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Akhilendra Pratap Singh ·
Pravesh Chandra Shukla ·
Joonsik Hwang · Avinash Kumar Agarwal
Editors

Simulations and Optical Diagnostics for Internal Combustion Engines

Current Status and Way Forward

 Springer

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Preface

Energy demand has been rising remarkably due to increasing population and urbanization. Global economy and society are significantly dependent on energy availability because it touches every facet of human life and activities. Transportation and power generation are two major examples. Without transportation by millions of personalized and mass transport vehicles and availability of 24×7 power, human civilization would not have reached contemporary living standards.

The International Society for Energy, Environment and Sustainability (ISEES) was founded at Indian Institute of Technology Kanpur (IIT Kanpur), India, in January 2014 with an aim to spread knowledge/awareness and catalyze research activities in the fields of energy, environment, sustainability and combustion. The Society's goal is to contribute to the development of clean, affordable and secure energy resources and a sustainable environment for the society and to spread knowledge in the above-mentioned areas and create awareness about the environmental challenges, which the world is facing today. The unique way adopted by the society was to break the conventional silos of specializations (engineering, science, environment, agriculture, biotechnology, materials, fuels, etc.) to tackle the problems related to energy, environment and sustainability in a holistic manner. This is quite evident by the participation of experts from all fields to resolve these issues. The ISEES is involved in various activities such as conducting workshops, seminars and conferences in the domains of its interests. The society also recognizes the outstanding works done by the young scientists and engineers for their contributions in these fields by conferring them awards under various categories.

Third International Conference on “Sustainable Energy and Environmental Challenges” (III-SEEC) was organized under the auspices of ISEES from December 18–21, 2018, at Indian Institute of Technology Roorkee. This conference provided a platform for discussions between eminent scientists and engineers from various countries including India, USA, Norway, Finland, Sweden, Malaysia, Austria, Hong Kong, Bangladesh and Australia. In this conference, eminent speakers from all over the world presented their views related to different aspects of energy, combustion, emissions and alternative energy resource for sustainable development and cleaner environment. The conference presented five high voltage

plenary talks from globally renowned experts on topical themes, namely “The Evolution of Laser Ignition Over more than Four Decades” by Prof. Ernst Wintner, Technical University of Vienna, Austria; “Transition to Low Carbon Energy Mix for India”, Dr. Bharat Bhargava, ONGC Energy Center; “Energy Future of India,” by Dr. Vijay Kumar Saraswat, Hon. Member (S&T) NITI Aayog, Government of India; “Air Quality Monitoring and Assessment in India” by Dr. Gurfan Beig, Safar and “Managing Large Technical Institutions and Assessment Criterion for Talent Recruitment and Retention” by Prof. Ajit Chaturvedi, Director, IIT Roorkee.

The conference included 24 technical sessions on topics related to energy and environmental sustainability including five plenary talks, 27 keynote talks and 15 invited talks from prominent scientists, in addition to 84 contributed talks and 50 poster presentations by students and researchers. The technical sessions in the conference included Advances in IC Engines, Solar Energy, Environmental Biotechnology, Combustion, Environmental Sustainability, Coal and Biomass Combustion/Gasification, Air and Water Pollution, Biomass to Fuels/Chemicals, Combustion/Gas Turbines/Fluid Flow/Sprays, Energy and Environmental Sustainability, Atomization and Sprays, Sustainable Transportation and Environmental Issues, New Concepts in Energy Conservation, Waste to Wealth. One of the highlights of the conference was the Rapid Fire Poster Sessions in (i) Engine/Fuels/Emissions, (ii) Renewable and Sustainable Energy and (iii) Biotechnology, where 50 students participated with great enthusiasm and won many prizes in a fiercely competitive environment. 200+ participants and speakers attended this four-day conference, which also hosted Dr. Vijay Kumar Saraswat, Hon. Member (S&T) NITI Aayog, Government of India, as the chief guest for the book release ceremony, where 14 ISEES books published by Springer, Singapore, under a special dedicated series “Energy, environment and sustainability” were released. This was the second time in a row that such significant and high-quality outcome has been achieved by any society in India. The conference concluded with a panel discussion on “Challenges, Opportunities and Directions for National Energy Security,” where the panelists were Prof. Ernst Wintner, Technical University of Vienna, Prof. Vinod Garg, Central University of Punjab, Bhatinda; Prof. Avinash Kumar Agarwal, IIT Kanpur; and Dr. Michael Sauer, Boku Univ. fo Natural resources, Austria. The panel discussion was moderated by Prof. Ashok Pandey, Chairman, ISEES. This conference laid out the road map for technology development, opportunities and challenges in energy, environment and sustainability domain. All these topics are very relevant for the country and the world in the present context. We acknowledge the support received from various funding agencies and organizations for the successful conduct of the third ISEES conference III-SEEC, where these books germinated. We would therefore like to acknowledge NIT Srinagar, Uttarakhand (TEQIP) (Special thanks to Prof. S. Soni, Director, NIT, UK), SERB, Government of India (Special thanks to Dr. Rajeev Sharma, Secretary); UP Bioenergy Development Board, Lucknow (Special thanks to Sh. P. S. Ojha), CSIR and our publishing partner Springer (Special thanks to Swati Meherishi).

