacement, velocity and acceleration amplitudes wrt frequency of vibration

- Harmonic motion: $x(t) = X \sin \omega t$

- Velocity: $v(t) = \dot{x}(t) = \omega X \cos \omega t = 2\pi f X \cos \omega t$

- Acceleration: $a(t) = \ddot{x}(t) = -\omega^2 X \sin \omega t = -4\pi^2 f^2 X \sin \omega t$

- Amplitude of velocity: $v_{\max} = 2\pi f X \qquad (9.4)$

- Amplitude of acceleration: $a_{\max} = -4\pi^2 f^2 X = -2\pi f v_{\max} \qquad (9.5)$

9.2 Vibration Nomograph and Vibration Criteria

- Taking log of Eq. 9.3 and Eq. 9.4:

$$\ln v_{max} = \ln(2\pi f) + \ln X$$

$$\ln v_{max} = -\ln a_{max} - \ln(2\pi f)$$

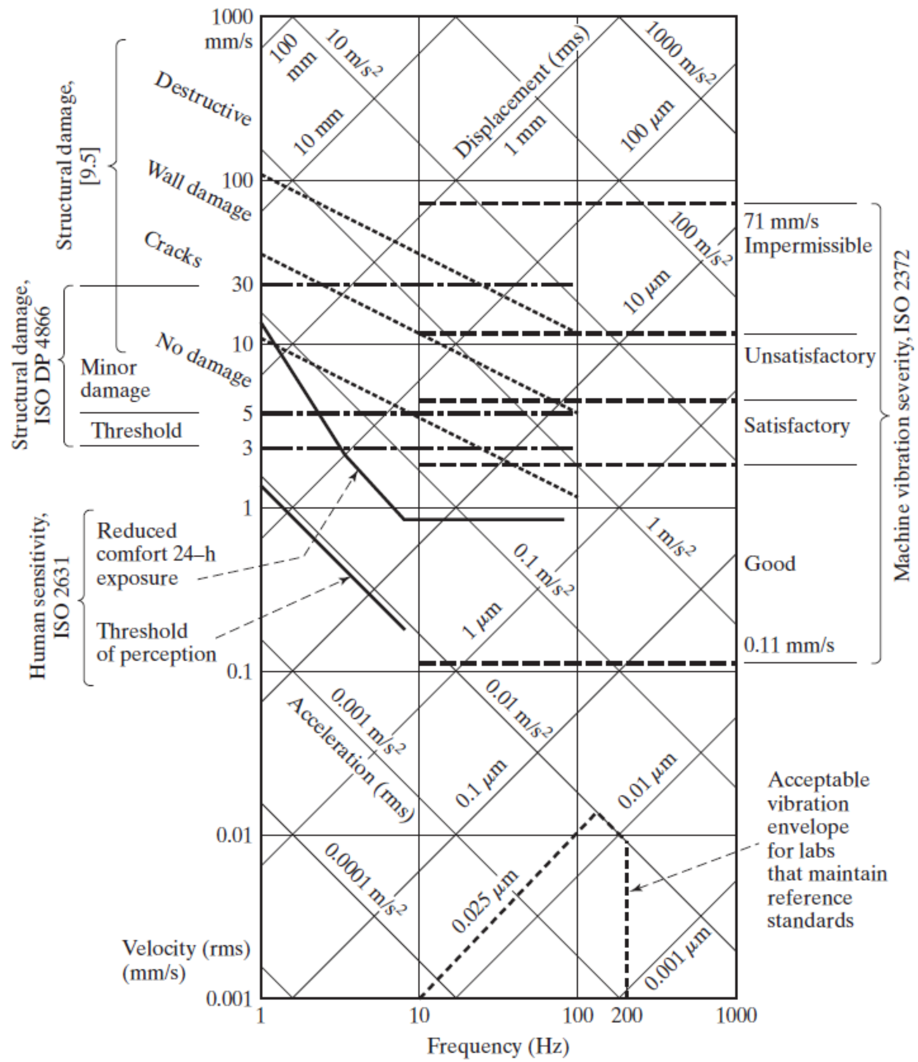
- When X is constant, ln v_{max} varies linearly with ln($2\pi f$)

- When a_{max} is constant, ln v_{max} varies linearly with ln($2\pi f$)

- This is shown as a nomograph in the next slide.

- Every point on the nomograph denotes a specific sinusoidal vibration.

9.2 Vibration Nomograph and Vibration Criteria



9.2 Vibration Nomograph and Vibration Criteria

- Vibration severity of machinery is defined in terms of the root mean square (rms) value of vibration velocity. (ISO 2372)
- Vibration severity of whole building vibration (ISO DP 4866)
- Vibration limits for human (ISO 2631)

9.3
Reduction of Vibration at the Source

9.3

9.3 Reduction of Vibration at the Source

- Try to alter the source so that it produces less vibration
- E.g. balance rotating or reciprocating machines, use close tolerances or better surface finish
- Some sources cannot be eliminated e.g. turbulence, engine combustion instability, road roughness

9.7
Control of Vibration

9.7

9.7 Control of Vibration

- Some import methods to control vibrations:
  - Control ω_n and avoid resonance under external excitations.
  - Introduce damping mechanism to prevent excessive response of system
  - Use vibration isolators to reduce transmission of excitation forces from one part of the machine to another
  - Add an auxiliary mass neutralizer or vibration absorber to reduce response of system

9.8
Control of Natural Frequencies

9.8

9.8 Control of Natural Frequencies

- Resonance →Large displacements →large strains and stresses →failure of system
- Often the excitation frequency cannot be controlled.
- Hence must control natural frequency by varying mass m or stiffness k to avoid resonance.
- Practically mass cannot be changed easily.
- Hence we change stiffness k by altering the material or number and location of bearings (boundary conditions).

9.9
Introduction of Damping

9.9

9.9 Introduction of Damping

- System may be required to operate over a range of speed, hence cannot avoid resonance

- Can use material with high internal damping to control the response (viscoelastic materials).

- Can also use bolted or riveted joints to increase damping.

- Bolted or riveted joints permit slip between surfaces and dissipate more energy compared to welded joints.