Preface

Though combustion is among the oldest sciences known to the human race, the advances in combustion have been for most part evolutionary, keeping pace with the increasing demands. Considerable progress has been made in combustion devices used for stationary power, as well as for propulsion applications. Current and future propulsion systems require increased energy release with reduced chamber volume, increased equilibrium temperatures, multiphase reacting flows with radiative heat transfer, and sometimes with electric and magnetic forces. Strong intercoupling of these phenomena in a very hostile environment makes conventional design methodology of building and testing a formidable approach. Recent advances in supercomputing and massively parallel processing has brought forth computational capabilities hitherto unheard-of. These, together with the advances in mathematical formulations, open a new avenue in the pursuit of advances, or may be a new generation of combustion systems.

Computational fluid dynamics has proven itself to be a highly successful tool in designing aerodynamic systems. Extension of CFD to combustion involves far more than adding a few more terms in the governing equations. When one realizes that combustion involves utilization of fuels and other species of vastly different molecular properties, chemical reactions with vastly different time scales, wide range of stoichiometry and load conditions, multiphase flows requiring precise thermal and exhaust management, and signature control, the complexity is obvious. This complexity is the challenge and the opportunity for the theoretical and computational combustion scientist. Precise numerical experiments can be performed, parametric studies can be executed, proper directives can be provided for verification experiments, and the final design tool can be fabricated by logical combination of analysis and computation of the combustion processes and interactions.

There has been an extensive analytical and computational research done world wide in the various disciplines relating to combustion, and there is a need to bring the various contributions in one volume as a reference tool for the researcher as well as practicing engineer. Selected papers presented at the International Colloquium on Advanced Computation and Analysis of Combustion held in Moscow, May 12–15, 1997, are assembled together in this volume. This volume is neither complete nor comprehensive to cover the numerous issues involved in developing future combustion systems. This is intended to be a tool to explore the present state of the art, and an avenue for further follow-up.

The book is divided into five Chapters, to identify the topics of current research challenges in combustion.

Chapter I, Reduced Chemical Kinetics and Kinetic–Turbulence Interaction, deals with the strategies of systematic reduction of detailed reaction mechanisms (Williams, Bykov *et al.*, Hamiroune *et al.*, Starik, Makarov), physico–chemical processes governing soot formation in flames (Krestinin, Warnatz *et al.*), and transient ignition — extinction phenomena in premixed flames with the emphasis to combustion chemistry (Borisov *et al.*, Vlachos *et al.*).

In *Chapter II, Multiphase Reacting Flows*, new numerical approaches for studies of multiphase reacting flows are reported (Kailasanath and Chang, Smirnov *et al.*, Mashayek *et al.*, Rose *et al.*), as well as the examples illustrating the qualitative and quantitative capabilities of the mathematical methods in predicting complex multiphase phenomena (Drobyshevich, Udaykumar *et al.*).

Reported in *Chapter III, High Speed Turbulent Combustion*, are the advanced approaches addressing mixing and combustion phenomena in high-speed flows (Sabel'nikov, Drummond, Morgentahler *et al.*, Buriko *et al.*, Borisov *et al.*), specific features of combustion in a vibrationally nonequilibrium mixture (Osipov *et al.*), and the application of mathematical modeling to pactical aspects of arranging supersonic combustion in scramjets (Berlyand *et al.*).

Chapter IV, Turbulent Combustion Modeling, is composed of the papers dealing with new modeling approaches to turbulent combustion (Pope, Ilegbusi, Lipatnikov, Kaminsky *et al.*, Hewett and Madnia, Kuhl and Oppenheim, Kuznetsov).

Chapter V, Numerical Simulation of Combustion, presents a whole spectrum of advanced numerical approaches, namely, the joint conditionally averaged velocity — concentration probability density function (PDF) approach (Frost), BML second order approach (Bailly *et al.*), joint scalar PDF method (Biagioli, Tatschl *et al.*), flowfield-dependent mixed explicit–implicit method (Chung), monotonically integrated Large Eddy Simulation (LES) method (Grinstein and Kailasanath), linear eddy model as a subgrid model in LES (DesJuardin *et al.*), joint velocity — scalar PDF method (Frolov *et al.*), flux and vortex methods (Mashayek *et al.*).

We have attempted to select a proper spectrum of papers to present as complete a picture as possible on the state of the art of analytical and numerical combustion, hoping to provide some insight to the reader with information that will suit their needs. We have to confess that we have been really pressed with time in editing as several papers came very late, and we wanted to make this volume available at the

colloquium. We like to express our deep appreciation to Ms. Olga Frolova for her excellent compilation of this volume and the personal interest and time she has taken to bring out this volume in a short time.

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G. D. Roy
Office of Naval Research
Arlington, VA, USA

S. M. Frolov
N. N. Semenov Institute of Chemical
Physics, Moscow, Russia

P. Givi
State University of
New York, Buffalo, NY, USA