

Determination of Unbalance in Rotating Machine Using Vibration Signature Analysis

B. Kiran Kumar¹, G. Diwakar², Dr. M. R. S. Satynarayana³

¹M. Tech Student, Mech Dept, P.V.P.S.I.T, KANURU, Vijayanada-7, Andhra Pradesh, INDIA

²Assoc. Professor, Mech Dept, P.V.P.S.I.T, KANURU, Vijayanada-7, Andhra Pradesh, INDIA

³Vice principal, Gitam University, Visakhapatnam, Andhra Pradesh, INDIA

ABSTRACT: Vibrations are found almost everywhere in rotating machines. Rotating machinery vibrates due to unbalances, misalignments and imperfect bearings. Vibrational analysis of rotating machinery is able to identify a large number of system ills. Shaft bow, shaft unbalance and coupling misalignments make up the major portion of the observed vibrational frequency spectra of rotating machinery. These vibrational spectra can be used to determine the type of rotating system abnormality. Unbalance is the most cause of machine vibration, an unbalanced rotor always cause more vibration and generates excessive force in the bearing area and reduces the life of the machine. In this paper, experimental studies were performed on a rotor to predict the unbalance in rotor. The vibration velocities were measured at five different speeds using FFT (Fast Fourier Transform) at initial condition. Based on vibration readings spectrum analysis and phase analysis was carried out to determine the cause of high vibrations. By observing the spectrum unbalance was identified. Then Rotor was balanced and found that vibrations were reduced. The experimental frequency spectra were obtained for both balanced and unbalanced condition under different unbalanced forces at different speed conditions. This paper aims at the implementation of condition based maintenance on rotating machine, by adopting Vibration spectrum analysis which is a predictive maintenance technology. It eliminates unnecessary opening of equipment with considerable savings in personnel resources.

Keyword: Vibration Signature Analysis, Vibration Spectrum Analysis, Unbalance, FFT

Nomenclature:

MINDE: Motor Non Drive End;

MDE: Motor Drive End;

PBE: Pillow Block End;

H: Horizontal;

V: Vertical

A: Axial

v: Velocity

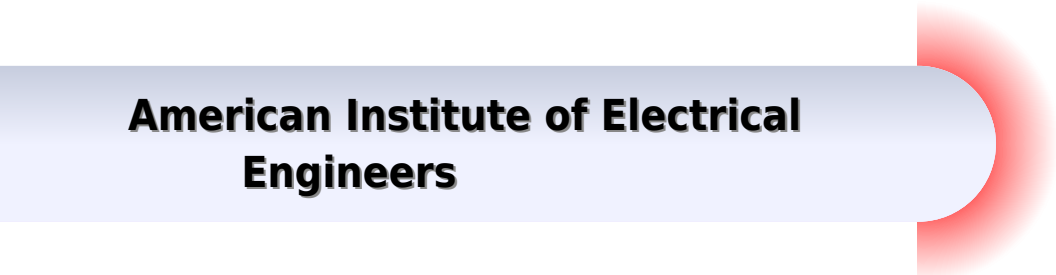
I. INTRODUCTION

Rotor unbalance is the most common reason in machine vibrations. Most of the rotating machinery problem can be solved by using the rotor balancing and misalignment. A very small amount of unbalance may cause severe problem in high speed rotating machines. Overhung rotors are used in many engineering applications like pump, fans, propellers and turbo machinery. The vibration signature of the overhung rotor is totally different from the center hung rotors. The vibration caused by unbalance may destroy critical parts of the machine, such as bearings, seals, gears and couplings. In practice, rotors can never be perfectly balanced because of manufacturing errors such as porosity in casting, non-uniform density of material, manufacturing tolerances and gain or loss of material during operation [1] As a result of mass unbalance, a centrifugal force is generated and must be reacted against by bearing and support structures. A number of analytical methods have been applied to unbalance response such as the transfer method [2]. Further, the unbalance part of the rotor rotates at the same speed as the rotor and therefore the force caused by the unbalance is synchronous [3]. However all the above investigations resulted in fu numerical solutions of the unbalance responses of coupled two-shaft rotor-bearing system. On the other hand, Rao [4] suggested analytical closed-form expressions for the major and minor axis radii of the unbalance response orbit for one-shaft rotor-bearing system. Rao *et al.* [5] and Shiao *et al.* [6]. Vibration signatures are widely used as a useful tool for studying progressive machine mechanical malfunctions, and also form the baseline signature for further comparative monitoring to detect mechanical faults [7]. In this paper a general method is presented for obtaining the unbalance response orbit based on the experimental, where the shafts rotate at different speeds. Unbalance system of an overhung rotors are considered for unbalance study. Experiments were conducted for a single mass, at five different speeds and corresponding results are plotted. The rotor unbalance can be detected by spectral and phase analysis.

