PREFACE

In the last ten to fifteen years, there have been substantial developments in non-intrusive combustion diagnostic techniques. Advances in diagnostics have been due largely to the rapid development of laser-based optical techniques, computer-coupled data acquisition systems, and digital image capture and analysis. The non-intrusive character of these methods is essential to prevent perturbation of the flow systems under study, and thus provide more realistic and accurate measurements than those provided by intrusive techniques. Advanced diagnostic techniques have been applied to various combustion and propulsion systems for measurements of concentrations of chemical species, temperatures of gaseous mixtures and particles, the velocity field of chemically reacting flows, the regression rate of condensed phase materials, etc. Using advanced non-intrusive diagnostic techniques, engineers and scientists are much better equipped to study combustion, propulsion, and environmentally related problems.

Experimental measurements are needed for a variety of purposes, including achieving a better understanding of flame and flow field structures in order to improve the design of existing combustion and propulsion systems, validating theoretical models and numerical codes, studying the formation mechanism of undesirable species in emission control, and conducting performance evaluations of combustion systems.

Although the design of many modern propulsion systems leans toward calculation and simulation rather than extensive hardware fabrication and testing, diagnostic techniques are still very important. Indeed, the rise in Computational Fluid Dynamics (CFD) is beginning to allow evaluation of complex flow and combustion systems over a wide range of design parameters more quickly, inexpensively, and thoroughly than can be accomplished with actual hardware tests. Reactive flows including multi-step kinetic considerations, such as supersonic combustion in ramjets or solid- propellant combustion in rocket motors, have become computationally tractable. However, these computational models often require adequate input of kinetic information in the form of submodels, which are based upon specific measurements or basic understanding of the chemical and physical mechanisms derived from experimental observations. In particular, experimental validation of computed results will be necessary to prove the predictive capability of theoretical models and computer codes before they are used for guiding actual designs. Advanced non-intrusive combustion diagnostics are an excellent way to provide required input and measured data for comparison with CFD results. Many modern diagnostic techniques allow multiparameter measurements which further improve the validation of CFD results. These multiparameter diagnostic measurements are even more valuable for some systems which, due to complicated geometries or operating conditions, are beyond the ability of current CFD calculations. For such systems, improvement of the design beyond simple trial and error can be enhanced greatly by non-intrusive diagnostic measurements of properties of chemically reacting flow fields.

Based upon strong interest and the need for greater communication on the topic of Non-Intrusive Combustion Diagnostics, the Third International Symposium on Special Topics in Chemical Propulsion was held May 10-14, 1993, in Scheveningen, The Netherlands. The objectives of this symposium were (1) to promote communication between researchers, instrument users, and manufacturers regarding the merits and limitations of advanced non-intrusive diagnostic instruments, (2) to compare different types of combustion diagnostic techniques in terms of their capability for specific property measurements in combustion environments associated with burning of various types of propellants and fuels in either liquid, gas or solid phases, (3) to promote the exchange of information, and (4) to encourage the development of new combustion diagnostic methods for chemical propulsion systems.

One hundred and twenty-five researchers from seventeen countries participated in the symposium. Eighty-one presentations were given, including eight invited talks, forty-nine oral papers, and twenty-four posters. The eight invited speakers were Professor Ronald K. Hanson of Stanford University, Professor Franz Durst of the University of Erlangen-Nürnberg, Dr. John Stufflebeam of the United Technologies Research Center, Dr. Katharina Kohse-Höinghaus of the DLR-Institut für Physikalische Chemie der Verbrennung, Professor Vladmir E. Zarko of the Russian Academy of Sciences, Professor Thomas Brill of the University of Delaware, Dr. Timothy P. Parr of the U.S. Naval Air Warfare Center, and Professor Robert W. Dibble of the University of California at Berkeley.

This edited book is not simply a record of symposium proceedings with papers reviewed based upon extended abstracts. The full manuscript of all papers has been evaluated through a comprehensive review process. Sixty-three of the eighty-one papers presented at the symposium were accepted for publication. We extend our deep appreciation to many specialists who reviewed and selected the manuscripts published in this volume. The accepted papers are grouped in ten chapters covering many topical areas, including (1) Laser-Induced Fluorescence (LIF and PLIF) Techniques, (2) Coherent and Spontaneous Raman Spectroscopies, (3) Absorption and Emission Spectroscopies, (4) Holographic and Microwave Interferometries, (5) Particle Diagnostics, (6) X-ray Diagnostics and Image Analyses of Combustion of Liquids and Solids, (7) Diagnostics of Gaseous Reaction Systems, (8) Flow Field Measurements and Visualization, (9) Combustion Diagnostics of Solid Propellants, and (10) Diagnostics in Practical Combustion Systems. Invited papers are presented at the beginning of each chapter. Since a large percentage of the papers employ multiple techniques in combustion diagnostics, it is difficult to group some of them into a specific area. It is recommended that readers interested in multiple measurement techniques scan all chapters. Written questions and comments raised by the audience after paper presentations and replies by the authors are given at the end of each paper.

The symposium was sponsored by TNO Prins Maurits Laboratory of The Netherlands, The Pennsylvania State University, the European Space Agency (ESA), the European Research Office of the U.S. Army, SNPE of France, and the EOARD of the U.S. Air Force. The International Science Foundation, a private charitable foundation established by Mr. George Soros, contributed to a portion of the travel costs for participants from the Commonwealth of Independent States. We would like to thank Dr. Ir. Hans J. Pasman, Dr. Tark Wijchers, Dr. Henk J. Reitsma, Ir. Paul A.O.G. Korting of TNO, and Dr. Herman F.R. Schoeyer of ESA for their help in developing the symposium and for local arrangements, and Mr. Slachmuylders of ESTEC of ESA for delivering the welcoming speech.

We thank the members of the steering committee for providing input into the structure and scope of the meeting, participating in the selection of invited speakers, assisting in the review and selection of abstracts for presentations, chairing sessions, and publicizing the meeting throughout the propulsion community. The volunteer assistance of Barbara Pein and Olivia J. Kuo during the symposium registration is appreciated, and we would like to thank Connie Peters and LaRue Jacobs for their help in maintaining excellent records of manuscripts, review comments, communication documents between various parties, developing the symposium program, and assisting in the preparation of this volume. Special thanks are given to Ruth Fergus for her assistance in the English editing of the manuscripts and for establishing a uniform format and style.

We believe that this book provides an excellent introduction to the state-of-the-art technology in non-intrusive combustion diagnostics for propulsion systems to researchers wishing to adopt the methods directly, to those interested in assessing the accuracy, advantages, and limitations of specific techniques, and to those seeking a starting point for new ideas toward advances in combustion diagnostics. This volume should serve as a basis for the future development of advanced instrumentation and diagnostic techniques with higher spatial and temporal resolutions for use in many challenging combustion environments and propulsion systems.

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