



*energies*

Special Issue Reprint

---

# Advanced Research on Internal Combustion Engines and Engine Fuels

---

Edited by  
Zongyu Yue and Haifeng Liu

[mdpi.com/journal/energies](https://mdpi.com/journal/energies)



# **Advanced Research on Internal Combustion Engines and Engine Fuels**



# Advanced Research on Internal Combustion Engines and Engine Fuels

Editors

Zongyu Yue

Haifeng Liu



Basel • Beijing • Wuhan • Barcelona • Belgrade • Novi Sad • Cluj • Manchester

*Editors*

Zongyu Yue  
Tianjin University  
Tianjin  
China

Haifeng Liu  
Tianjin University  
Tianjin  
China

*Editorial Office*

MDPI  
St. Alban-Anlage 66  
4052 Basel, Switzerland

This is a reprint of articles from the Special Issue published online in the open access journal *Energies* (ISSN 1996-1073) (available at: [https://www.mdpi.com/journal/energies/special\\_issues/Internal\\_Combustion\\_Engine\\_and\\_Fuels](https://www.mdpi.com/journal/energies/special_issues/Internal_Combustion_Engine_and_Fuels)).

For citation purposes, cite each article independently as indicated on the article page online and as indicated below:

Lastname, A.A.; Lastname, B.B. Article Title. <i>Journal Name</i> Year, Volume Number, Page Range.
--

ISBN 978-3-7258-0451-1 (Hbk)

ISBN 978-3-7258-0452-8 (PDF)

[doi.org/10.3390/books978-3-7258-0452-8](https://doi.org/10.3390/books978-3-7258-0452-8)

© 2024 by the authors. Articles in this book are Open Access and distributed under the Creative Commons Attribution (CC BY) license. The book as a whole is distributed by MDPI under the terms and conditions of the Creative Commons Attribution-NonCommercial-NoDerivs (CC BY-NC-ND) license.

# Contents

About the Editors . . . . .	vii
<b>Zongyu Yue and Haifeng Liu</b> Advanced Research on Internal Combustion Engines and Engine Fuels Reprinted from: <i>Energies</i> 2023, 16, 5940, doi:10.3390/en16165940 . . . . .	1
<b>Huabing Wen, Yue Yu, Jingrui Li, Changchun Xu, Haiguo Jing and Jianhua Shen</b> Numerical Investigation on the Influence of Injection Location and Injection Strategy on a High-Pressure Direct Injection Diesel/Methanol Dual-Fuel Engine Reprinted from: <i>Energies</i> 2023, 16, 4518, doi:10.3390/en16114518 . . . . .	9
<b>Hiroshi Enomoto and Ryo Nakagawa</b> Reduction in CO Emission from Small Reciprocating Engine Operated with Wood Gasifier by Mixture LHV Changing Reprinted from: <i>Energies</i> 2023, 16, 2563, doi:10.3390/en16062563 . . . . .	35
<b>Xingyu Sun, Mengjia Li, Jincheng Li, Xiongbo Duan, Can Wang, Weifan Luo, et al.</b> Nitrogen Oxides and Ammonia Removal Analysis Based on Three-Dimensional Ammonia-Diesel Dual Fuel Engine Coupled with One-Dimensional SCR Model Reprinted from: <i>Energies</i> 2023, 16, 908, doi:10.3390/en16020908 . . . . .	49
<b>Leszek Chybowski</b> Study of the Relationship between the Level of Lubricating Oil Contamination with Distillation Fuel and the Risk of Explosion in the Crankcase of a Marine Trunk Type Engine Reprinted from: <i>Energies</i> 2023, 16, 683, doi:10.3390/en16020683 . . . . .	67
<b>Le Zhao, Yu Zhang, Yuanjiang Pei, Anqi Zhang and Muhsin M. Ameen</b> Numerical Optimization of Spray-Guided Spark Assistance for Cold Idle Operation in a Heavy-Duty Gasoline Compression Ignition Engine Reprinted from: <i>Energies</i> 2023, 16, 637, doi:10.3390/en16020637 . . . . .	105
<b>Eliezer Toledo, Fabián Guerrero, German Amador and Mario Toledo</b> Experimental Assessment of the Performance and Fine Particulate Matter Emissions of a LPG-Diesel Dual-Fuel Compression Ignition Engine Reprinted from: <i>Energies</i> 2022, 15, 9035, doi:10.3390/en15239035 . . . . .	119
<b>Ahmad Alshwawra, Ahmad Abo Swerih, Ahmad Sakhrieh and Friedrich Dinkelacker</b> Structural Performance of Additively Manufactured Cylinder Liner—A Numerical Study Reprinted from: <i>Energies</i> 2022, 15, 8926, doi:10.3390/en15238926 . . . . .	133
<b>Ahmad O. Hasan, Khamis Essa and Mohamed R. Goma</b> Synthesis, Structure Characterization and Study of a New Kind of Catalyst: A Monolith of Nickel Made by Additive Manufacturing Coated with Platinum Reprinted from: <i>Energies</i> 2022, 15, 7575, doi:10.3390/en15207575 . . . . .	149
<b>Chao Jin, Tianyun Sun, Teng Xu, Xueli Jiang, Min Wang, Zhao Zhang, et al.</b> Influence of Glycerol on Methanol Fuel Characteristics and Engine Combustion Performance Reprinted from: <i>Energies</i> 2022, 15, 6585, doi:10.3390/en15186585 . . . . .	162
<b>Jerzy Cisek, Szymon Leśniak, Andrzej Borowski, Włodzimierz Przybylski and Vitaliy Mokretskyy</b> Visualisation and Thermovision of Fuel Combustion Affecting Heat Release to Reduce NO <sub>x</sub> and PM Diesel Engine Emissions Reprinted from: <i>Energies</i> 2022, 15, 4882, doi:10.3390/en15134882 . . . . .	176

