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Principal component analysis approach for detecting faults in rotary machines based on vibrational and electrical fused data

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ABSTRACT

Rotating machines are frequently used in industrial applications. However, due to their severity, mechanical failures such as rotor imbalance, shaft imbalance, pulley imbalance, structural breakage, and bearing imbalance can lead to unplanned shutdowns. While vibration analysis-based condition monitoring techniques can detect and diagnose many early errors, certain mechanical faults have associated vibration characteristics that make it difficult to identify and distinguish these faults. To address this issue, this paper proposes a method based on data fusion for vibrational and electrical signatures to achieve new fused signatures for healthy and different faulty cases. The weighted decision fusion method generates the fused decision by weighting and combining the output of multiple sensors. Conventional vibration evaluation parameters diagnose unbalance, pulley misalignment, belt damage, and combined faults. However, these parameters have more dimensions and correlated features for some faulty cases, such as unbalance and misalignment. Therefore, the Principal Component Analysis (PCA) was applied to reduce the dimensionality of evaluating parameters and preserve almost all data variation. The PCA produces uncorrelated Principal Components (PCs) for each case. A backpropagation neural network (BPNN) was constructed to construct an integrated fault diagnosis framework. The first and second PC was inserted as input parameters in the training set of BPNN. It was observed that BPNN achieves 2.1762×10^{-29} Mean Squared Error (MSE) demonstrates superior data fusion solutions and PCA in the condition monitoring of rotating machines. Overall, this study proposes an effective method for diagnosing mechanical faults in rotating machines, which can improve reliability and reduce downtime in industrial applications.

1. Introduction

Rotary machines driven by the electromechanical system, such as the induction motor, are widely used in industrial applications due to their cost-effectiveness, simplicity, and ease of maintenance. The traditional maintenance management approach involves time-based preventive maintenance, which involves rebuilding or repairing machines based on pre-determined schedules derived from failure statistics. However, these statistics vary widely depending on operating and plant-specific variables, resulting in ineffective

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Mechanical Design A Rotary Component Approach

Michael Brown

Mechanical Design A Rotary Component Approach:

Advances in Mechanical Design Jianrong Tan,Yu Liu,Hong-Zhong Huang,Jingjun Yu,Zequn Wang,2024-06-19 This book gathers selected papers from 2023 International Conference on Mechanical Design 2023 ICMD held in Chengdu China The main objectives are to bring the community of researchers in the fields of mechanical design together to exchange and discuss the most recent investigations challenging problems and new trends and to encourage the wider implementation of the advanced design technologies and tools in the world particularly throughout China The theme of 2023 ICMD is Innovative Design Drives High Quality Development and the event devotes to providing an excellent forum for the scholars all around the world to share their innovative ideas cutting edge research results **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 Robust Engineering Design-by-reliability with Emphasis on Mechanical Components & Structural Reliability Dimitri Kececioglu,2003 Extending in practice design by reliability concepts and techniques this book addresses their application to key mechanical components and systems The first part devotes a chapter to the reliability of each type of component including pressure vessels beams gear bearing and electrical components The second part provides tabular data on material strengths and their cycles to failure covering cast iron steel aluminum copper magnesium lead and titanium This is the ideal companion to the authors Practical Tools and Applications and Fatigue of Mechanical Components volumes of his Robust Engineering Design by Reliability series

Mechanical Design of Machine Components Ansel C. Ugural,2018-09-03 Analyze and Solve Real World Machine Design Problems Using SI Units Mechanical Design of Machine Components Second Edition SI Version strikes a balance between

