

Hung Nguyen-Schäfer

Aero and Vibroacoustics of Automotive Turbochargers

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Mekuannint M. Messele



Aero And Vibroacoustics Of Automotive Turbochargers:

Aero and Vibroacoustics of Automotive Turbochargers Hung Nguyen-Schäfer, 2013-01-06 Aero and Vibroacoustics of Automotive Turbochargers is a topic involving aspects from the working fields of thermodynamics of turbomachinery aerodynamics rotordynamics and noise propagation computation In this broadly interdisciplinary subject thermodynamics of turbomachinery is used to design the turbocharger and to determine its operating conditions Aerodynamics is needed to study the compressor flow dynamics and flow instabilities of rotating stall and surge which can produce growling and whining type noises Rotordynamics is necessary to study rotor unbalance and self excited oil whirl instabilities which lead to whistling and constant tone type noises in rotating floating oil film type bearings For the special case of turbochargers using ball bearings some high order harmonic and wear noises also manifest in the rotor operating range Lastly noise propagation computation based on Lighthill's analogy is required to investigate airborne noises produced by turbochargers in passenger vehicles The content of this book is intended for advanced undergraduates graduates in mechanical engineering research scientists and practicing engineers who want to better understand the interactions between these working fields and the resulting impact on the interesting topic of Aero and Vibroacoustics of Automotive Turbochargers

Rotordynamics of Automotive Turbochargers Hung Nguyen-Schäfer, 2012-03-06 This book deals with rotordynamics of automotive turbochargers while encompassing the analysis of the dynamics of rotating machines at very high rotor speeds of 300 000 rpm and above This interdisciplinary field involves 1 thermodynamics and turbo matching knowledge to compute working conditions of turbochargers 2 fluid and bearing dynamics to calculate various operating thrust loads and to design the rotating floating ring bearings two oil film bearings and 3 tribology to improve the rotor stability and to reduce the bearing friction Mathematical background in modeling and simulation methods is necessary however the prerequisites have been kept to a minimum The book addresses both practitioners working in the field of rotordynamics of automotive turbochargers and graduate students in mechanical engineering

Rotordynamics of Automotive Turbochargers Hung Nguyen-Schäfer, 2015-05-15 Rotordynamics of automotive turbochargers is dealt with in this book encompassing the widely working field of small turbomachines under real operating conditions at the very high rotor speeds up to 300000 rpm The broadly interdisciplinary field of turbocharger rotordynamics involves 1 Thermodynamics and Turbo Matching of Turbochargers 2 Dynamics of Turbomachinery 3 Stability Analysis of Linear Rotordynamics with the Eigenvalue Theory 4 Stability Analysis of Nonlinear Rotordynamics with the Bifurcation Theory 5 Bearing Dynamics of the Oil Film using the Two Phase Reynolds Equation 6 Computation of Nonlinear Responses of a Turbocharger Rotor 7 Aero and Vibroacoustics of Turbochargers 8 Shop and Trim Balancing at Two Planes of the Rotor 9 Tribology of the Bearing Surface Roughness 10 Design of Turbocharger Platforms using the Similarity Laws The rotor response of an automotive turbocharger at high rotor speeds is studied analytically computationally and experimentally Due to the nonlinear characteristics of the oil film bearings

some nonlinear responses of the rotor besides the harmonic response 1X such as oil whirl oil whip and modulated frequencies occur in Waterfall diagram Additionally the influences of the surface roughness and oil characteristics on the rotor behavior friction and wear are discussed This book is written by an industrial R D expert with many years of experience in the automotive and turbocharger industries The all in one book of turbochargers is intended for scientific and engineering researchers practitioners working in the rotordynamics field of automotive turbochargers and graduate students in applied physics and mechanical engineering

Predicting Flow-Induced Acoustics at Near-Stall Conditions in an Automotive Turbocharger Compressor Roberto Navarro García, 2018-01-10 This thesis offers new insights into the fluid flow behavior of automotive centrifugal compressors operating under near stall conditions Firstly it discusses the validation of three dimensional computational fluid dynamics CFD unsteady simulations against acoustic experimental measurements using an original procedure based on plane wave pressure decomposition It then examines the configuration of the CFD cases highlighting the key parameters needed for a successful calculation Moreover it describes both the compressor mean and unsteady flow field from best efficiency to near surge operating points Lastly it provides readers with explanations of the various phenomena that arise when the mass flow rate is reduced and the compressor is driven to poor and noisy performance Written for students researchers and professionals who want to improve their understanding of the complex fluid flow behavior in centrifugal compressors the thesis offers valuable practical insights into reducing the acoustic emissions of turbochargers

