

READ FREE INVESTIGATION INTO ROTOR BLADE AERODYNAMICS ECN

Investigation Into Rotor Blade Aerodynamics

A wind-tunnel investigation was conducted in which independent, steady-state aerodynamic forces and moments were measured on a 2.24-m-diam, two-bladed helicopter rotor and on several different bodies. The objective was to determine the mutual interaction effects for variations in velocity, thrust, tip-path-plane angle of attack, body angle of attack, rotor/body position, and body geometry. The results of the investigation show that the body longitudinal aerodynamic characteristics are significantly affected by the presence of a rotor and hub, and that the hub interference may be a major part of such interaction. This report presents the effects of various parameters on the interactions and discusses the difficulties encountered in determining the effect of the body on the rotor performance.

Rotor/body Aerodynamic Interactions

IFTToMM conferences have a history of success due to the various advances achieved in the field of rotor dynamics over the past three decades. These meetings have since become a leading global event, bringing together specialists from industry and academia to promote the exchange of knowledge, ideas, and information on the latest developments in the dynamics of rotating machinery. The scope of the conference is broad, including e.g. active components and vibration control, balancing, bearings, condition monitoring, dynamic analysis and stability, wind turbines and generators, electromechanical interactions in rotor dynamics and turbochargers. The proceedings are divided into four volumes. This fourth volume covers the following main topics: aero-engines; turbochargers; eolian (wind) generators; automotive rotating systems; and hydro power plants.

An Analytical Investigation of the Aerodynamic and Performance Characteristics of an Unpowered Rotor Entry Vehicle

This book presents the state of the art in the analyses of three-dimensional flow over rotating wind turbine blades. Systematic studies for wind turbine rotors with different sizes were carried out numerically employing three different simulation approaches, namely the Euler, URANS and DDES methods. The main mechanisms of the lift augmentation in the blade inboard region are described in detail. The physical relations between the inviscid and viscous effects are presented and evaluated, emphasizing the influence of the flow curvature on the resulting pressure distributions. Detailed studies concerning the lift augmentation for large wind turbine rotors are considered as thick inboard airfoils characterized by massive separation are desired to stronger contribute to power production. Special attention is given to the analyses of wind turbine loads and flow field that can be helpful for the interpretation of the occurring physical phenomena. The book is aimed at students, researchers, engineers and physicists dealing with wind engineering problems, but also for a wider audience involved in flow computations.

Proceedings of the 10th International Conference on Rotor Dynamics – IFTToMM

The aerodynamic characteristics of nontwisted-rotor-blade turbines are approximately those of free-vortex turbines intended for similar application for values of hub-tip-radius that are used in current turbines.

Three-Dimensional Flow in the Root Region of Wind Turbine Rotors

This book deals with horizontal-axis wind turbine aerodynamic performance prediction methods. It focuses on the traditional and newly-developed methods for the wind turbine aerodynamic performance calculation. The fundamental theories of fluid mechanics essential for understanding the other parts of this book are firstly introduced in Part I, followed by the blade element momentum theory in Part II, with special attentions to a systematic review of various correction models. Part III is mainly about the prescribed and free vortex wake methods, while the state-of-art computational fluid dynamics (CFD) methods are detailed in Part IV. Part III thoroughly describes the prescribed and free vortex wake methods which are still of great importance towards realistic investigation of wind turbine performance. Despite the highly computational cost, the CFD methods in Part IV have received increasing interest from the academic community since they provide more detailed information about the flow field around the wind turbine. This has shed a light in combination with the correction models introduced in Part II on more advanced research for wind turbine. This book is intended for researchers and students interested in aerodynamics of wind turbine and is particularly suitable for practicing engineers in wind energy. Readers can gain a comprehensive understanding in both classical and up-to-date methods for the study of wind turbine aerodynamics. The authors hope that this book can promote the research and development of wind turbines.