method and theory and fills a void in the world of design Relevant to mechanical and related engineering curricula the book is useful in college classes and also serves as a reference for practicing engineers This book combines the needed engineering mechanics concepts analysis of various machine elements design procedures and the application of numerical and computational tools It demonstrates the means by which loads are resisted in mechanical components solves all examples and problems within the book using SI units and helps readers gain valuable insight into the mechanics and design methods of machine components The author presents structured worked examples and problem sets that showcase analysis and design techniques includes case studies that present different aspects of the same design or analysis problem and links together a variety of topics in successive chapters SI units are used exclusively in examples and problems while some selected tables also show U S customary USCS units This book also presumes knowledge of the mechanics of materials and material properties New in the Second Edition Presents a study of two entire real life machines Includes Finite Element Analysis coverage supported by examples and case studies Provides MATLAB solutions of many problem samples and case studies included on the book s website Offers access to additional information on selected topics that includes website addresses and open ended web based problems Class tested and divided into three sections this comprehensive book first focuses on the fundamentals and covers the basics of loading stress strain materials deflection stiffness and stability This includes basic concepts in design and analysis as well as definitions related to properties of engineering materials Also discussed are detailed equilibrium and energy methods of analysis for determining stresses and deformations in variously loaded members The second section deals with fracture mechanics failure criteria fatigue phenomena and surface damage of components The final section is dedicated to machine component design briefly covering entire machines The fundamentals are applied to specific elements such as shafts bearings gears belts chains clutches brakes and springs **Engineering Approaches to Mechanical and Robotic Design for Minimally Invasive Surgery (MIS)** Ali Faraz,Shahram Payandeh,2012-12-06 Within the past twenty years the field of robotics has been finding many areas of applications ranging from space to underwater explo rations One of these areas which is slowly gaining popularity among the users group is the notion of service robotics This book is an in vestigation and exploration of engineering principles in the design and development of mechanisms and robotic devices that can be used in the field of surgery Specifically the results of this book can be used for designing tools for class of Minimally Invasive Surgery MIS Generally Minimal Invasive Surgery MIS e g laparoscopic surgery is performed by using long surgical tools that are inserted through small incisions at the ports of entry to the body e g abdominal wall for reaching the surgical site The main drawback of current designs of en doscopic tools is that they are not able to extend all the movements and sensory capabilities of the surgeon s hand to the surgical site By im proving surgical procedures training and more practice it is possible for surgeons to reduce completion time for each task and increase their level of skill However even in the best cases the level of performance of a surgeon in Minimally Invasive

Surgery is still a fraction of the con ventional surgery Any dramatically improvement is usually driven by introduction of new tools or systems that in turn bring totally new pro cedures and set of skills *Methods to Extend Mechanical Component Life* Dieter K. Huzel,1993 This book identifies and classifies the causes of component wear and failure It then turns to the analytical and investigative methods to find the causes of excessive wear and failure at the mechanical dynamic interfaces within tested components weak links These methods are described in a cookbook fashion They are supported by a thorough discussion of the experiences with the application of these processes to actual components the weak links found the corrective actions taken and the significant improvements in service life achieved The great effect that properties of nonmetallic materials have on component life are included This includes an introduction to the family tree of polymeric materials and an extensive tabulation of 120 dynamic interface configurations and designs that were investigated and rated

Mechanical Design for the Stage Alan Hendrickson,2012-09-10 Scenic effects involving rotating turntables tracking stage wagons and the vertical movement of curtains and painted drops have become common in both Broadway and Regional theatre productions The machines that drive these effects range from small pneumatic cylinders pushing loads of a few pounds an inch or two to 40 horsepower winches running multi ton scenery at speeds 6 feet per second or more Usually this machinery is designed by theatre technicians specifically for a particular show s effect Compared to general industry this design process is short often only a few days long it is done by one person design teams are rare and it is done in the absence of reference material specifically addressing the issues involved The main goal of this book is to remedy this last situation Mechanical Design for the Stage will be a reference for you that will provide the basic engineering formulas needed to predict the forces torques speeds and power required by a given move give a technician a design process to follow which will direct their work from general concepts to specific detail as a design evolves and show many examples of traditional stage machinery designs The book s emphasis will be on following standard engineering design and construction practices and developing machines that are functional efficient to build easily maintained and safe to use Mechanical Design P.R.N. Childs,2003-12-04 This book introduces the subject of total design and introduces the design and selection of various common mechanical engineering components and machine elements These provide building blocks with which the engineer can practice his or her art The approach adopted for defining design follows that developed by the SEED Sharing Experience in Engineering Design programme where design is viewed as the total activity necessary to provide a product or process to meet a market need Within this framework the book concentrates on developing detailed mechanical design skills in the areas of bearings shafts gears seals belt and chain drives clutches and brakes springs and fasteners Where standard components are available from manufacturers the steps necessary for their specification and selection are developed The framework used within the text has been to provide descriptive and illustrative information to introduce principles and individual components and to expose the reader to the detailed methods and calculations necessary to specify and design or