Tensor Analysis and Elementary Differential Geometry for Physicists and Engineers Hung Nguyen-Schäfer, Jan-Philip Schmidt, 2016-08-16 This book presents tensors and differential geometry in a comprehensive and approachable manner providing a bridge from the place where physics and engineering mathematics end and the place where tensor analysis begins Among the topics examined are tensor analysis elementary differential geometry of moving surfaces and k differential forms The book includes numerous examples with solutions and concrete calculations which guide readers through these complex topics step by step Mindful of the practical needs of engineers and physicists book favors simplicity over a more rigorous formal approach The book shows readers how to work with tensors and differential geometry and how to apply them to modeling the physical and engineering world The authors provide chapter length treatment of topics at the intersection of advanced mathematics and physics and engineering General Basis and Bra Ket Notation Tensor Analysis Elementary Differential Geometry Differential Forms Applications of Tensors and Differential Geometry Tensors and Bra Ket Notation in Quantum Mechanics The text reviews methods and applications in computational fluid dynamics continuum mechanics electrodynamics in special relativity cosmology in the Minkowski four dimensional space time and relativistic and non relativistic quantum mechanics Tensor Analysis and Elementary Differential Geometry for Physicists and Engineers benefits research scientists and practicing engineers in a variety of fields who use tensor analysis and differential geometry in the context of applied physics and electrical and mechanical engineering It will also interest

graduate students in applied physics and engineering

Computational Design of Rolling Bearings Hung

Nguyen-Schäfer, 2016-04-10 This book comprehensively presents the computational design of rolling bearings dealing with many interdisciplinary difficult working fields They encompass elastohydrodynamics EHD Hertzian contact theory oil film thickness in elastohydrodynamic lubrication EHL bearing dynamics tribology of surface textures fatigue failure mechanisms fatigue lifetimes of rolling bearings and lubricating greases Weibull distribution rotor balancing and airborne noises NVH in the rolling bearings Furthermore the readers are provided with hands on essential formulas based on the up to date DIN ISO norms and helpful examples for computational design of rolling bearings The topics are intended for undergraduate and graduate students in mechanical and material engineering research scientists and practicing engineers who want to understand the interactions between these working fields and to know how to design the rolling bearings for automotive industry and many other industries

Computational Tapered and Cylinder Roller Bearings Hung

Nguyen-Schäfer, 2019-01-09 This monograph presents computational models that describe electro mechanical characteristics of tapered and cylinder roller bearings in various industrial applications Applying the Levenberg Marquardt s algorithm to solving strongly nonlinear coupled equation systems the computational models consisting of many circular slices per rolling element enable computations of the local Hertzian pressures at the elastohydrodynamic EHD contact area the relating oil film thickness in elastohydrodynamic lubrication EHL the limiting voltage of electro pitting bearing frictions and fatigue lifetimes of the bearings for various load spectra Using the best known machine learning method for clustering the load spectrum is clustered in k cluster means based on the invariant damage number to accelerate the load spectrum Furthermore the accelerated load spectrum is used for the testing procedure of the bearings to reduce the testing time and costs as well The target audience of this book primarily comprises graduate students in mechanical engineering and practicing engineers of electro machines and transmission systems who want to computationally design tapered and cylinder roller bearings for the automotive industry and other industries and to deeply dive into these relating working fields

Aeroacoustic and Vibroacoustic Advancement in Aerospace and Automotive Systems Roberto Citarella, Luigi

Federico, 2018-06-26 This book is a printed edition of the Special Issue Advances in Vibroacoustics and Aeroacoustics of Aerospace and Automotive Systems that was published in Applied Sciences

International Aerospace Abstracts, 1997

Annual Index/abstracts of SAE Technical Papers, 2006

Aeroacoustic and Vibroacoustic Advancement in

Aerospace and Automotive Systems Luigi Federico, Roberto Citarella, 2018 Aeroacoustic and Vibroacoustic Advancement in Aerospace and Automotive Systems

11th International Conference on Turbochargers and Turbocharging

IMEchE, 2014-08-25 The future market forces and environmental considerations in the passenger car and commercial vehicle sector mean more stringent engine downsizing is far more prevalent Therefore novel systems are required to provide boosting solutions including hybrid electric motor and exhaust waste energy recovery systems for high efficiency response

reliability durability and compactness The current emission legislations and environmental trends for reducing CO₂ and fuel consumption are the major market forces in the land and marine transport industries The internal combustion engine is the key product and downsizing efficiency and economy are the driving forces for development for both spark ignition SI and compression ignition CI engines in both markets Future market forces and environmental considerations for transportation specifically in the passenger car commercial vehicle and the marine sectors mean more stringent engine downsizing This international conference is the latest in the highly successful and prestigious series held regularly since 1978 These proceedings from the Institution s highly successful and prestigious series address current and novel aspects of turbocharging systems design boosting solutions for engine downsizing and improvements in efficiency and present the latest research and development in this growing and innovative area Focuses on boosting solutions including hybrid electric motor and exhaust waste energy recovery systems Explores the current need for high efficiency reliability durability and compactness in recovery systems Examines what new systems developments are underway