Analytical Evaluation of Aerodynamic Characteristics of Turbines with Nontwisted Rotor Blades

Design Optimization of Fluid Machinery: Applying Computational Fluid Dynamics and Numerical Optimization Drawing on extensive research and experience, this timely reference brings together numerical optimization methods for fluid machinery and its key industrial applications. It logically lays out the context required to understand computational fluid dynamics by introducing the basics of fluid mechanics, fluid machines and their components. Readers are then introduced to single and multi-objective optimization methods, automated optimization, surrogate models, and evolutionary algorithms. Finally, design approaches and applications in the areas of pumps, turbines, compressors, and other fluid machinery systems are clearly explained, with special emphasis on renewable energy systems. Written by an international team of leading experts in the field Brings together optimization methods using computational fluid dynamics for fluid machinery in one handy reference Features industrially important applications, with key sections on renewable energy systems Design Optimization of Fluid Machinery is an essential guide for graduate students, researchers, engineers working in fluid machinery and its optimization methods. It is a comprehensive reference text for advanced students in mechanical engineering and related fields of fluid dynamics and aerospace engineering.

Wind Turbine Aerodynamic Performance Calculation

This investigation was made to determine the effects of 6 degree full-span and 3 degree partial-span leading-edge flaps in combination with chord-extensions or fences on the aerodynamic characteristics of a wing-fuselage configuration with a 45 degree sweptback wing of aspect ratio 4, taper ratio 0.3, and NACA 65A006 airfoil sections. The investigation was made in the Langley high-speed 7- by 10-foot tunnel over a Mach number range of 0.40 to 0.93 and an angle-of-attack range of about -2 degrees to 24 degrees. Lift, drag, and pitching-moment data were obtained for all configurations. From overall considerations of stability and performance it appears that with the model of this investigation the 6 degree full-span leading-edge flaps in combination with the chord-extension over the outboard 35 percent of the span, with or without leading-edge camber, would be the most desirable configuration.

Investigation of Helicopter Rotor Blade Flutter and Flapwise Bending Response in Hovering

This book provides a holistic, interdisciplinary overview of offshore wind energy, and is a must-read for

advanced researchers. Topics, from the design and analysis of future turbines, to the decommissioning of wind farms, are covered. The scope of the work ranges from analytical, numerical and experimental advancements in structural and fluid mechanics, to novel developments in risk, safety & reliability engineering for offshore wind. The core objective of the current work is to make offshore wind energy more competitive, by improving the reliability, and operations and maintenance (O&M) strategies of wind turbines. The research was carried out under the auspices of the EU-funded project, MARE-WINT. The project provided a unique opportunity for a group of researchers to work closely together, undergo multidisciplinary doctoral training, and conduct research in the area of offshore wind energy generation. Contributions from expert, external authors are also included, and the complete work seeks to bridge the gap between research and a rapidly-evolving industry.

Design Optimization of Fluid Machinery

This book is developed to serve as a concise text for a course on helicopter aerodynamics at the introductory level. It introduces to the rotary-wing aerodynamics, with applications to helicopters, and application of the relevant principles to the aerodynamic design of a helicopter rotor and its blades. The basic aim of this book is to make a complete text covering both the basic and applied aspects of theory of rotary wing flying machine for students, engineers, and applied physicists. The philosophy followed in this book is that the subject of helicopter aerodynamics is covered combining the theoretical analysis, physical features and the application aspects. Considerable number of solved examples and exercise problems with answers are coined for this book. This book will cater to the requirement of numerical problems on helicopter flight performance, which is required for the students of aeronautical/aerospace engineering.. **SALIENT FEATURES** • To provide an introductory treatment of the aerodynamic theory of rotary-wing aircraft • To study the fundamentals of rotor aerodynamics for rotorcraft in hovering flight, axial flight, and forward flight modes • To perform blade element analysis, investigate rotating blade motion, and quantify basic helicopter performance

Investigation of the Effects of Leading-edge Chord-extensions and Fences in Combination with Leading-edge Flaps on the Aerodynamic Characteristics at Mach Numbers from 0.40 to 0.93 of a 45 Degree Sweptback Wing of Aspect Ratio 4