select a component To provide the reader with sufficient information to develop the necessary skills to repeat calculations and selection processes detailed examples and worked solutions are supplied throughout the text This book is principally a Year Level 1 and 2 undergraduate text Pre requisite skills include some year one undergraduate mathematics fluid mechanics and heat transfer principles of materials statics and dynamics However as the subjects are introduced in a descriptive and illustrative format and as full worked solutions are provided it is possible for readers without this formal level of education to benefit from this book The text is specifically aimed at automotive and mechanical engineering degree programmes and would be of value for modules in design mechanical engineering design design and manufacture design studies automotive power train and transmission and tribology as well as modules and project work incorporating a design element requiring knowledge about any of the content described The aims and objectives described are achieved by a short introductory chapters on total design mechanical engineering and machine elements followed by ten chapters on machine elements covering bearings shafts gears seals chain and belt drives clutches and brakes springs fasteners and miscellaneous mechanisms Chapters 14 and 15 introduce casings and enclosures and sensors and actuators key features of most forms of mechanical technology The subject of tolerancing from a component to a process level is introduced in Chapter 16 The last chapter serves to present an integrated design using the detailed design aspects covered within the book The design methods where appropriate are developed to national and international standards e g ANSI ASME AGMA BSI DIN ISO The first edition of this text introduced a variety of machine elements as building blocks with which design of mechanical devices can be undertaken The approach adopted of introducing and explaining the aspects of technology by means of text photographs diagrams and step by step procedures has been maintained A number of important machine elements have been included in the new edition fasteners springs sensors and actuators They are included here Chapters on total design the scope of mechanical engineering and machine elements have been completely revised and updated New chapters are included on casings and enclosures and miscellaneous mechanisms and the final chapter has been rewritten to provide an integrated approach Multiple worked examples and completed solutions are included **Mechanical Support for Heart Failure** Jamshid H. Karimov,Kiyotaka Fukamachi,Randall C. Starling,2020-09-04 This book provides a comprehensive overview of mechanical circulatory support of the failing heart in adults and children The book uniquely combines engineering knowledge and the clinician s perspective into a single resource while also providing insights into current and future development of mechanical circulatory support technology such as ventricular assist devices the total artificial heart and catheter based technologies for heart failure Topics featured in this book include The history of mechanical circulatory device development Fundamentals of hemodynamics support Clinical management of mechanical circulatory devices Surgical implantation techniques Current limitations of device therapies in advanced heart failure Advanced and novel devices in the development pipeline Opportunities for advancement in the field Mechanical Support for Heart Failure Current Solutions and

New Technologies is a must have resource for not only physicians residents fellows and medical students in cardiology and cardiac surgery but also clinical and basic researchers in biomedical engineering with an interest in mechanical circulatory support heart failure and new technological applications in medicine *Recent Advances in Mechanical Infrastructure* Ajit Kumar Parwani,PL. Ramkumar,2019-10-18 The book contains high quality papers presented in conference Recent Advances in Mechanical Infrastructure ICRAM 2019 held at IITRAM Ahmedabad India from 20 21 April 2019 The topics covered in this book are recent advances in thermal infrastructure manufacturing infrastructure and infrastructure planning and design *Design Tools and Methods in Industrial Engineering* Caterina Rizzi,Angelo Oreste Andrisano,Francesco Leali,Francesco Gherardini,Fabio Pini,Alberto Vergnano,2019-09-19 This book reports on cutting edge design methods and tools in industrial engineering advanced findings in mechanics and material science and relevant technological applications Topics span from geometric modelling tools to applications of virtual augmented reality from interactive design to ergonomics human factors research and reverse engineering Further topics include integrated design and optimization methods as well as experimental validation techniques for product processes and systems development such as additive manufacturing technologies This book is based on the International Conference on Design Tools and Methods in Industrial Engineering ADM 2019 held on September 9 10 2019 in Modena Italy and organized by the Italian Association of Design Methods and Tools for Industrial Engineering and the Department of Engineering Enzo Ferrari of the University of Modena and Reggio Emilia Italy It provides academics and professionals with a timely overview and extensive information on trends and technologies in industrial design and manufacturing Mechanical Engineering Practices in Industry Dhruba J Syam,2023-06-02 The four year undergraduate course in Engineering is loaded with theoretical contents and the students hardly find enough time and opportunity to adequately grasp the physical and practical aspects of application of various engineering theories that are being taught Therefore certain practice oriented knowledge inputs in these years may help them acquire and enhance proficiency in the industrial working systems and processes This book attempts to provide certain practice oriented knowledge inputs which may help young mechanical engineers who aspire to make a successful career in engineering goods manufacturing enterprises The book seeks to provide a combination of Engineering and Production Manufacturing Management aspects to enable young mechanical engineers to make a confident start at the workplace and eventually ascend to leading positions in the organization Print edition not for sale in South Asia India Sri Lanka Nepal Bangladesh Pakistan and Bhutan *Advances in Mechanism and Machine Science and Engineering in China* Yan Chen,Lujiang Liu,Xinjun Liu,Haitao Liu,Ming Li,Tao Sun,2025-05-02 This book collects selected papers of the 24th IFToMM China International Conference on Mechanism and Machine Science and Engineering CCMMS 2024 CCMMS was initiated in 1982 and it is the most important forum held in China for exchange of research ideas presentation of technical and scientific achievements and discussion of future directions in the field of mechanism and machine science The topics include