Description of the Experimental Setup: The Experimental apparatus is shown in photograph of Figure 2 and Figure 3. It consists of a 0.5 hp A.C. Induction motor 1440 rpm speed, a fixed type flange coupling and a single disk rotor. The rotor shaft is supported by single identical ball bearing (pillow block) and has a length of 1000 mm with a bearing span of 750 mm. The diameter of the rotor shaft is 16 mm. A disk of 220 mm in diameter and 6 mm in thickness is mounted on the rotor shaft at bearing end. The rotor shaft is driven by 0.5 hp A.C. motor. The speed of the motor is controlled by using VFD (Variable Frequency Drive) which is mainly used for A.C motors, to increase or decrease the speeds of the motor in the range of 500 to1440 rpm. The instrument used in experiment includes FFT which measures the vibration in terms of velocity at MINDE, MDE & PBE housing and gives the corresponding values.

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Machine Analysis with Computer Applications for Mechanical Engineers James Doane, 2015-09-28 The aim of this book is to motivate students into learning Machine Analysis by reinforcing theory and applications throughout the text The author uses an enthusiastic hands on approach by including photos of actual mechanisms in place of abstract line illustrations and directs students towards developing their own software for mechanism analysis using Excel Matlab An accompanying website includes a detailed list of tips for learning machine analysis including tips on working homework problems note taking preparing for tests computer programming and other topics to aid in student success Study guides for each chapter that focus on teaching the thought process needed to solve problems by presenting practice problems are included as are computer animations for common mechanisms discussed in the text Principles of Vibration Analysis with Applications in Automotive Engineering Ronald L Huston, C Q Liu, 2011-01-10 This book written for practicing engineers designers researchers and students summarizes basic vibration theory and established methods for analyzing vibrations Principles of Vibration Analysis goes beyond most other texts on this subject as it integrates the advances of modern modal analysis experimental testing and numerical analysis with fundamental theory No other book brings all of these topics together under one cover The authors have compiled these topics compared them and provided experience with practical application This must have book is a comprehensive resource that the practitioner will reference time and again Vibratory Condition Monitoring of Machines J. S. Rao, 2000 Vibratory Condition Monitoring of Machines discusses the basic principles applicable in understanding the vibratory phenomena of rotating and reciprocating machines It also addresses the defects that influence vibratory phenomenon instruments and analysis procedures for maintenance vibration related standards and the expert systems that help ensure good maintenance programs The author offers a minimal treatment of the mathematical aspects of the subject focusing instead on imparting a physical understanding to help practicing engineers develop maintenance programs and operate machines efficiently Vibration Spectrum Analysis Steve Goldman, 1999 Written for vibration analysts predictive maintenance specialists field mechanics and a wide variety of engineers Vibration Spectrum Analysis assumes no prior knowledge of advanced mathematics or mechanical engineering It carefully guides the reader through sophisticated analysis techniques in a logical easy to understand manner **BOOK JACKET** **Vibration Spectrum Analysis and Machine Reliability** Pasquale De Marco, 2025-07-23 Vibration Spectrum Analysis and Machine Reliability provides a comprehensive overview of vibration analysis techniques and their application to the diagnosis and correction of machine problems Written in a clear and concise style this book is an essential resource for engineers technicians and anyone else who works with machines or structures This book covers the basic concepts of vibration including frequency amplitude and damping It then introduces the various techniques used to measure and analyze vibration including time domain analysis frequency domain analysis and spectral analysis The book also discusses the common vibration problems that occur in

machines and structures such as unbalance misalignment looseness bearing faults and gear faults The book provides detailed guidance on how to diagnose and correct these problems In addition to its coverage of basic vibration analysis this book also discusses more advanced topics such as vibration control vibration testing and vibration simulation These topics are essential for engineers who need to design and operate machines and structures that are safe and reliable This book is a valuable tool for anyone who works with machines or structures and it can help to ensure the safety and reliability of these systems Key Features Comprehensive coverage of vibration analysis techniques Written in a clear and concise style Essential resource for engineers technicians and anyone else who works with machines or structures Covers the basic concepts of vibration Introduces the various techniques used to measure and analyze vibration Discusses the common vibration problems that occur in machines and structures Provides detailed guidance on how to diagnose and correct these problems Covers more advanced topics such as vibration control vibration testing and vibration simulation If you like this book write a review

