TEQIP – III Sponsored Short-Term Course

Vibration Analysis of Rotor Bearing Systems

(March 2-6, 2020)

Venue: Department of Mechanical Engineering, Indian Institute of Technology Delhi, New Delhi – 110016

Course Coordinator: Prof. Ashish K Darpe

Faculty: Prof. K Gupta, Prof. J K Dutt and Prof. Ashish K Darpe

Department of Mechanical Engineering, IIT Delhi

IIT Delhi, established in 1961, is one of the premier technical engineering institutions in the country, with a vision to contribute to India and the world through excellence in scientific and technical education and research. The institute is located at center of the city, Delhi, a symbol of the country’s rich past and thriving present, where ancient and modern blend seamlessly together. The institute has nearly 35 academic units that imparts knowledge on Engineering, Science, Design, Social Science, among others. The institute has always been the source of valuable resource for industry and society, and to remain a source of pride for all Indians. Recently, IIT Delhi has been elevated to the status of “Institution of Eminence” by GOI.

Contact us:

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Last date of registration 15th February, 2020
Registration form: https://docs.google.com/forms/d/e/1FAIpQLSdF0cSY4nMZJho4YHhpSAw8qTfx63eJ9AEKeCWTfUqSiu4ww/viewform?vc=0&c=0&w=1
Scope of the Course:

This course builds on a fundamental theory of vibrations to explore the unique features of dynamics of a rotor. It is suited for the research scholars and graduate students who wish to understand the complexities of dynamics of rotor that is different in many aspects from the general structural vibration. Fundamental understanding of the rotor dynamics can help better comprehend robust approach to condition monitoring and fault diagnosis of machinery. Apart from the basic modelling and analysis approach to rotor vibration problems, influence of support elements such as bearings and seals on the rotor dynamics and its stability will be a major topic that will help the students realize the importance of fundamental understanding of dynamic coefficients of the support elements for the robust design of rotating machines. One of the complex issues in the design of turbomachinery is dynamic instability, which will be illustrated in a unique lucid way. Finally, the torsional vibrations in a planetary gearbox and use of fault modelling and analysis for bearings and gears will be discussed. The course will give an extensive overview of key rotor dynamic phenomenon and correlation to the rotor design parameters.

Learning Objective of the course

- To be able to model any given rotor-bearing system using a simplified model
- To be able to analyse steady state and transient response
- Understand the role of support elements on rotor dynamics
- Mathematical modelling and analysis of common rotor-bearing faults

Learning Outcomes

- Analyse the vibration features associated with typical rotor bearing faults
- Understand the role played by bearings and seals on the vibration response
- Understand the reasons and sources of instability in rotor bearing system

Accommodation

Boarding and lodging will be arranged for the selected candidates, as per TEQIP-III norms, on sharing basis from 1st March 2020 to 6th March 2020. However, due to a limited number of rooms in the guest house, the allotment will be on first-come, first-served basis.

Travel

Travelling Allowances will be provided for the candidates (belonging to institutions listed under TEQIP-III) from their hometown to IIT Delhi up to a maximum of the 3rd A/C train fare.

Registration

No registration fee for TEQIP-III participants (Research scholar and Faculty of TEQIP-III institution). However, a refundable security deposit of ₹2,000, for completion of registration process is mandatory.

For ‘non TEQIP-III participants’ mandatory registration fee for participation as following:

- ₹ 5,000/- + (18%)GST – Research Scholars
- ₹ 10,000/- + (18%)GST – Faculty
- ₹ 30,000/- + (18%)GST – Industry participants

Fee is payable online (via net banking) to the IIT Delhi CEP Account. The account details are:

Account holder: IITD CEP Account
Account number: 36819334799
Name of the Bank: SBI, IIT Delhi
IFS Code: SBIN0001077
SWIFT Code: SBININBB547
MICR Code: 110002156
IITD PAN no.: AAATI0393L
GSTN: 07AAATI0393L1ZI
# Lecture Plan and Contents

**Pre-requisite:** Basic understanding of dynamics and differential equations. Basic understanding of mechanical vibration is desirable, but not essential.

<table>
<thead>
<tr>
<th>Day</th>
<th>Topic</th>
<th>Sub-topic</th>
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| 1   | Basics of Rotor Dynamics, Introduction to vibration phenomenon | a. Unique features of vibration phenomenon in a rotor against a structure  
   b. Rigid versus Flexible rotor  
   c. Natural Frequency, Mode shapes and Damping  
   d. Excitation, synchronous and asynchronous response  
   e. Various excitation mechanisms in rotating systems |
|     | Basics of Rotor Dynamics (contd.) | a. Free and forced vibration response, forward/backward whirls  
   b. Gyroscopic effects  
   c. Campbell diagram, Critical Speed Maps, Natural Frequency Maps  
   d. Steady state and transient vibration response (coast up/rundown)  
   Demonstration of Maps and Response using MATLAB program |
| 2   | Vibration response of Rotors in presence of typical faults | Rotor asymmetry, rotor bow, fatigue crack, rotor – stator rub, etc.  
   a. Mathematical models  
   b. Signal processing and analysis  
   c. Demonstration of fault features in the response using MATLAB program |
|     | Balancing of Rotors | a. Rigid rotor balancing  
   b. Flexible rotor balancing  
   c. MATLAB Program based exercise |
| 3   | Influence of Bearings | a. Bearings: types, selection and modelling  
   b. Evaluation of bearing dynamic coefficients and its influence on rotor dynamic behaviour  
   c. Case study on dynamics of a turbo-pump |
|     | Instability in Rotors | a. Fundamental Understanding of dynamic instability in rotors |
| 4   | Instability in Rotor Bearing Systems | a. Effect of dynamic stiffness and damping coefficients of bearings and seals in rotors  
   b. Various sources of instability in rotors |
|     | Torsional Vibration Analysis | a. Discrete system approach for modelling and analysis of torsional vibrations of coupled rotor system  
   b. Application to Planetary gearbox dynamics |
| 5   | Condition Monitoring and Diagnostics | a. Fault modelling and simulation  
   b. Sensors and instrumentation  
   c. Data processing and analysis  
   d. Recent Research directions on Bearing and Gearbox Fault Diagnostics  
   e. Case study |