theoretical and computational kinematics dynamics and control engines and transmission systems parallel hybrid mechanisms and industrial robotics compliant mechanisms origami mechanisms and soft robotics metamorphic mechanisms and robotics deployable structures and mechanisms aerospace mechanisms and environmental effects micro nano mechanisms and robotics biologically inspired mechanisms and robotics medical and rehabilitation robotics mobile robotics and heavy non road mobile machines history of mechanisms machines and robotics and engineering education on mechanisms This book provides a state of the art overview of current advances in mechanism and machine science in China The inspiring ideas presented in the papers will enlighten the trend in academic research and industrial application The potential readers include academic researchers and industrial professionals in the field of mechanism and machine science

Advanced methods for fault diagnosis and fault-tolerant control Steven X. Ding,2020-11-24 The major objective of this book is to introduce advanced design and online optimization methods for fault diagnosis and fault tolerant control from different aspects Under the aspect of system types fault diagnosis and fault tolerant issues are dealt with for linear time invariant and time varying systems as well as for nonlinear and distributed including networked systems From the methodological point of view both model based and data driven schemes are investigated To allow for a self contained study and enable an easy implementation in real applications the necessary knowledge as well as tools in mathematics and control theory are included in this book The main results with the fault diagnosis and fault tolerant schemes are presented in form of algorithms and demonstrated by means of benchmark case studies The intended audience of this book are process and control engineers engineering students and researchers with control engineering background **Heat Exchangers** Kuppan Thulukkanam,2024-02-29 Heat Exchangers Classification Selection and Thermal Design Third Edition discusses heat exchangers and their various applications such as refrigeration air conditioning automobiles gas turbines process industries refineries and thermal power plants With a focus on thermal design methods including rating and sizing the book covers thermohydraulic fundamentals and thermal effectiveness charts for various flow configurations and shell and tube heat exchangers It provides construction details geometrical features and correlations and thermo hydraulic details for tube fin plate fin air cooled shell and tube microchannel and plate heat exchangers and thermal design methods like rating and sizing The book explores additive manufacturing of heat exchangers printed circuit heat exchangers and heat transfer augmentation methods The book also describes recuperators and regenerators of gas turbine cycles waste heat recovery devices and phase change phenomena including boiling condensation and steam generation The book serves as a useful reference for researchers graduate students and engineers in the field of heat exchanger design including heat exchanger manufacturers Innovative Processing Methods For Synthesizing Advanced Structural And Functional Materials Dr. Mohamed Zakaulla, **Nonlinear Approaches in Engineering Applications** Reza N. Jazar,Liming Dai,2016-05-27 This book looks at the broad field of engineering science through the lens of nonlinear approaches Examples focus on issues in

vehicle technology including vehicle dynamics vehicle road interaction steering and control for electric and hybrid vehicles Also included are discussions on train and tram systems aerial vehicles robot human interaction and contact and scratch analysis at the micro nanoscale Chapters are based on invited contributions from world class experts in the field who advance the future of engineering by discussing the development of more optimal accurate efficient and cost and energy effective systems This book is appropriate for researchers students and practicing engineers who are interested in the applications of nonlinear approaches to solving engineering and science problems **New Approaches to Gear Design and Production** Veniamin Goldfarb,Evgenii Trubachev,Natalya Barmina,2020-01-25 This is the third book in a series devoted to gear design and production Comprising papers by scientists and gear experts from around the globe it covers recent developments in practically all spheres of mechanical engineering related to gears and transmissions It describes advanced approaches to research design testing and production of various kinds of gears for a vast range of applications with a particular focuses on advanced computer aided approaches for gear analysis simulation and design the application of new materials and tribological issues *Innovations in Industrial Engineering IV* Jose Machado, The Shock and Vibration Digest ,1992