14th International Conference on Turbochargers and Turbocharging Institution of Mechanical Engineers, 2020-09-30 14th International Conference on Turbochargers and Turbocharging addresses current and novel turbocharging system choices and components with a renewed emphasis to address the challenges posed by emission regulations and market trends The contributions focus on the development of air management solutions and waste heat recovery ideas to support thermal propulsion systems leading to high thermal efficiency and low exhaust emissions These can be in the form of internal combustion engines or other propulsion technologies eg Fuel cell in both direct drive and hybridised configuration 14th International Conference on Turbochargers and Turbocharging also provides a particular focus on turbochargers superchargers waste heat recovery turbines and related air managements components in both electrical and mechanical forms

The Development and Introduction of the Automotive Turbocharger Larry Ronan, 1979 [Analysis of Automotive Turbocharger Nonlinear Response Including Bifurcations](#) Arian Vistamehr, 2010 Automotive turbochargers TCs increase internal combustion engine power and efficiency in passenger and commercial vehicles TC rotors are usually supported on floating ring bearings FRBs or semi floating ring bearings SFRBs both of which are inexpensive to manufacture However fluid film bearings are highly nonlinear components of TC units and contribute to the complex behavior i e bifurcations and frequency jumps between a first whirl frequency and a second whirl frequency of the entire rotor bearing system RBS The frequency jump phenomenon concerns the TC manufacturing industry due to increased levels of noise generation This thesis presents progress on assessing the effects of some bearing parameters and operating conditions on the RBS dynamic forced performance and the frequency jump phenomenon A fluid film bearing model is integrated into a finite element rotordynamics computational model for numerical prediction of the TC linear and nonlinear time transient forced response Since automotive TCs operate with variable rotational speed predictions are conducted with shaft

acceleration deceleration Over most of its operating speed range TC rotor nonlinear response predictions display two subsynchronous whirl frequencies w_1 and w_2 representing a conical mode and a cylindrical bending mode respectively At low shaft speeds w_1 is present up to a shaft speed Ω bifurcation where there is a frequency jump from w_1 to w_2 The second whirl frequency may persist up to the highest shaft speeds depending on operating conditions Results show during rotor deceleration the Ω bifurcation may be different from the one during rotor acceleration hysteresis Predictions show the following factors delay the Ω bifurcation increasing oil supply pressure decreasing oil supply temperature and increasing shaft acceleration Also rotor imbalance distribution greatly affects Ω bifurcation and the shaft amplitude of total motion Overall this study shows the sensitivity of bifurcations and frequency jump phenomenon in TC nonlinear response due to various bearing parameters and operating conditions Further analysis is required to generalize these findings and to assess the effect of other bearing parameters i.e. clearances outer film length ring rotation etc on this phenomenon In addition further validation of the predictions against test data is required for refinement of the predictive tool

The Development and Introduction of the Automotive Turbocharger: a Case of Innovation in Response to Fuel Economy Regulation. Final Report Larry Ronan, 1979 **Global Market Review of Automotive Turbochargers** William Kimberly, 2008 **Aerodynamic and Thermal Characterization of Turbocharger Turbines** Alessandro Romagnoli, 2010

Nonlinear Dynamics of Rotor Bearing System in Automotive Turbochargers Liang Tian, Wei Ji Wang, 2013 Turbochargers are widely used in modern vehicle engines for boosting power improving emission and increasing energy efficiency Apart from the obvious benefit the complexity of their nonlinear dynamic behaviours has to be encountered As a high speed rotating device a modern turbocharger rotor is commonly supported by floating ring bearings This book is particularly to focus on analyzing their interesting dynamic behaviours **Numerical Simulation and Modeling of a Turbocharger Compressor and Turbine to Improve Aerodynamics and Acoustics Performance** Mekuannint M. Messele, 2021 Downsizing modern automotive engines poses a challenge to turbocharger designs Turbocharger compressors are required to provide a wide operating range with high efficiency levels The compressors are equipped with either passive or active casing treatments ACTs to achieve this goal On the turbine side the ever increasing EGR flow into the engine demands an efficient scroll design that addresses both the performance and packaging limits The present study conducts numerical aerodynamic and acoustic performance investigation of a turbocharger compressor equipped with a dual slot active casing treatment ACT to widen the compressor's low and high flow rate operating limits independently The first slot surge slot positioned between the leading edge of the main and splitter blades improves the surge margin of the compressor Similar to the widely applied self recirculating casing treatment the surge slot removes stagnant fluid from the boundary layer region of the inducer and delivers it to the impeller inlet when the compressor operates near the surge limit The second slot choke slot positioned downstream of the aerodynamic throat increases the choke margin of the compressor A new combination of loss

