

# Preface

For the past seventy-six years, since 1941 when Hoffman first proposed the use of detonation waves for propulsion applications, there has been sustained efforts by many researchers throughout the world to develop a real and practical propulsion system which employs detonation waves in a controllable manner. Especially noteworthy achievements are early efforts on rotating detonation engines by Nicholls at the University of Michigan and by Voitsekhovskiy in Novosibirsk in the 1950s and 1960s, and continual research activities worldwide on pulse detonation engines that were initiated by Bussing's engine demonstration in the 1990s. Recently, through theoretical performance studies, experimental investigation, and analysis via numerical simulations, the technology development of rotating detonation engines has been revisited by international leading researchers and has proven to be capable of implementation in real applications for different purposes, such as in rocket motors, ramjets, and turbojets. These leading researchers are devoting to carry out examinations and verification of system-level rotating detonation engines currently to allow this technology to achieve a higher level of technology readiness level as can be seen in the effort by Piotr Wolański, Sergey Frolov, Kailas Kailasanath, Fred Schauer, Matthew Fotia, Christopher Brophy, Frank Lu, Kenneth Yu, Jiro Kasahara, Nobuyuki Tsuboi, Ken Matsuoka, Francois Falempin, Bruno Le Enaour, Jeong-Yeol Choi, Jian-Ping Wang, Boo Cheong Khoo, Chiang Juay Teo, and Jiun-Ming Li.

This book is a collection of state-of-the-art research contributions from these international leading experts who have presented their works at the 2016 International Workshop on Detonation for Propulsion (IWDP) held in Singapore and the 2015 IWDP held in Beijing. This workshop has successfully brought together scientists from various parts of the world for the exchange of cutting-edge technical knowledge and has served as a platform to promote more collaborative opportunities internationally since 2011 (2011, Bourges and Pusan; 2012, Tsukuba; 2013, Tainan; 2014, Warsaw). These forms of knowledge and experience sharing involving various aspects by the different groups constitute one of the main reasons why the rotating detonation engine has progressed remarkably rapidly in recent years.

The chapters in this book strive to meet the needs of scientists, young researchers, young engineers, students, and others in the field of shock waves, combustion, and aerospace propulsion. Each chapter manuscript was subjected to a peer-review process and subsequently revised by the chapter authors accordingly. A system-level design of the novel detonation engines (RDE & PDE), performance analysis, and investigation employing advanced experimental and numerical methods are presented. The world's first successful sled demonstration of a rocket RDE system and innovations in the development of a kilohertz PDE system are reported. It is hoped that readers will obtain in a straightforward manner an understanding of the RDE & PDE design, operation and testing approaches, and further specific integration schemes for diverse applications, e.g., rocket motor for space propulsion and turbojet/ramjet engines for air-breathing propulsion. A comprehensive survey of detonation-based engine technology is also introduced for the readers to have a broad overview and development to date. Finally, a fundamental research on basic detonation re-initiation phenomenon is included because such knowledge of detonation re-initiation mechanism serves as a useful guide for the detonation chamber design of RDE & PDE. In addition, the materials involving the use of optical diagnostics techniques in this study, such as Schlieren imaging, planar laser-induced fluorescence (PLIF), open shutter photography, and soot foil technique will be useful for researchers and engineers involved in the relevant fields. This book hopefully attracts the interests of young researchers/engineers to join in the ongoing revolution of new propulsion system. Lastly, this book can serve as a reference textbook for faculty and graduate students and for graduate-level courses in shock waves, combustion, and propulsion in universities. The following is a brief outline of what the readers can glean for each chapter:

Chapter 1 Critical design of rotation detonation engine for air-breathing propulsion and performance evaluation process for rotation detonation engine.

Chapter 2 Strategic schemes to integrate turbojet and rotating detonation chamber and its direct performance measurement using gaseous hydrogen and liquid Jet-A as fuels.

Chapter 3 Investigations of detonation liquid rocket engine with natural gas for space propulsion and development of computational methods to simulate detailed flow structure within an operating continuous-detonation combustor with nozzle.

Chapter 4 Sled demonstration of rotation detonation rocket engine for thrust measurement and propellant injector shape effect on engine performance.

Chapter 5 Computational method development with robust-weighted compact nonlinear scheme for two-dimensional simulation of rotating detonation engine.

Chapter 6 Background, current progress, and challenge of rotating detonation engines.

Chapter 7 Progress and accomplishments of rotating detonation engine research at Peking University, China.

Chapter 8 Novel kilohertz pulse detonation chamber: concept, experiment, and one-dimensional numerical analysis.

Chapter 9 Fundamental detonation re-initiation phenomenon of stable and unstable detonation with multiple diagnostic methods: Schlieren photography, planar laser-induced fluorescence, open shutter photography, and soot foil technique.

The last section of this book constitutes the minutes of the Panel Discussion conducted at the 2016 International Workshop on Detonation for Propulsion (IWDP). Readers can gain further insights on the main concerns, critical research issues, and challenges of detonation-based engines for propulsion based on the dialogue of the leading researchers.

The editors would like to thank all chapter authors for contributing their latest valuable research results to promote these special collections for detonation engine development. Specifically, we wish to express our appreciation to Piotr Wolański and Sergey Frolov for their unwavering support. The editors would like to extend appreciation to the reviewers for their timely cooperation and expertise. During the early work on the manuscript, we have benefited from many colleagues who attended the 2015 IWDP and we would like to show our gratitude to the organizers of the 2015 IWDP (co-editors of this book): Jian-Ping Wang and Cheng Wang.

Finally, we are greatly thankful to Christopher Coughlin of Springer Publishers. His initiative and encouragement made this volume possible in the series on Shock Wave and High Pressure Phenomena. We would also like to express our appreciation to Springer editors Dominic Manoharan and HoYing Fan for their recommendation and close cooperation during the preparation of the book manuscript.

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