This report describes work performed on Contract NAS3-27720AoI 13 as part of the NASA Advanced Subsonic Transport (AST) Noise Reduction Technology effort. Computer codes were developed to provide quantitative prediction, design, and analysis capability for several aircraft engine noise sources. The objective was to provide improved, physics-based tools for exploration of noise-reduction concepts and understanding of experimental results. Methods and codes focused on fan broadband and 'buzz saw' noise and on low-emissions combustor noise and compliment work done by other contractors under the NASA AST program to develop methods and codes for fan harmonic tone noise and jet noise. The methods and codes developed and reported herein employ a wide range of approaches, from the strictly empirical to the completely computational, with some being semiempirical analytical, and/or analytical/computational. Emphasis was on capturing the essential physics while still considering method or code utility as a practical design
and analysis tool for everyday engineering use. Codes and prediction models were developed for: (1) an improved empirical correlation model for fan rotor exit flow mean and turbulence properties, for use in predicting broadband noise generated by rotor exit flow turbulence interaction with downstream stator vanes; (2) fan broadband noise models for rotor and stator/turbulence interaction sources including 3D effects, noncompact-source effects. directivity modeling, and extensions to the rotor supersonic tip-speed regime; (3) fan multiple-pure-tone in-duct sound pressure prediction methodology based on computational fluid dynamics (CFD) analysis; and (4) low-emissions combustor prediction methodology and computer code based on CFD and actuator disk theory. In addition, the relative importance of dipole and quadrupole source mechanisms was studied using direct CFD source computation for a simple cascade gust interaction problem, and an empirical combustor-nois...The book describes recent developments in aeroacoustic measurements in wind tunnels and the interpretation of the resulting data. The reader will find the latest measurement techniques described along with examples of the results. Computational Fluid Dynamics (CFD) is an important design tool in engineering and also a substantial research tool in various physical sciences as well as in biology. The objective of this book is to provide university students with a solid foundation for understanding the numerical methods employed in today’s CFD and to familiarise them with modern CFD codes by hands-on experience. It is also intended for engineers and scientists starting to work in the field of CFD or for those who apply CFD codes. Due to the detailed index, the text can serve as a reference handbook too. Each chapter includes an extensive bibliography, which provides an excellent basis for further studies. Mechanics of Flow-Induced Sound and Vibration enables readers to fully understand flow-induced vibration and sound, unifying the disciplines of fluid dynamics, structural dynamics, vibration, acoustics, and statistics, in order to classify and examine each of the leading sources of vibration and sound induced by various types of fluid motion. The sources considered include jet noise, flow-induced tones and self-excited vibration, dipole sound from rigid and flexible acoustically compact surface, cavitation noise, acoustic transmission characteristics and sound radiation from bubbly liquids. Starting from classical theories of aeroacoustics and hydroacoustics, a formalism of integral solutions valid for sources near boundaries is developed, and then broadened to address the different source types mentioned above. Step-by-step derivations clearly identify any assumptions made throughout. Each chapter is illustrated with comparisons of leading formulas and measured data. The extensive reference lists are intended to support all chapters of the book with up-to-date background and additional information. The formalisms developed are suitable for computer modeling, and along with its companion book Mechanics of Flow-Induced Sound and Vibration: Complex Flow-Structure Interactions covers everything an engineer needs to understand about flow-induced sound and vibration. Every important topic in flow-induced sound and vibration is covered. All aspects of these topics are