Modeling and Stability Analysis of Inverter-Based Resources Lingling Fan,Zhixin Miao,2023-11-29 Renewable energy sources interface with the ac grids via inverters are termed inverter based resources IBRs They are replacing traditional fossil fuel based synchronous generators at a dazzling speed In turn unprecedented dynamic events have occurred threatening power grid reliability Modeling and Stability Analysis of Inverter Based Resources provides a fundamental understanding of IBR dynamics Developing reliability solutions requires a thorough understanding of challenges and in this case IBR associated dynamics Modeling and stability analysis play an indispensable role in revealing a mechanism of dynamics This book covers the essential techniques of dynamic model building for IBRs including type 3 wind farms type 4 wind farms and solar photovoltaics Besides modeling this book offers readers the techniques of stability analysis The text includes three parts Part 1 concentrates on tools including electromagnetic transient simulation analysis and measurement based modeling Part 2 focuses on IBR modeling and analysis details Part 3 highlights generalized dynamic circuit representation a unified modeling framework for dynamic and harmonic analysis This topic of IBR dynamic modeling and stability analysis is interesting challenging and intriguing The authors have led the effort of publishing the 2020 IEEE Power and Energy Society's TR 80 taskforce report Wind Energy Systems Subsynchronous Oscillations Modeling and Events and the two taskforce papers on investigation of real world IBR dynamic events In this book the authors share with readers many insights into modeling and analysis for real world IBR dynamic events investigation

Advances on Analysis and Control of Vibrations Mauricio Zapateiro,Francesc Pozo,2012-09-05 Vibration is a phenomenon that we can perceive in many systems Their effects are as diverse as the personal discomfort that can produce the unevenness of a road or the collapse of a building or a bridge during an earthquake This book is a compendium of research works on vibration analysis and control It goes through new methodologies that help us understand and mitigate this phenomenon This book is divided into two sections The first one is devoted to new advances on vibration analysis while the second part is a series of case studies that

illustrate novel techniques on vibration control The applications are varied and include areas such as vehicle suspension systems wind turbines and civil engineering structures **Vibration Analysis, Instruments, and Signal Processing** Jyoti Kumar Sinha,2014-12-17 Provides Typical Abstract Representations of Different Steps for Analyzing Any Dynamic System Vibration and dynamics are common in everyday life and the use of vibration measurements tests and analyses is becoming standard for various applications Vibration Analysis Instruments and Signal Processing focuses on the basic understanding of vibrat Vibration Engineering and Technology of Machinery, Volume I Rajiv Tiwari,Y. S. Ram Mohan,Ashish K. Darpe,V. Arun Kumar,Mayank Tiwari,2023-12-12 This book presents the proceedings of the XVI International Conference on Vibration Engineering and Technology of Machinery VETOMAC 2021 It gathers the latest advances innovations and applications in the field of vibration and technology of machinery Topics include concepts and methods in dynamics dynamics of mechanical and structural systems dynamics and control condition monitoring machinery and structural dynamics rotor dynamics experimental techniques finite element model updating industrial case studies vibration control and energy harvesting and MEMS The contributions which were selected through a rigorous international peer review process share exciting ideas that will spur novel research directions and foster new multidisciplinary collaborations The book is useful for the researchers engineers and professionals working in the area of vibration engineering and technology of machinery **ICAMDMS 2024** Rangasamy Rudramoorthy,M Senthilkumar,M R Pratheesh Kumar,J Pradeep Kumar,R Rajamani,Jeevarathinam Baskaran,2024-06-17 We the Department of Production Engineering PSG College of Technology Coimbatore Tamil Nadu India are delighted to introduce the proceedings of the International Conference on the Advancements in Materials Design and Manufacturing for Sustainable Development ICAMDMS 2024 The conference proceedings encapsulate the knowledge of diverse insights and cutting edge research shared by the participants of the conference in significant domains such as materials design manufacturing industrial and production engineering converging on the theme of sustainable development The technical program of ICAMDMS 2024 consists of 46 full papers including nine oral presentation sessions at the main conference themes The conference themes are Track 1 Advanced Materials Track 2 Design Track 3 Manufacturing and Track 4 Industrial and Production Engineering Aside from the high quality technical paper presentations the technical program also featured eight keynote lectures The eight keynote speakers are 1 Dr Redouane Zitoune from Paul Sabatier University Toulouse III France 2 Dr Jinyang Xu from Shanghai Jiao Tong University China 3 Dr Juan Pablo from Escobedo Daiz UNSW Canberra Australia 4 Dr Santhakumar Mohan from IIT Palakkad 5 Dr Afzaal Ahmed from IIT Palakkad 6 Dr Ravi K R from IIT Jodhpur 7 Mr Vijay V from Lakshmi Machine Works Advanced Technology Center Coimbatore and 8 Ms Thangamalar from Research and Development Tractors and Farm Equipment TAFE Chennai The Conference was enlightened with an industrial talk by Dr S Chandrasekar Corporate Director Roots Group of Companies Coimbatore ICAMDMS 2024 was sponsored by Propel Industries Pvt Ltd Coimbatore PSG Centre for Academic

