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Special Issue on Recent Advances in Turbulent Premixed Combustion Modeling The importance of fuel-lean combustion in premixed mode for modern gas turbine and automotive engines has been well recognized. This combustion mode is prone to combustion-induced oscillation, which is usually addressed by introducing some partial premixing.

Turbulent combustion sits at the interface of two important nonlinear, multiscale phenomena: chemistry and turbulence. Its study is extremely timely in view of the need to develop new combustion technologies in order to address challenges associated with climate change, energy source uncertainty, and air pollution. Despite the fact that modeling of turbulent combustion is a subject that has been researched for a number of years, its complexity implies that key issues are still eluding, and a theoretical description that is accurate enough to make turbulent combustion models rigorous and quantitative for industrial use is still lacking. In this book, prominent experts review most of the available approaches in modeling turbulent combustion, with particular focus on the exploding increase in computational resources that has allowed the simulation of increasingly detailed phenomena. The relevant algorithms are presented, the theoretical methods are explained, and various application examples are given. The book is intended for a relatively broad audience, including seasoned researchers and graduate students in engineering, applied mathematics and computational science, engine designers and computational fluid dynamics (CFD) practitioners, scientists at funding agencies, and anyone wishing to understand the state-of-the-art and the future directions of this scientifically challenging and practically important field.

Turbulent combustion sits at the interface of two important nonlinear, multiscale phenomena: chemistry and turbulence. Its study is extremely timely in view of the need to develop new combustion technologies in order to address challenges associated with climate change, energy source uncertainty, and air pollution. Despite the fact that modeling of turbulent combustion is a subject that has been researched for a number of years, its complexity implies that key issues are still eluding, and a theoretical description that is accurate enough to make turbulent combustion models rigorous and quantitative for industrial use is still lacking. In this book, prominent experts review most of the available approaches in modeling turbulent combustion, with particular focus on the exploding increase in computational resources that has allowed the simulation of increasingly detailed phenomena. The relevant algorithms are presented, the theoretical methods are explained, and various application examples are given. The book is intended for a relatively broad audience, including seasoned researchers and graduate students in engineering, applied mathematics and computational science, engine designers and computational fluid dynamics (CFD) practitioners, scientists at funding agencies, and anyone wishing to understand the state-of-the-art and the future directions of this scientifically challenging and practically important field.

Explore a thorough overview of the current knowledge, developments and outstanding challenges in turbulent combustion and application.

In spite of the increasing presence of

renewable energy sources, fossil fuels will remain the primary supply of the world's energy needs for the upcoming future. Modern gas-turbine based systems represent one of the most efficient large-scale power generation technology currently available. Alongside this, gas-turbine power plants operate with very low emissions, have flexible operational characteristics and are able to utilize a broad range of fuels. It is expected that gas-turbine based plants will play an important role as an effective means of converting combustion energy in the future as well, because of the vast potential energy savings. The numerical approach to the design of complex systems such as gas-turbines has gained a continuous growth of interest in the last few decades. This because simulations are foreseen to provide a tremendous increase in the combustor efficiency, fuel-flexibility and quality over the next future. In this dissertation, an advanced turbulent combustion technique is implemented and progressively developed for the simulation of all the features that are typically observed in stationary gas-turbine combustion, including hydrogen as a fuel. The developed turbulent combustion model retains most of the accuracy of a detailed simulation while drastically reducing its computational time. As a result of this work, the advancement of power generation plants can be accelerated, paving the way for future developments of alternative fuel usage in a cleaner and more efficient combustion.

The combustion of fossil fuels remains a key technology for the foreseeable future. It is therefore important that we understand the mechanisms of combustion and, in particular, the role of turbulence within this process. Combustion always takes place within a turbulent flow field for two reasons: turbulence increases the mixing process and enhances combustion, but at the same time combustion releases heat which generates flow instability through buoyancy, thus enhancing the transition to turbulence. The four chapters of this book present a thorough introduction to the field of turbulent combustion. After an overview of modeling approaches, the three remaining chapters consider the three distinct cases of premixed, non-premixed, and partially premixed combustion, respectively. This book will be of value to researchers and students of engineering and applied mathematics by demonstrating the current theories of turbulent combustion within a unified presentation of the field.