addressed, from the fundamental theory to the analytical formulae used in practice, and results of academic research. The theory and mathematical formulae reproduced here are the building blocks of computer modeling for flow-induced sound and vibration. We are delighted to present this book which contains the Proceedings of the Fifth International Conference on Computational Fluid Dynamics (ICCFD5), held in Seoul, Korea from July 7 through 11, 2008. The ICCFD series has established itself as the leading international conference series for scientists, mathematicians, and engineers specialized in the computation of fluid flow. In ICCFD5, 5 Invited Lectures and 3 Keynote Lectures were delivered by renowned researchers in the areas of innovative modeling of flow physics, innovative algorithm development for flow simulation, optimization and control, and advanced multidisciplinary applications. There were a total of 198 contributed abstracts submitted from 25 countries. The executive committee consisting of C. H. Bruneau (France), J. J. Chattot (USA), D. Kwak (USA), N. Satofuka (Japan), and myself, was responsible for the selection of papers. Each of the members had a separate subcommittee to carry out the evaluation. As a result of this careful peer review process, 138 papers were accepted for oral presentation and 28 for poster presentation. Among them, 5 (3 oral and 2 poster presentation) papers were withdrawn and 10 (4 oral and 6 poster presentation) papers were not presented. The conference was attended by 201 delegates from 23 countries. The technical aspects of the conference were highly beneficial and informative, while the non-technical aspects were fully enjoyable and memorable. In this book, 3 invited lectures and 1 keynote lecture appear first. Then 99 contributed papers are grouped under 21 subject titles which are in alphabetical order. This book presents the proceedings of the first vehicle engineering and vehicle industry conference. It captures the outcome of theoretical and practical studies as well as the future development trends in a wide field of automotive research. The themes of the conference include design, manufacturing, economic and educational topics. "Fluid Machinery and Fluid Mechanics: 4th International Symposium (4th ISFMFE)" is the proceedings of 4th International Symposium on Fluid Machinery and Fluid Engineering, held in Beijing November 24-27, 2008. It contains 69 highly informative technical papers presented at the Mei Lecture session and the technical sessions of the symposium. The Chinese Society of Engineering Thermophysics (CSET) organized the First, the Second and the Third International Symposium on Fluid Machinery and Fluid Engineering (1996, 2000 and 2004). The purpose of the 4th Symposium is to provide a common forum for exchange of scientific and technical information worldwide on fluid machinery and fluid engineering for scientists and engineers. The main subject of this symposium is "Fluid Machinery for Energy Conservation". The "Mei Lecture" reports on the most recent developments of fluid machinery in commemoration of the late professor Mei Zuyan. The book is intended for researchers and engineers in fluid machinery and fluid engineering. Jianzhong Xu is a professor at the Chinese Society of Engineering Thermophysics, Chinese
Academy of Sciences, Beijing. Aerodynamics, from a modern point of view, is a branch of physics that study physical laws and their applications, regarding the displacement of a body into a fluid, such concept could be applied to any body moving in a fluid at rest or any fluid moving around a body at rest. This Book covers a small part of the numerous cases of stationary and non stationary aerodynamics; wave generation and propagation; wind energy; flow control techniques and, also, sports aerodynamics. It's not an undergraduate text but is thought to be useful for those teachers and/or researchers which work in the several branches of applied aerodynamics and/or applied fluid dynamics, from experiments procedures to computational methods. Volume is indexed by Thomson Reuters CPCI-S (WoS). This work brings together some 400 peer-reviewed papers on Nanoscience and Materials Technology, and is intended to promote the development of Mechanical Engineering and Materials Engineering; thus strengthening international academic cooperation and communication and the exchange of research ideas. A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system and announced in Scientific and technical aerospace reports (STAR) and International aerospace abstracts (IAA).
turbine aerodynamic design and flow control, and the multidisciplinary conjugate problems involved with
gas turbines. This book should be helpful for scientific and technical staffs, college teachers,
graduate students, and senior college students, who are involved in research and design of gas
turbines. An up-to-date survey of airplane noise, this single-volume reference thoroughly addresses the
key problems facing aeronautical engineers. By tackling the most important aspects of jet aeroacoustics,
including theories of jet noise, the design of jet noise facilities, and how jet noise is measured, this
thoroughly researched analysis outlines a plan for first limiting the current distress being vocalized
in issues of passenger cabin comfort and protests by those living near airports and later for finding an
overall solution to jet noise. Noise pollution around airports, trains, and industries increasingly
attracts environmental concern and regulation. Designers and researchers have intensified the use of
large-eddy simulation (LES) for noise reduced industrial design and acoustical research. This 2007 book,
written by 30 experts, presents the theoretical background of acoustics and of LES, followed by details
about numerical methods, e.g. discretization schemes, boundary conditions, coupling aspects.
