Principles of Vibration Control - Web course

COURSE OUTLINE

Oscillation or Vibration is ubiquitous in various fields of engineering including mechanical, aerospace and structural. In most cases, vibration with a lot of associated ill-effects is undesirable. The bad effects of unwanted vibration include loss of quality, malfunctioning, resonance or fatigue failure, excessive wear, generation of noise and other harmful effects on human operators.

Thus, understanding and controlling vibration to bring it down to acceptable level are of paramount importance.

The course will start with a brief recapitulation of basic physics required for understanding and expressing various oscillatory phenomena. This will be followed by a systematic classification and description of various available control methods. Both passive and active methods will be covered. Different methods will be shown to be appropriate depending on the situations.

For large systems, still the passive methods are more popular, some modifying the source and some others modifying the system. Some remedial measures suggest add-on systems to control the vibration of the original system under consideration.

The concept of active vibration control (AVC) has found its early applications in the field of large flexible space structures (LSS). LSS include satellites for communication, space telescopes and multipurpose space platforms like space station. The drive for developing lightweight space structure has increased the sensibility of LSS to low frequency vibration.

There are also numerous examples where AVC could be chosen as a competitive alternate to passive damping. One such growing field of importance is micro-vibration isolation/control. Active materials like Electro and Magneto-Rheological Fluids (ERF and MRF respectively) are being increasingly used in such cases.

NP-TEL

NPTEL

http://nptel.iitm.ac.in

Mechanical Engineering

Pre-requisites:

- Applied Dynamics and Mechanical Vibration

Additional Reading:

1. Vibration Control, Macduff J N and Curreri J R
2. Advanced Structural Dynamics and active control of Structures, Gawronski W K

Hyperlinks:

- http://www.cmmacs.ernet.in/cmmacs/pdf/model_raja.pdf
- Active Vibration Control: http://www.micromega-dynamics.com/vibration-control.htm
- www.isvr.soton.ac.uk/COURSES/Mscauto/Flyers/vibcontrol.pdf

Coordinators:

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Vibration isolation of advanced cars, high speed rail-bogies and isolation of seismic forces are also being mitigated using ERF and MRFs. The course will give a broad overview of different active and semi-active vibration control strategies applied in these fields.

COURSE DETAIL

Module No.	Topic	Lectures
1.	Introduction and Overview of Vibration Control - Basics of vibration will be covered through a series of exciting examples. A brief overview of different methods of vibration control will be discussed - covering a. Vibration Reduction at Source b. Isolation of the Source c. System Redesign d. Remedial Measures e. Active Feedback Control and Shunt Damping	3
2.	Excitation reduction at source and Factors affecting vibration level a. Source Classification b. Control of Flow Induced, Self-excited and Parametrically-excited Systems c. Field Balancing of	5

		Rigid/Flexible Rotors d. Resonance: Detuning and Decoupling e. Damping: Models and Measures		
3.	Dynamic Properties and Selection of Materials a. Damping-Stress relationship b. Selection criteria for linear hysteretic materials c. Design for enhanced material damping d. Linear viscoelastic model e. Relaxation f. Frequency and temperature dependence of complex modulus g. Constrained layer damping - use of viscoelastic laminae	7	
4.	Dynamic Vibration Absorbers a. Dynamic Vibration Neutralizers b. Self-tuned Pendulum Neutralizer c. Optimum Design of Damped Absorbers	5	

		d. Absorber with ideal spring and viscous dashpot e. Gyroscopic vibration absorbers f. Impact Absorbers g. Absorbers attached to continuous systems		
	5.	Vibration isolation of single degree of freedom systems a. Isolators with complex stiffness b. Isolators with Coulomb Damping c. Three-element isolators d. Two-stage isolators e. Pneumatic suspension f. Quasi-zero stiffness isolators	5	
	6.	Principles of Active Vibration Control Tuned Vibration Absorber using Hysteretic Shape Memory Alloy, Electro-magnetic Proof-Mass Actuator, Feedback, Feed-forward and Hybrid techniques for Vibration control, Collocated Vs. Non-collocated Control, Energy conversion and Shunting of mechanical energy, Vibration source isolation using electro/magneto rheological fluids,	5	

	Distributed Control Strategy - Active Tendon Control of Cable Structures, Control of Plate Vibration.		
7.	Piezoelectric and Magnetostrictive Transducers - Piezoelectric ceramics and Piezoelectric Polymeric Materials, Single Crystal vs. Polycrystalline Sensors, Constitutive Relationship, Basic Design of Piezoelectric Strain and Acceleration Sensors, Amplifiers for Piezoelectric Sensors, Giant Magnetostrictive Materials, Magnetostrictive Mini-Actuators, Delay-Line Sensors, Strain and Torque Sensors based on Villari-and Matteuci effect. Distributed Vibration Control - Active Damping Strategy of Cable Stayed Structures, Distributed Transducers for Active Control of Plate and Beam Vibration.	5	
8.	Shape Memory Actuators for Vibration Control - Shape Memory Materials - Nitinol Alloy and Shape memory Polymers, Pseudo-elasticity and Shape-Memory Effect, Tuned Vibration Absorbers using SMA, Low frequency Vibration Control using discretely attached SMA wire, Control of instabilities in pipes	5	

	using SMA. Basics of Electro- and Magneto- Rheological Fluids, Active Vibration Isolation using ERF and MRF, Isolation of Vibrating Systems from Random External Excitation - feed-forward and feed-back control strategies.		

References:

1. Principles of Vibration Control, A. K. Mallik
2. Passive Vibration Control, D. J. Mead
3. Vibration Control of Active Structures, A Premount
4. Journal Papers on this subject