Summary: Performance calculations are presented for a typical helicopter rotor in which three types of airfoil section were successively used. The types represented are the rough conventional, the smooth conventional, and the laminar-flow or low-drag sections as developed for helicopter use. The performance items covered are rotor thrust for fixed power in hovering, range and endurance at cruising speed, and power required at a relatively high forward speed. Contours showing the conditions of operation encountered by the blade section and weighting curves showing the relative importance of the various section angles of attack for specified flight conditions are included as an aid in the interpretation of the results. The calculations indicated that the use of a smooth conventional section will result in marked performance gains throughout the flight range. Definite, though smaller, additional gains in take-off weight and in range and endurance may be realized by the use of a low-drag section. At high forward speeds or at moderate forward speeds and high loadings, however, losses are indicated for the low-drag sections in contrast with the smooth conventional sections. It is demonstrated that, if these losses are to be avoided, the low-drag sections must be designed to avoid the extreme rise in drag coefficient at the higher angles of attack which is characteristic of the low-drag sections now available for use in helicopters.

MARE-WINT

Modern and larger horizontal-axis wind turbines with power capacity reaching 15 MW and rotors of more than 235-meter diameter are under continuous development for the merit of minimizing the unit cost of energy production (total annual cost/annual energy produced). Such valuable advances in this competitive

source of clean energy have made numerous research contributions in developing wind industry technologies worldwide. This book provides important information on the optimum design of wind energy conversion systems (WECS) with a comprehensive and self-contained handling of design fundamentals of wind turbines. Section I deals with optimal production of energy, multi-disciplinary optimization of wind turbines, aerodynamic and structural dynamic optimization and aeroelasticity of the rotating blades. Section II considers operational monitoring, reliability and optimal control of wind turbine components.

HELICOPTER AERODYNAMICS

This handbook provides both a comprehensive overview and deep insights on the state-of-the-art methods used in wind turbine aerodynamics, as well as their advantages and limits. The focus of this work is specifically on wind turbines, where the aerodynamics are different from that of other fields due to the turbulent wind fields they face and the resultant differences in structural requirements. It gives a complete picture of research in the field, taking into account the different approaches which are applied. This book would be useful to professionals, academics, researchers and students working in the field.

Aerodynamics of the Helicopter

With rapid economic and industrial development in China, India and elsewhere, fluid-related structural vibration and noise problems are widely encountered in many fields, just as they are in the more developed parts of the world, causing increasingly grievous concerns. Turbulence clearly has a significant impact on many such problems. On the other hand, new opportunities are emerging with the advent of various new technologies, such as signal processing, flow visualization and diagnostics, new functional materials, sensors and actuators, etc. These have revitalized interdisciplinary research activities, and it is in this context that the 2nd symposium on fluid-structure-sound interactions and control (FSSIC) was organized. Held in Hong Kong (May 20-21, 2013) and Macau (May 22-23, 2013), the meeting brought together scientists and engineers working in all related branches from both East and West and provided them with a forum to exchange and share the latest progress, ideas and advances and to chart the frontiers of FSSIC. The Proceedings of the 2nd Symposium on Fluid-Structure-Sound Interactions and Control largely focuses on advances in the theory, experimental research and numerical simulations of turbulence in the contexts of flow-induced vibration, noise and their control. This includes several practical areas for interaction, such as the aerodynamics of road and space vehicles, marine and civil engineering, nuclear reactors and biomedical science etc. One of the particular features of these proceedings is that it integrates acoustics with the study of flow-induced vibration, which is not a common practice but is scientifically very helpful in understanding, simulating and controlling vibration. This offers a broader view of the discipline from which readers will benefit greatly. These proceedings are intended for academics, research scientists, design engineers and graduate students in engineering fluid dynamics, acoustics, fluid and aerodynamics, vibration, dynamical systems and control etc. Yu Zhou is a professor in Institute for Turbulence-Noise-Vibration Interaction and Control at Harbin Institute of Technology. Yang Liu is an associate professor at The Hong Kong Polytechnic University. Lixi Huang, associate professor, works at the University of Hong Kong. Professor Dewey H. Hodges works at the School of Aerospace Engineering, Georgia Institute of Technology.