This book presents a comprehensive review of state-of-the-art models for turbulent combustion, with special emphasis on the theory, development and applications of combustion models in practical combustion systems. It simplifies the complex multi-scale and nonlinear interaction between chemistry and turbulence to allow a broader audience to understand the modeling and numerical simulations of turbulent combustion, which remains at the forefront of research due to its industrial relevance. Further, the book provides a holistic view by covering a diverse range of basic and advanced topics—from the fundamentals of turbulence – chemistry interactions, role of high-performance computing in combustion simulations, and optimization and reduction techniques for chemical kinetics, to state-of-the-art modeling strategies for turbulent premixed and nonpremixed combustion and their applications in engineering contexts.

This book highlights recent research advances in the area of turbulent flows from both industry and academia for applications in the area of Aerospace and Mechanical engineering. Contributions include modeling, simulations and experiments meant for researchers, professionals and students in the area.

This volume gathers the contributions of six world experts to a course on combustion modelling. Therefore, a pedagogical effort has been made in writing up these texts, which cover state of the art advances in most aspects of combustion science. The book is aimed at students, researches and engineers, as was the course.

A work on turbulent premixed combustion is timely because of increased concern about the environmental impact of combustion and the search for new combustion concepts and technologies. An improved understanding of lean fuel turbulent premixed flames must play a central role in the fundamental science of these new concepts. Lean premixed flames have the potential to offer ultra-low emission levels, but they are notoriously susceptible to combustion oscillations. Thus, sophisticated control measures are inevitably required. The editors' intent is to set out the modeling aspects in the field of turbulent premixed combustion. Good progress has been made recently on this topic. Thus, it is timely to edit a cohesive volume containing contributions from international experts on various subtopics of the lean premixed flame problem.

Three approaches toward efficient and predictive turbulent combustion modeling are investigated in this dissertation. The first approach focuses on the development of locally reduced chemistry and advanced solvers for efficient time integration of stiff chemical kinetic systems. In particular, a numerical technique using dynamic adaptive chemistry (DAC) with splitting schemes is developed and demonstrated in one-dimensional (1-D) premixed flames. A sparse stiff chemistry solver based on dynamic adaptive hybrid integration (AHI) and sparse matrix techniques (AHI-S), and an iterative uncoupled quasi-steady-state (IU-QSS) method for improved stability of explicit solvers, are further developed and shown to be more computationally efficient than other chemistry solvers in various flame configurations. In the second approach, a computational diagnostic tool, namely the chemical explosive mode analysis (CEMA), is extended to account for the interactions between chemical reactions and transport processes. Different local combustion modes, including the auto-ignition, diffusion-assisted ignition, and extinction modes, are demarcated by projecting the chemical and transport source terms to the chemical explosive mode. A criterion based on the local combustion modes is proposed to distinguish between two premixed flame propagation modes, that is the auto-ignition and diffusion-controlled deflagration waves, respectively. The new criterion is validated in 1-D premixed flames and 2-D homogeneous charge compression ignition (HCCI) systems. CEMA-based diagnostics are then employed to investigate the local structures of strongly turbulent premixed n-dodecane flames, and to understand the propagation modes and stabilization mechanisms of a turbulent lifted dimethyl ether (DME) jet flame, based on direct numerical simulation (DNS) data. The third approach is to construct a dynamic adaptive combustion modeling framework for turbulent flames that involve both premixed and non-premixed features. CEMA is adopted as a flame segmentation tool, and appropriate sub-models are assigned on-the-fly to different flame zones. The proposed modeling framework is tested in a turbulent lifted n-dodecane spray flame using large eddy simulations (LES). The new model is found to predict the ignition delay and lift-off length more accurately compared with the low-cost flamelet models, while the overall computational cost can be substantially reduced compared with the high-cost regime-independent models that incorporate finite rate chemistry.