The editors would like to express their sincere gratitude to a large number of authors from all over the world for submitting their high-quality work in a timely manner and revising it appropriately at a short notice. We would like express our

special thanks to Dr. Atul Dhar, Dr. Pravesh Chandra Shukla, Dr. Nirendra Nath Mustafi, Prof. V. S. Moholkar, Prof. V. Ganeshan, Dr. Joonsik Hwang, Dr. Biplab Das and Dr. Veena Chaudhary, Dr. Jai Gopal Gupta, Dr. Chetan Patel, who reviewed various chapters of this monograph and provided their valuable suggestions to improve the manuscripts.

This book is based on combustion simulations and optical diagnostics techniques, which are currently used in internal combustion engines. This book includes a variety of simulation techniques including in-cylinder combustion, numerical investigations of fuel spray and effects of different fuels and engine technologies. This book includes a few chapters on alternative fuels such as DEE, biomass and alcohols which provides valuable information related to alternative fuel utilization in IC engines. Few chapters based on the use of combustion simulations and optical techniques in advanced techniques such as microwave-assisted plasma ignition and laser ignition are another important aspect of this book. Chapters include recent results and more focussed on current trends of the automotive sector. In this book, readers will get the idea about the combustion simulations and optical diagnostics, which will help them in analyzing various issues related to in-cylinder combustion, pollutant formation and alternative fuels. Few chapters of this book are based on a review of state-of-the-art models for combustion, with special focus on the theory, development and applications of these combustion models in internal combustion systems. We hope that the book would be of great interest to the professionals, postgraduate students involved in fuels, IC engines, engine instrumentation and environmental research.

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About the Editors



Dr. Akhilendra Pratap Singh is working at IIT Kanpur. He received his Masters and Ph.D. in Mechanical Engineering from Indian Institute of Technology Kanpur, India, in 2010 and 2016, respectively. His areas of research include advanced low-temperature combustion; optical diagnostics with special reference to engine endoscopy and PIV; combustion diagnostics; engine emissions measurement; particulate characterization and their control; and alternative fuels. Dr. Singh has edited seven books and authored 21 book chapters, 40 research articles in international journals and conferences. He has been awarded “ISEES Best Ph.D. Thesis Award” (2017), “SERB Indo-US Postdoctoral Fellowship” (2017) and “IEI Young Engineer Award” (2017). He is a member of numerous professional societies, including SAE, ASME and ISEES.



Dr. Pravesh Chandra Shukla is Assistant Professor in the Department of Mechanical Engineering at Indian Institute of Technology Bhilai. Dr. Shukla received his PhD from Indian Institute of Technology Kanpur. Prior to joining IIT Bhilai, he was a postdoctoral researcher in the Division of Combustion Engines, Department of Energy Sciences, Lund University, Sweden. He briefly worked in Ecole Centrale de Nantes, France, in the field of dual-fuel combustion. He is a recipient of Young Scientist Award from the International Society for Energy, Environment and Sustainability. Dr. Shukla mainly works in the field of Internal Combustion Engines and Alternative fuels for transportation. He worked on the development of additives for high compression ratio heavy duty engines fueled with alcohol. He is involved in investigating the emission characteristics for alternative fuels like biodiesel, HVO and alcohols for conventional and advanced heavy duty compression ignition engines. During his doctoral, he was mainly involved in physico-chemical characterization of diesel engine exhaust using non-noble metal-based mixed oxides diesel oxidation catalysts. Till now, he has published more than 24 technical articles in international journals and conference proceedings.



Dr. Joonsik Hwang is currently a postdoctoral fellow in Sandia National Laboratory, USA. He received his Masters and Ph.D. in Mechanical Engineering from Korea Advanced Institute of Science and Technology (KAIST), Daejeon, Korea. His areas of research include advanced low-temperature combustion; combustion diagnostics; spray and combustion characteristics; particulate characterization; and alternative fuels. Dr. Hwang has published more than 25 research articles in international journals and conferences. He has been awarded “ISEES Best Ph.D. Thesis Award” (2017) and several travel fellowship awards.



Prof. Avinash Kumar Agarwal joined IIT Kanpur in 2001. He worked at the Engine Research Center, UW-Madison, USA, as a postdoctoral fellow (1999 – 2001). His interests are IC engines, combustion, alternate and conventional fuels, lubricating oil tribology, optical diagnostics, laser ignition, HCCI, emissions and particulate control and large bore engines. Prof. Agarwal has published 270+ peer-reviewed international journal and conference papers, 35 edited books, 63 books chapters and has 7850+ Scopus and 11900+ Google scholar citations. He is associate editor of ASME Journal of Energy Resources Technology. He has edited “Handbook of Combustion” (5 Volumes; 3168 pages), published by Wiley–VCH, Germany. Prof. Agarwal is a Fellow of SAE (2012), Fellow of ASME (2013), Fellow of NASI (2018), Fellow of Royal Society of Chemistry (2018), Fellow of ISEES (2015) and Fellow of INAE (2015). He is a recipient of several prestigious awards such as Clarivate Analytics India Citation Award-2017 in Engineering and Technology, NASI-Reliance Industries Platinum Jubilee Award-2012; INAE Silver Jubilee Young Engineer Award-2012; Dr. C. V. Raman Young Teachers Award: 2011; SAE Ralph R. Teetor Educational Award -2008; INSA Young Scientist Award-2007; UICT Young Scientist Award-2007; and INAE Young Engineer Award-2005. Prof. Agarwal received Prestigious Shanti Swarup Bhatnagar Award-2016 in Engineering Sciences.

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