Effect on Helicopter Performance of Modifications in Profile-drag Characteristics of Rotor-blade Airfoil Sections

The first rotor performance predictions were published by Joukowski exactly 100 years ago. Although a century of research has expanded the knowledge of rotor aerodynamics enormously, and modern computer power and measurement techniques now enable detailed analyses that were previously out of reach, the concepts proposed by Froude, Betz, Joukowski and Glauert for modelling a rotor in performance calculations are still in use today, albeit with modifications and expansions. This book is the result of the author's curiosity as to whether a return to these models with a combination of mathematics, dedicated computations and wind tunnel experiments could yield more physical insight and answer some of the old

questions still waiting to be resolved. Although most of the work included here has been published previously, the book connects the various topics, linking them in a coherent storyline. This book will be of interest to those working in all branches of rotor aerodynamics – wind turbines, propellers, ship screws and helicopter rotors. It has been written for proficient students and researchers, and reading it will demand a good knowledge of inviscid (fluid) mechanics. Jens Nørkær Sørensen, DTU, Technical University of Denmark: “(...) a great piece of work, which in a consistent way highlights many of the items that the author has worked on through the years. All in all, an impressive contribution to the classical work on propellers/wind turbines.” Peter Schaffarczyk, Kiel University of Applied Sciences, Germany: “(...) a really impressive piece of work!” Carlos Simão Ferreira, Technical University Delft: “This is a timely book for a new generation of rotor aerodynamicists from wind turbines to drones and personal air-vehicles. In a time where fast numerical solutions for aerodynamic design are increasingly available, a clear theoretical and fundamental formulation of the rotor-wake problem will help professionals to evaluate the validity of their design problem. ‘The Fluid Dynamic Basis for Actuator Disc and Rotor Theories’ is a pleasure to read, while the structure, text and figures are just as elegant as the theory presented.” The cover shows ‘The Red Mill’, by Piet Mondriaan, 1911, collection Gemeentemuseum Den Haag. Cover image: © 2018 Mondrian/Holtzman Trust.

Energy Research Abstracts

A theoretical investigation is presented of the contribution of horizontal tails to the lift and pitching moment due to angle of attack, a constant rate of pitch, and a constant vertical acceleration. Numerical values of the aerodynamic coefficients associated with these motions are presented for a number of two-dimensional wing-tail combinations, a triangular wing-tail combination, and a number of rectangular-wing - triangular-tail combinations.

Design Optimization of Wind Energy Conversion Systems with Applications

This report presents the results of an investigation conducted in the Langley 300 mph 7- 10-foot wind tunnel for the purpose of determining the aerodynamic characteristics of a model wing-propeller combination, and of the wing and propeller separately at angles of attack up to 90 degrees. The tests covered thrust coefficients corresponding to free-stream velocities from zero forward speed to the normal range of cruising speeds. The results indicate that increasing the thrust coefficient increases the angle of attack for maximum lift and greatly diminishes the usual reduction in lift above the angle of attack for maximum lift.

Full-scale Wind-tunnel Investigation of the Longitudinal Characteristics of a Tilting-rotor Convertiplane

The book introduces the fundamentals of fluid-mechanics, momentum theories, vortex theories and vortex methods necessary for the study of rotors aerodynamics and wind-turbines aerodynamics in particular. Rotor theories are presented in a great level of details at the beginning of the book. These theories include: the blade element theory, the Kutta-Joukowski theory, the momentum theory and the blade element momentum method. A part of the book is dedicated to the description and implementation of vortex methods. The remaining of the book focuses on the study of wind turbine aerodynamics using vortex-theory analyses or vortex-methods. Examples of vortex-theory applications are: optimal rotor design, tip-loss corrections, yaw-models and dynamic inflow models. Historical derivations and recent extensions of the models are presented. The cylindrical vortex model is another example of a simple analytical vortex model presented in this book. This model leads to the development of different BEM models and it is also used to provide the analytical velocity field upstream of a turbine or a wind farm under aligned or yawed conditions. Different applications of numerical vortex methods are presented. Numerical methods are used for instance to investigate the influence of a wind turbine on the incoming turbulence. Sheared inflows and aero-elastic simulations are investigated using vortex methods for the first time. Many analytical flows are derived in details: vortex rings, vortex cylinders, Hill's vortex, vortex blobs etc. They are used throughout the book to devise simple

rotor models or to validate the implementation of numerical methods. Several Matlab programs are provided to ease some of the most complex implementations.