models is proposed to predict the compressor performance providing satisfactory results. A novel methodology is developed to estimate the full compressor map from CFD results by incorporating Greitzer's surge model. The compressor performance analysis revealed that the choke slot closed configuration resulted in an isentropic efficiency penalty at higher compressor speeds. The efficiency penalty is addressed by optimizing the choke slot thickness to reduce the mass flow recirculating in the channel. On the other hand, the casing treatment provides an additional path for the unsteady compressor flow, increasing the noise level of the compressor. In this work, acoustic analogies are used to study the noise generated by different compressor casing treatment configurations. The transient aeroacoustic simulations are completed for both a choke slot closed design near surge and a choke slot open design near the maximum efficiency point. The simulation results revealed that the broadband and blade passing frequency BPF noise levels in the inlet and exit pipes decreased as the probe points moved away from the impeller. Further, the double inlet turbine performance is assessed numerically at even and uneven turbine inlet flows for three cases representing different engine operating conditions ranging from low load to full load. The CFD setup in this study is validated by using nine experimental data points with equal admissions at the two volute inlets. A significant amount of performance drop is observed when the turbine operates at uneven turbine inlet flow cases. The performance drop is more pronounced when the turbine operating point moves from low to high loads. Additionally, an energy audit of the turbine assembly is completed by estimating the local entropy production rate at eleven sub regions. In all flow cases, the tip region losses dominate the impeller losses at even and uneven flows. The volute flow is affected sharply by the mass flow imbalance across the turbine inlets, most notably at high engine loads. In the last section of this work, the impact of volute design geometric parameters on the aerodynamic performance of the turbine with nozzle blades is explored by using a three-dimensional computational fluid dynamics method. The volute tongue angle, tongue clearance, and volute shape are assessed in detail to determine how they impact the turbine's isentropic efficiency and the pressure loss coefficient of the volute. The numerical results show that the optimal tongue angle is approximately 15° for single scroll volutes. The study results also indicate that higher tongue clearance improves turbine performance as it enhances flow development. Finally, symmetrical cross-sectional shapes boosted the turbine's aerodynamic performance in single scroll turbines by uniformly distributing the volute exit flow from the hub to the shroud.

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Table of Contents Aero And Vibroacoustics Of Automotive Turbochargers

1. Understanding the eBook Aero And Vibroacoustics Of Automotive Turbochargers
 - The Rise of Digital Reading Aero And Vibroacoustics Of Automotive Turbochargers
 - Advantages of eBooks Over Traditional Books
2. Identifying Aero And Vibroacoustics Of Automotive Turbochargers
 - 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 an Aero And Vibroacoustics Of Automotive Turbochargers
 - User-Friendly Interface
4. Exploring eBook Recommendations from Aero And Vibroacoustics Of Automotive Turbochargers
 - Personalized Recommendations
 - Aero And Vibroacoustics Of Automotive Turbochargers User Reviews and Ratings
 - Aero And Vibroacoustics Of Automotive Turbochargers and Bestseller Lists
5. Accessing Aero And Vibroacoustics Of Automotive Turbochargers Free and Paid eBooks
 - Aero And Vibroacoustics Of Automotive Turbochargers Public Domain eBooks
 - Aero And Vibroacoustics Of Automotive Turbochargers eBook Subscription Services
 - Aero And Vibroacoustics Of Automotive Turbochargers Budget-Friendly Options
6. Navigating Aero And Vibroacoustics Of Automotive Turbochargers eBook Formats
 - ePub, PDF, MOBI, and More
 - Aero And Vibroacoustics Of Automotive Turbochargers Compatibility with Devices
 - Aero And Vibroacoustics Of Automotive Turbochargers Enhanced eBook Features
7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Aero And Vibroacoustics Of Automotive Turbochargers
 - Highlighting and Note-Taking Aero And Vibroacoustics Of Automotive Turbochargers
 - Interactive Elements Aero And Vibroacoustics Of Automotive Turbochargers

8. Staying Engaged with Aero And Vibroacoustics Of Automotive Turbochargers
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Aero And Vibroacoustics Of Automotive Turbochargers
9. Balancing eBooks and Physical Books Aero And Vibroacoustics Of Automotive Turbochargers
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Aero And Vibroacoustics Of Automotive Turbochargers
10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
11. Cultivating a Reading Routine Aero And Vibroacoustics Of Automotive Turbochargers
 - Setting Reading Goals Aero And Vibroacoustics Of Automotive Turbochargers
 - Carving Out Dedicated Reading Time
12. Sourcing Reliable Information of Aero And Vibroacoustics Of Automotive Turbochargers
 - Fact-Checking eBook Content of Aero And Vibroacoustics Of Automotive Turbochargers
 - 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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