Industrially relevant, hybrid RANS/LES techniques for acoustic source predictions are presented in
detail. Many applications are featured ranging from simple geometries for mixing layers and jet flows to
complex wing and car geometries. Selected applications include scientific investigations at industrial
and university research institutions. Computational aeroacoustics (CAA) is a relatively new research
area. CAA algorithms have developed rapidly and the methods have been applied in many areas of
aeroacoustics. The objective of CAA is not simply to develop computational methods but also to use these
methods to solve practical aeroacoustics problems and to perform numerical simulation of aeroacoustic
phenomena. By analysing the simulation data, an investigator can determine noise generation mechanisms
and sound propagation processes. This is both a textbook for graduate students and a reference for
researchers in CAA and as such is self-contained. No prior knowledge of numerical methods for solving
partial differential equations (PDEs) is needed, however, a general understanding of partial
differential equations and basic numerical analysis is assumed. Exercises are included and are designed
to be an integral part of the chapter content. In addition, sample computer programs are included to
illustrate the implementation of the numerical algorithms. Computational aeroacoustics is rapidly
emerging as an essential element in the study of aerodynamic sound. As with all emerging technologies,
it is paramount that we assess the various opportunities and establish achievable goals for this new
technology. Essential to this process is the identification and prioritization of fundamental
aeroacoustics problems which are amenable to direct numerical simulation. Questions, ranging from the
role numerical methods play in the classical theoretical approaches to aeroacoustics, to the correct
specification of well-posed numerical problems, need to be answered. These issues provided the impetus
for the Workshop on Computational Aeroacoustics sponsored by ICASE and the Acoustics Division of NASA LaRC on April 6-9, 1992. The participants of the Workshop were leading aeroacousticians, computational fluid dynamicists and applied mathematicians. The Workshop started with the opening remarks by M. Y. Hussaini and the welcome address by Kristin Hessenius who introduced the keynote speaker, Sir James Lighthill. The keynote address set the stage for the Workshop. It was both an authoritative and up-to-date discussion of the state-of-the-art in aeroacoustics. The presentations at the Workshop were divided into five sessions - i) Classical Theoretical Approaches (William Zorumski, Chairman), ii) Mathematical Aspects of Acoustics (Rodolfo Rosales, Chairman), iii) Validation Methodology (Allan Pierce, Chairman), iv) Direct Numerical Simulation (Michael Myers, Chairman), and v) Unsteady Compressible Flow Computational Methods (Douglas Dwoyer, Chairman).

Aeroacoustics of Low Mach Number Flows: Fundamentals, Analysis, and Measurement provides a comprehensive treatment of sound radiation from subsonic flow over moving surfaces, which is the most widespread cause of flow noise in engineering systems. This includes fan noise, rotor noise, wind turbine noise, boundary layer noise, and aircraft noise. Beginning with fluid dynamics, the fundamental equations of aeroacoustics are derived and the key methods of solution are explained, focusing both on the necessary mathematics and physics. Fundamentals of turbulence and turbulent flows, experimental methods and numerous applications are also covered. The book is an ideal source of information on aeroacoustics for researchers and graduate students in engineering, physics, or applied math, as well as for engineers working in this field. Supplementary material for this book is provided by the authors on the website www.aeroacoustics.net. The website provides educational content designed to help students and researchers in understanding some of the principles and applications of aeroacoustics, and includes example problems, data, sample codes, course plans and errata. The website is continuously being reviewed and added to. Explains the key theoretical tools of aeroacoustics, from Lighthill’s analogy to the Ffowcs Williams and Hawkings equation Provides detailed coverage of sound from lifting surfaces, boundary layers, rotating blades, ducted fans and more Presents the fundamentals of sound measurement and aeroacoustic wind tunnel testingThe development of physics-based noise prediction tools for analysis of aerodynamic noise sources is of paramount importance since noise regulations have become more stringent. Direct simulation of aerodynamic noise remains prohibitively expensive for engineering problems because of the resolution requirements. Therefore, hybrid approaches that consist of predicting nearfield flow quantities by a suitable CFD simulation and farfield sound radiation by aeroacoustic integral methods are more attractive. In this work, we apply the fast multipole method (FMM) to accelerate the solution of boundary integral equation methods such as the boundary element method (BEM) and the Ffowcs Williams & Hawkings (FWH) acoustic analogy formulation. The FMM-BEM is implemented for the solution of acoustic scattering problems and the effects of non-uniform
potential flows on acoustic scattering are investigated. The FMM-FWH is implemented for the solution of two and three-dimensional problems of sound propagation. The effects of flow convection and non-linear quadrupole sources are assessed through the study of sound generated by unsteady laminar flows. Finally, a hybrid methodology is applied for the investigation of airfoil noise. This study is important for the design of aerodynamic shapes such as wings and high-lift devices, as well as wind turbine blades, fans and propellers. The present investigation of airfoil self-noise generation and propagation concerns the broadband noise that arises from the interaction of turbulent boundary layers with the airfoil trailing edge and tonal noise that arises from vortex shedding generated by laminar boundary layers. Nearfield acoustic sources are computed using compressible large eddy simulation (LES) and acoustic predictions are performed by the FMM-FWH. Numerical simulations are conducted for a NACA0012 airfoil with tripped boundary layers and blunt rounded trailing edge at different Mach numbers and angles of incidence. The effects of non-linear quadrupole sources and convection are assessed. In order to validate the numerical solutions, flow simulation and acoustic prediction results are compared to experimental data available in the literature and excellent agreement is observed.

