Module 9 : Forced Vibration with Harmonic Excitation; Undamped Systems and resonance; Viscously Damped

Systems; Frequency Response Characteristics and Phase Lag; Systems with Base Excitation;

Transmissibility and Vibration Isolation; Whirling of Shafts and Critical Speed.

Lecture 24 : Transmissibility and Isolation

Objectives

In this lecture you will learn the following

- Transmissibility of force and motion

- Considerations in isolation

Transmissibility and Vibration Isolation

When a machine is operating, it is subjected to several time varying forces because of which it tends to exhibit vibrations. In the process, some of these forces are transmitted to the foundation – which could undermine the life of the foundation and also affect the operation of any other machine on the same foundation. Hence it is of interest to minimize this force transmission. Similarly when a system is subjected to ground motion, part of the ground motion is transmitted to the system as we just discussed e.g., an automobile going on an uneven road; an instrument mounted on the vibrating surface of an aircraft etc. In these cases, we wish to minimize the motion transmitted from the ground to the system. Such considerations are used in the design of machine foundations and in order to understand some of the basic issues involved, we will study this problem based on the single d.o.f model discussed so far.

From eqn (9.2.4), we get the expression for force transmitted to the base as follows:

$$F_T = \sqrt{(kX_0)^2 + (c\Omega X_0)^2} \qquad (9.4.1)$$

where

$$X_0 = X_g \sqrt{\frac{k^2 + (c\Omega)^2}{(k - (m\Omega)^2)^2 + (c\Omega)^2}}$$

$$(9.4.2)$$

"Transmissibility Ratio (TR)" is the term commonly used and a plot of the variation of the TR is shown in Fig. 9.4.1. It is observed that when the system is designed such that $\eta <$ (1.414), the TR actually exceeds unity. In order that the TR is sufficiently small, it is desirable to keep the frequency ratio about 5 i.e., the natural frequency of the system must be about 5 times lower than the operating frequency. However, if the springs are made very soft so as to keep the natural frequency low, it could result in excessive static deflection (under the weight of the machine itself). Thus the mountings need to be carefully designed.

Often the mounting system is made up of rubber mounts (e.g., engine mounts in a car), or cork pads apart from the conventional helical coil springs, shock absorbers etc.It is also observed that as $\eta > \sqrt{2}$, damping actually increases the T.R. Thus it would appear necessary to have as low damping as possible. However, to reach an

operating point corresponding to $\eta \rangle \sqrt{2}$ (i.e., $\Omega \rangle \sqrt{2}\omega_n$) one needs to pass through $\Omega = \omega_n$, resonance. To limit resonance amplitudes. We need to have sufficient damping in the system.

Fig 9.4.1

Recap

In this lecture you have learnt the following

- Concept of force transmissibility to the base.

- Variation of transmissibility ratio with frequency ratio

Congratulations, you have finished Lecture 4. To view the next lecture select it from the left hand side menu of the page