Handbook of Wind Energy Aerodynamics

As part of the general helicopter research program being undertaken by the National Advisory Committee for Aeronautics to provide designers with fundamental rotor information, the forward-flight performance characteristics of a typical single-rotor helicopter, which is equipped with main and tail rotors, have been investigated in the Langley full-scale tunnel. The test conditions included operation at tip-speed ratios from 0.10 to 0.27 and at thrust coefficients from 0.0030 to 0.0060. Results obtained with the production rotor were compared with those for an alternate set of blades having closer rib spacing and a smoother and more accurately contoured surface in order to evaluate the performance gains that are available by the use of rotor blades having an improved surface condition.

Fluid-Structure-Sound Interactions and Control

The lack of progress in understanding the physics of rotorcraft loads and vibration over the last 30 years is addressed in this paper. As befits this extraordinarily difficult problem, the reasons for the lack of progress are complicated and difficult to ascertain. It is proposed here that the difficulty lies within at least three areas: 1) a loss of perspective as to what are the key factors in rotor loads and vibration, 2) the overlooking of serious unsolved problems in the field, and 3) cultural barriers that impede progress. Some criteria are suggested for future research to provide a more concentrated focus on the problem.

The Fluid Dynamic Basis for Actuator Disc and Rotor Theories

Amid the dynamic growth of artificial intelligence, this book presents a collection of findings and advancements from the second edition of the A2IA-Artificial Intelligence and Industrial Applications conference. The conference, hosted by ENSAM-Meknès at Moulay Ismail University, Morocco, fosters knowledge exchange in AI, focusing primarily on its industrial applications. Covering a wide range of topics, the book highlights the adaptable nature of AI and its increasing impact on industrial sectors. It brings together contributions from an international cohort of researchers, discussing themes such as intelligent manufacturing and maintenance, intelligent supply chain management, various modes of learning including supervised, unsupervised, reinforcement, semi-supervised, and graph-based, as well as neural networks, deep learning, planning, and optimization. A defining feature of this edition is its extensive scope and emphasis on the practical applications of AI, along with its foundational elements. It facilitates an understanding of AI's current state and potential future direction, showcasing recent developments that bridge the gap between theory and practice. Designed for a diverse readership, this book is of interest to AI practitioners, academics, and enthusiasts, as well as to those new to the field. It provides an opportunity to explore AI's critical role in industrial applications, and the practical insights it offers are likely to be beneficial for decision-making within industrial settings.

A Theoretical Investigation of the Aerodynamics of Wing-tail Combinations Performing Time-dependent Motions at Supersonic Speeds

Wind Turbine Airfoils and Blades introduces new ideas in the design of wind turbine airfoils and blades based on functional integral theory and the finite element method, accompanied by results from wind tunnel testing. The authors also discuss the optimization of wind turbine blades as well as results from aerodynamic analysis. This book is suitable for researchers and engineers in aeronautics and can be used as a textbook for graduate students.

Investigation of the Aerodynamic Characteristics of a Model Wing-propeller Combination and of the Wing and Propeller Separately at Angles of Attack Up to 90°

The purpose of this book is to provide engineers and researchers in both the wind power industry and energy research community with comprehensive, up-to-date, and advanced design techniques and practical approaches. The topics addressed in this book involve the major concerns in the wind power generation and wind turbine design.