Research and Excellence Coimbatore Janatics India Pvt Ltd Coimbatore Baarga Die Castings Coimbatore Crossfields Water Purifiers Pvt Ltd Coimbatore TESA Technology Coimbatore Guruvayurappan Textile Pvt Ltd Udumalpet Sakthi Gear Products Coimbatore and 2017 21 and 2018 22 alumni of the Department of Production Engineering In this compendium one can find a wealth of knowledge covering advanced materials innovative designs and sustainable manufacturing practices We extend our gratitude to the Management Principal PSGCT Head of the Department Production Engineering ICAMDMS 2024 advisory committee conference committee sponsors participants faculty members staff and students who have contributed to the ICAMDMS 2024 and made it a platform for meaningful discourse As we delve into this intellectual journey we anticipate that this proceeding will be a valuable resource for researchers academicians and professionals worldwide fostering collaboration and inspiring future endeavors toward achieving a sustainable environment Dr R Rudramoorthy Dr M Senthilkumar Dr M R Pratheesh Kumar Dr J Pradeep Kumar Dr R Rajamani and Dr J Baskaran **Vibration Analysis: A Practical Guide**

Pasquale De Marco,2025-03-10 Vibration Analysis A Practical Guide is a comprehensive introduction to vibration analysis covering the principles techniques and applications of this field Written in a clear and concise style with numerous examples and case studies this book is suitable for engineers scientists and technicians who are interested in learning about vibration analysis Vibration analysis is a powerful tool for understanding the dynamic behavior of structures machines and systems It involves measuring and analyzing vibration signals to identify and diagnose faults optimize performance and ensure safety This book provides a thorough understanding of the concepts and methods of vibration analysis enabling readers to apply these techniques to real world problems The book begins with an overview of vibration analysis including its history applications and challenges It then discusses vibration measurement techniques including transducers signal conditioning and data acquisition systems The book also covers vibration signal processing techniques such as time domain analysis frequency domain analysis and modal analysis The remaining chapters of the book discuss vibration analysis applications in various fields such as rotating machinery structures vehicles aerospace structures marine structures and electronic devices Each chapter includes a discussion of common vibration problems vibration analysis techniques condition monitoring fault diagnosis and case studies Key Features Comprehensive coverage of the principles techniques and applications of vibration analysis Clear and concise writing style with numerous examples and case studies Suitable for engineers scientists and technicians who are interested in learning about vibration analysis Covers a wide range of vibration analysis applications including rotating machinery structures vehicles aerospace structures marine structures and electronic devices This book is a valuable resource for anyone who is interested in learning about vibration analysis It provides a comprehensive overview of the field including the principles techniques and applications of vibration analysis The book is also written in a clear and concise style with numerous examples and case studies to illustrate the concepts discussed If you like this book write a review *Modeling and Analysis of Dynamic Systems* Ramin S. Esfandiari,Bei Lu,2014-04-24 Modeling and Analysis of

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Condition

Monitoring and Diagnostic Engineering Management Y.H.J. Au, B. Griffiths, B.K. Rao, 2012-12-06 Proceedings of COMADEM 90 the Second International Congress of Condition Monitoring and Diagnostic Engineering Management

Basics of Vibration and Condition Analysis Kameshwar Upadhyay, 2020-07-22 The book aims to impart basic knowledge of vibration and its effects on the process functions and life of industrial machinery and acceptable limits of vibration derived from different international standards It highlights characteristics of vibration amplitude displacement velocity and acceleration frequency and phase It explains the basics of vibration theories of free forced single and double degree damped and un damped vibration systems mode shapes critical speeds of rotor and presents solution of complex vibrations in simplified mathematical models Vibration measurement techniques various types of transducers and their applications are also illustrated briefly The book elaborates fault diagnosis condition analysis techniques through simplified tabular charts for machines and mechanical modelling solution of vibration on complex bodies Condition analysis by machine performance like efficiency water rate fuel consumption or output and specific functional deviations in machine is elaborated specially for setting alarms at suitable parameter of vibration The static and dynamic balancing techniques are explored for single plane balancing using only amplitude amplitude and phase or only phase for practical applications In situ two plane balancing by graphical mathematical and computerized techniques are described in a simplified manner to achieve acceptable value of unbalance reference international standards for different types of machines The case studies of single or multi degree freedom damped or un damped torsional and translational vibration are described for understanding trouble diagnosis and their remedial actions to resolve the problems

