

Determination of Unbalance in Rotating Machine Using Vibration Signature Analysis

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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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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.

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 vibration.

MSA-mechanical Signature Analysis Simon G. Braun, 1983 **Vibration Analysis** Rao V. Dukkipati, 2004 Discusses in a concise but thorough manner fundamental statements of the theory, principles, and methods of mechanical vibrations.

Mechanics of Machinery Clarence Walter Ham, Edward Jameson Crane, 1927 **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.

Introduction to Machinery Analysis and Monitoring John Steward Mitchell, 1993 This edition examines a technology that has significantly improved reliability and reduced maintenance costs for a broad range of industrial organizations. Machinery analysis Chapter 15 is for readers who

are new to the benefits of on condition or predictive maintenance It helps them to gain a perspective prior to focusing on the specifics of the technology and implementation Masters Theses in the Pure and Applied Sciences Wade H. Shafer,2013-11-21 Masters Theses in the Pure and Applied Sciences was first conceived published and disseminated by the Center for Information and Numerical Data Analysis and Synthesis CINDAS at Purdue University in 1957 starting its coverage of theses with the academic year 1955 Beginning with Volume 13 the printing and dissemination phases of the activity were transferred to University Microfilms Xerox of Ann Arbor Michigan with the thought that such an arrangement would be more beneficial to the academic and general scientific and technical community After five years of this joint undertaking we had concluded that it was in the interest of all concerned if the printing and distribution of the volume were handled by an international publishing house to assure improved service and broader dissemination Hence starting with Volume 18 Masters Theses in the Pure and Applied Sciences has been disseminated on a worldwide basis by Plenum Publishing Corporation of New York and in the same year the coverage was broadened to include Canadian universities All back issues can also be ordered from Plenum We have reported in Volume 20 thesis year 1975 a total of 10 374 theses titles from 28 Canadian and 239 United States universities We are sure that this broader base for theses titles reported will greatly enhance the value of this important annual reference work The organization of Volume 20 is identical to that of past years It consists of theses titles arranged by discipline and by university within each discipline

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Table of Contents Determination Of Unbalance In Rotating Machine Using

1. Understanding the eBook Determination Of Unbalance In Rotating Machine Using
 - The Rise of Digital Reading Determination Of Unbalance In Rotating Machine Using
 - Advantages of eBooks Over Traditional Books
2. Identifying Determination Of Unbalance In Rotating Machine Using
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in a Determination Of Unbalance In Rotating Machine Using
 - User-Friendly Interface
4. Exploring eBook Recommendations from Determination Of Unbalance In Rotating Machine Using
 - Personalized Recommendations
 - Determination Of Unbalance In Rotating Machine Using User Reviews and Ratings
 - Determination Of Unbalance In Rotating Machine Using and Bestseller Lists
5. Accessing Determination Of Unbalance In Rotating Machine Using Free and Paid eBooks
 - Determination Of Unbalance In Rotating Machine Using Public Domain eBooks
 - Determination Of Unbalance In Rotating Machine Using eBook Subscription Services
 - Determination Of Unbalance In Rotating Machine Using Budget-Friendly Options
6. Navigating Determination Of Unbalance In Rotating Machine Using eBook Formats
 - ePub, PDF, MOBI, and More
 - Determination Of Unbalance In Rotating Machine Using Compatibility with Devices
 - Determination Of Unbalance In Rotating Machine Using Enhanced eBook Features
7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Determination Of Unbalance In Rotating Machine Using
 - Highlighting and Note-Taking Determination Of Unbalance In Rotating Machine Using
 - Interactive Elements Determination Of Unbalance In Rotating Machine Using
8. Staying Engaged with Determination Of Unbalance In Rotating Machine Using

- Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Determination Of Unbalance In Rotating Machine Using
9. Balancing eBooks and Physical Books Determination Of Unbalance In Rotating Machine Using
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Determination Of Unbalance In Rotating Machine Using
 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
 11. Cultivating a Reading Routine Determination Of Unbalance In Rotating Machine Using
 - Setting Reading Goals Determination Of Unbalance In Rotating Machine Using
 - Carving Out Dedicated Reading Time
 12. Sourcing Reliable Information of Determination Of Unbalance In Rotating Machine Using
 - Fact-Checking eBook Content of Determination Of Unbalance In Rotating Machine Using
 - Distinguishing Credible Sources
 13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
 14. Embracing eBook Trends
 - Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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