A CFD analysis is presented for a set of baseline and noise suppression mixed flow nozzles with and without a pylon installation. The five model configurations are as follows; a baseline core/fan dual-stream nozzle with an external plug, a chevron mixer nozzle with a peak on the symmetry plane with external plug, both of the above nozzles with an installed bifurcating pylon and lastly a clocked chevron mixer nozzle such that a trough is aligned with the center of the pylon. The fluid flow is simulated by solving the asymptotically steady, compressible, Reynolds-averaged Navier-Stokes equations using an implicit, up-wind, flux-difference splitting finite volume scheme and standard two equation k-epsilon turbulence model with a linear stress representation. All computations are performed using the multiblock, parallel, structured code PAB3D. Results indicate that the clocked chevron with pylon case achieves the most optimal levels of average and peak turbulence kinetic energy and vorticity and therefore is expected to be the quietest of the five configurations tested. Further study is required to refine expressions which are indicative of noise and mate these with rigorous noise prediction models.

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COMPUTATIONAL FLUID DYNAMICS; PLUG NOZZLES; AEROACOUSTICS; ANALYSIS (MATHEMATICS); FINITE VOLUME METHOD; FLUX DIFFERENCE SPLITTING; NOISE PREDICTION; TAKEOFF; NAVIER-STOKES EQUATION; NOISE REDUCTION; TURBULENCE; REYNOLDS EQUATION

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Page 7/9
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This textbook is a collection of technical papers that were presented at the 10th International Symposium on Unsteady Aerodynamics, Aeroacoustics, and Aeroelasticity of Turbomachines held September 8-11, 2003 at Duke University in Durham, North Carolina. The papers represent the latest in state of the art research in the areas of aeroacoustics, aerothermodynamics, computational methods, experimental testing related to flow instabilities, flutter, forced response, multistage, and rotor-stator effects for turbomachinery. Axial Flow Fans: Design and Practice focuses on the design of axial flow fans and the practices involved in their applications. The manuscript first offers information on the fluid mechanics of ducted fans, boundary layer and skin friction relations, and aerofoil data for blade design. Discussions focus on flow deflection in cascade of aerofoils, pitching moment, lift, surface roughness in turbulent boundary layers, turbulent boundary layers in pressure gradients, laminar skin friction, viscosity and boundary layers, and similarity and non-dimensional numbers. The text then ponders on vortex flows in ducting and fan, ducts, and introduction to fan design methods. The book takes a look at the momentum and blade element considerations on free vortex flow of rotor and rotor losses. Topics include momentum considerations, profile drag, tip clearance losses, optimum conditions in terms of the flow and swirl coefficients, pressure relations and velocity vectors, and thrust and torque gradients. Tail fairing design and
associated losses, overall efficiencies, torque, thrust, and power, and the design of fan unit with arbitrary vortex flow are also discussed. The publication is a dependable source of information for engineers and readers interested in the design of axial flow fans and practices involved in their operation. Elektrofahrzeuge sind für Entwickler der Fahrzeugakustik ebenso eine Herausforderung wie eine höhere NVH-Performance durch Leichtbaustrukturen und kleinere Motoren mit Turbolader. Die Automobilforschung muss das Akustikmanagement im Fahrzeug neu denken. Die internationale Automotive Acoustics Conference bietet dazu als Fachtagung das notwendige Expertenwissen, um die künftigen Anforderungen an Antriebsstrang, Antriebssysteme und Fahrzeugarchitekturen zu erfüllen. Simulationsprozesse und Verfahren der Multiphysik sind dabei essenziell, um Ruhe in die Passagierkabine zu bringen. Die Konferenz zur car acoustics bietet dazu neustes Expertenwissen. Those interested in state of the art in computational fluid dynamics will find this publication a valuable source of reference. The contributions are drawn from The International Conference on Computational Fluid Dynamics (ICCFD) held in 2004. The conference is staged every two years and brings together physicists, mathematicians and engineers who review and share recent advances in mathematical and computational techniques for modeling fluid dynamics.

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