Gas Turbines Gurrappa Injeti, 2015-02-25 This book presents current

research in the area of gas turbines for different applications It is a highly useful book providing a variety of topics ranging from basic understanding about the materials and coatings selection designing and modeling of gas turbines to advanced technologies for their ever increasing efficiency which is the need of the hour for modern gas turbine industries The target audience for this book is material scientists gas turbine engine design and maintenance engineers manufacturers mechanical engineers undergraduate post graduate students and academic researchers The design and maintenance engineers in aerospace and gas turbine industry will benefit from the contents and discussions in this book This book presents current research in the area of gas turbines for different applications It is a highly useful book providing a variety of topics ranging from basic understanding about the materials and coatings selection designing and modeling of gas turbines to advanced technologies for their ever increasing efficiency which is the need of the hour for modern gas turbine industries The target audience for this book is material scientists gas turbine engine design and maintenance engineers manufacturers mechanical engineers undergraduate post graduate students and academic researchers The design and maintenance engineers in aerospace and gas turbine industry will benefit from the contents and discussions in this book Machinery ,1923

Vibration Engineering and Technology of Machinery Jyoti K. Sinha,2014-08-14 The VETOMAC X Conference covered a holistic plethora of relevant topics in vibration and engineering technology including condition monitoring machinery and structural dynamics rotor dynamics experimental techniques finite element model updating industrial case studies vibration control and energy harvesting and signal processing These proceedings contain not only all of the nearly one hundred peer reviewed presentations from authors representing more than twenty countries but also include six invited lectures from renowned experts Professor K Gupta Mr W Hahn Professor A W Lees Professor John Mottershead Professor J S Rao and Dr P Russhard This work is of interest to researchers and practitioners alike and is an essential book for most of libraries of higher academic institutes *Mechanical Design and Manufacturing of Electric Motors* Wei Tong,2022-05-19 This Second Edition of Mechanical Design and Manufacturing of Electric Motors provides in depth knowledge of design methods and developments of electric motors in the context of rapid increases in energy consumption and emphasis on environmental protection alongside new technology in 3D printing robots nanotechnology and digital techniques and the challenges these pose to the motor industry From motor classification and design of motor components to model setup and material and bearing selections this comprehensive text covers the fundamentals of practical design and design related issues modeling and simulation engineering analysis manufacturing processes testing procedures and performance characteristics of electric motors today This Second Edition adds three brand new chapters on motor breaks motor sensors and power transmission and gearing systems Using a practical approach with a focus on innovative design and applications the book contains a thorough discussion of major components and subsystems such as rotors shafts stators and frames alongside various cooling techniques including natural and forced air direct and indirect liquid phase change and other newly emerged innovative

cooling methods It also analyzes the calculation of motor power losses motor vibration and acoustic noise issues and presents engineering analysis methods and case study results While suitable for motor engineers designers manufacturers and end users the book will also be of interest to maintenance personnel undergraduate and graduate students and academic researchers

Advances in Rotor Dynamics, Control, and Structural Health Monitoring Subashisa Dutta, Esin Inan, Santosha Kumar Dwivedy, 2020-08-29 This book consists of selected and peer reviewed papers presented at the 13th International Conference on Vibration Problems ICOVP 2017 The topics covered in this book are broadly related to the fields of structural health monitoring vibration control and rotor dynamics In the structural health monitoring section studies on nonlinear dynamic analysis damage identification viscoelastic model of concrete and seismic damage assessment are thoroughly discussed with analytical and numerical techniques The vibration control part includes topics such as multi storeyed stacked tuned mass dampers vibration isolation with elastomeric mounts and nonlinear active vibration absorber This book will be useful for beginners researchers and professionals interested in the field of vibration control structural health monitoring and rotor dynamics

Mechanical Engineering for Sustainable Development Amit Pal, 2025-03-25 The book covers four research areas 1 Thermal and Energy Engineering 2 Industrial Engineering and Management 3 Computational Design and Simulations and 4 Materials and Manufacturing Topics covered include robotics micro electro mechanical systems cryogenics composites and cellular and molecular biomechanics Keywords Green Hydrogen Economy Renewable Energy Systems Additive Manufacturing Lithium Ion Batteries Air Pollution Control Photothermal Material Electric Vehicle Cloud Computing Wastegate Turbocharger Machine Intelligence Shear Deformation Friction Stir Welding Biogas Production Green Combustion

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