Reviewing **Mechanical Design A Rotary Component Approach**: Unlocking the Spellbinding Force of Linguistics

In a fast-paced world fueled by information and interconnectivity, the spellbinding force of linguistics has acquired newfound prominence. Its capacity to evoke emotions, stimulate contemplation, and stimulate metamorphosis is actually astonishing. Within the pages of "**Mechanical Design A Rotary Component Approach**," an enthralling opus penned by a highly acclaimed wordsmith, readers set about an immersive expedition to unravel the intricate significance of language and its indelible imprint on our lives. Throughout this assessment, we shall delve into the book is central motifs, appraise its distinctive narrative style, and gauge its overarching influence on the minds of its readers.

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Mechanical Design A Rotary Component Approach Introduction

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instruments heard on the song (except for the piano ... He Reigns Forever | PDF He Reigns Forever. Brooklyn Tabernacle Choir. [Verse:] Sing praises to the King for He is the King of Kings. x2. [Chorus:] Give Him glory for He's the King. He Reigns Forever (Brooklyn Tabernacle Choir) Midi Instrumental Gospel Performance Tracks, Midi Files, Click Tracks and Play-Along Tracks and more!! He Reigns Forever Buy He Reigns Forever Sheet Music. Composed by Marshal Carpenter. Arranged by Carol Cymbala. For SATB Sheet Music. Published by Brooklyn Tabernacle. He Reigns Forever (We Sing Praises) Verse We sing praises to the King for He is the King of Kings. Sop / ALTO AND TENOR. We sing praises to the King (Hallelujah) for He is the King of Kings. (All ... He Reigns Forever. Good Choir Song. Sheet Music ... - YouTube He Reigns Forever (SATB) by CARPENTER, M Buy He Reigns Forever (SATB) by CARPENTER, M / at jwpepper.com. Choral Sheet Music. He Reigns Forever Brooklyn Tabernacle Choir Need a last-minute song? Get music in 3-4 business days. Praise & worship; Vocal solo arrangements; Choir sing-along tracks. Get Details. Join Our Music ... My Story: Master Sgt. Benjamin Hunt Jul 10, 2020 — Benjamin Hunt joined the Indiana Air National Guard because it was a family tradition to serve, serve his community, plus the benefits and life ... SGT Benjamin Casey Hunt Obituary - Killeen, TX May 1, 2019 — Benjamin was born on September 27, 1983 in Twin Falls, ID to Lori Smith and Kenneth Hunt. He Joined the Army on January 3rd, 2008. His eleven ... Military Service Records The National Archives is the official repository for records of military personnel who have been dis charged from the U.S. Air Force, Army, Marine Corps, Navy ... What is the worst thing you've ever experienced in ... Sep 3, 2015 — When my Drill sergeant looked at me and said “You're going home.” I was on week six, had just one more week to go before graduating and going on ... Experiencing God's Presence in my Military Service (Part 1) Feb 8, 2020 — God used me to love my neighbors by meeting their needs; God gave me understanding about the eternal value of military service; God was with me ... U.S. Bases in Thailand During the Vietnam War and Agent ... Aug 12, 2019 — The first base of operations for American forces was at Takhli Royal Thai Air force Base, which is located approximately 144 miles northwest of ... House Report 117-391 - MILITARY CONSTRUCTION ... ... military personnel and their families' quality of life is preserved. The total ... Evans, Deputy Chief of Staff of the Army, G9 Sergeant Major Michael A. Ranger Hall of Fame Aug 31, 2023 — Staff Sergeant Robert J. Pruden is inducted into the Ranger Hall of Fame for extraordinary courage and gallantry in action as a Ranger qualified ... On Point: the United States Army in Operation Iraqi Freedom Mar 23, 2003 — On Point is a study of Operation IRAQI FREEDOM (OIF) as soon after the fact as feasible. The Army leadership chartered this effort in a message ...