Wind Turbine Aerodynamics and Vorticity-Based Methods

This book presents numerical and experimental research in the field of wind energy exploitation in urban environments. It comprises a selection of the best papers from the international colloquium “Research and Innovation on Wind Energy Exploitation in Urban Environment” (TUrbWind), held in Riva del Garda, Italy in September 2018. The book includes contributions from different research fields in urban wind resources, wind energy conversion systems, and urban integration, mainly focusing on the following topics: · turbine concepts for urban and sub-urban environment; · measuring and modelling wind resource; · rotor aerodynamics, wakes and noise; · design, loads, and supporting structures; · novel shapes and materials; · building concepts for wind energy exploitation; · planning approaches for wind exploitation in urban areas. It is a valuable resource for researchers and practitioners interested in the integration of wind energy systems and turbines in urban areas.

Full-scale Investigation of the Aerodynamic Characteristics of a Typical Single-rotor Helicopter in Forward Flight

Aerodynamics of Wind Turbines is the established essential text for the fundamental solutions to efficient wind turbine design. Now in its second edition, it has been entirely updated and substantially extended to reflect advances in technology, research into rotor aerodynamics and the structural response of the wind turbine structure. Topics covered include increasing mass flow through the turbine, performance at low and high wind speeds, assessment of the extreme conditions under which the turbine will perform and the theory for calculating the lifetime of the turbine. The classical Blade Element Momentum method is also covered, as are eigenmodes and the dynamic behaviour of a turbine. The new material includes a description of the effects of the dynamics and how this can be modelled in an ‘aeroelastic code’, which is widely used in the design and verification of modern wind turbines. Further, the description of how to calculate the vibration of the whole construction, as well as the time varying loads, has been substantially updated.

Putting the Aero Back Into Aeroelasticity

A review of the aerodynamics, design and analysis, and optimization of wind turbines, combined with the author’s unique software Aerodynamics of Wind Turbines is a comprehensive introduction to the aerodynamics, scaled design and analysis, and optimization of horizontal-axis wind turbines. The author – a noted expert on the topic – reviews the fundamentals and basic physics of wind turbines operating in the atmospheric boundary layer. He then explores more complex models that help in the aerodynamic analysis and design of turbine models. The text contains unique chapters on blade element momentum theory, airfoil aerodynamics, rotational augmentation, vortex-wake methods, actuator-line modeling, and designing aerodynamically scaled turbines for model-scale experiments. The author clearly demonstrates how effective analysis and design principles can be used in a wide variety of applications and operating conditions. The book integrates the easy-to-use, hands-on XTurb design and analysis software that is available on a companion website for facilitating individual analyses and future studies. This component enhances the learning experience and helps with a deeper and more complete understanding of the subject matter. This important book: Covers aerodynamics, design and analysis and optimization of wind turbines Offers the author’s XTurb design and analysis software that is available on a companion website for individual analyses and future studies Includes unique chapters on blade element momentum theory, airfoil aerodynamics,

rotational augmentation, vortex-wake methods, actuator-line modeling, and designing aerodynamically scaled turbines for model-scale experiments Demonstrates how design principles can be applied to a variety of applications and operating conditions Written for senior undergraduate and graduate students in wind energy as well as practicing engineers and scientists, Aerodynamics of Wind Turbines is an authoritative text that offers a guide to the fundamental principles, design and analysis of wind turbines.

Elements of Propeller and Helicopter Aerodynamics

Document from the year 2011 in the subject Engineering - System Science, , language: English, abstract: A wind turbine is a device that extracts kinetic energy of the wind and converts it into useful energy. The power produced by a wind turbine depends on the interaction between the wind turbine rotor and the wind. Thus, wind turbine aerodynamics is an important field of study for designing a blade and analyzing the aerodynamic performance of the rotor. A number of scientists have derived various methods for aerodynamic analysis of wind turbine rotors. These methods are presented here.

Artificial Intelligence and Industrial Applications

This title reports on the latest research in the area of aerodynamic efficiency of various fixed-wing, flapping wing, and rotary wing concepts. It presents the progress made by over fifty active researchers in the field.

Wind Turbine Airfoils and Blades

Wind Power Generation and Wind Turbine Design

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