<b>Kai Niu, Baofeng Yao, Yonghong Xu, Hongguang Zhang, Zhicheng Shi and Yan Wang</b> Study on Chemical Kinetics Mechanism of Ignition Characteristics of Dimethyl Ether Blended with Small Molecular Alkanes Reprinted from: <i>Energies</i> <b>2022</b> , <i>15</i> , 4652, doi:10.3390/en15134652 . . . . .	208
<b>Xinyan Wang and Hua Zhao</b> Modelling Study of Cycle-To-Cycle Variations (CCV) in Spark Ignition (SI)-Controlled Auto-Ignition (CAI) Hybrid Combustion Engine by Using Reynolds-Averaged Navier–Stokes (RANS) and Large Eddy Simulation (LES) Reprinted from: <i>Energies</i> <b>2022</b> , <i>15</i> , 4478, doi:10.3390/en15124478 . . . . .	225
<b>Zhishuang Li, Ziman Wang, Haoyang Mo and Han Wu</b> Effect of the Air Flow on the Combustion Process and Preheating Effect of the Intake Manifold Burner Reprinted from: <i>Energies</i> <b>2022</b> , <i>15</i> , 3260, doi:10.3390/en15093260 . . . . .	246
<b>Masataka Arai</b> Interpretative Review of Diesel Spray Penetration Normalized by Length and Time of Breakup (Similarity Law of Diesel Spray and Its Application) Reprinted from: <i>Energies</i> <b>2022</b> , <i>15</i> , 4926, doi:10.3390/en15134926 . . . . .	263

# About the Editors

## Zongyu Yue

Zongyu Yue is an Associate Professor at the State Key Laboratory of Engines (SKLE) at Tianjin University. He earned his Ph.D. degree in Mechanical Engineering from the Engine Research Center (ERC) at the University of Wisconsin–Madison, and worked at Argonne National Laboratory as a postdoctoral researcher before joining Tianjin University. His research focuses on advanced combustion theory, high-efficiency combustion systems, carbon-neutral fuels and renewable energy systems. He has co-authored more than 40 journal and peer-reviewed conference papers and 3 book chapters.

## Haifeng Liu

Haifeng Liu is a Professor at the State Key Laboratory of Engines (SKLE) at Tianjin University. His research focuses on the modulation and application of low- or zero-carbon fuels; the spray, combustion and emission control of IC engines; the laser diagnostics of spray and combustion; and artificial intelligence applications in spray and combustion systems. He has co-authored 160 journal papers, 49 peer-reviewed conference papers and 2 books. He has received several awards including Elsevier's Highly Cited Chinese Researchers (2020, 2021, 2022), NSFC Excellent Young Scientists (2019), National Awards for Scientific and Technological Progress of Second Class (2017), etc. He serves as a board member of the Thermal Management Section of Energies, an Associate Editor for *National Science Open (NSO)*, and an Associate Editor for *Frontiers in Thermal Engineering*.





# Advanced Research on Internal Combustion Engines and Engine Fuels

Zongyu Yue \* and Haifeng Liu \*

State Key Laboratory of Engines, Tianjin University, No.92 Weijin Road, Nankai District, Tianjin 300072, China  
\* Correspondence: zongyuyue@tju.edu.cn (Z.Y.); haifengliu@tju.edu.cn (H.L.)

**Abstract:** Internal combustion (IC) engines serve as power devices that are widely applied in the fields of transport, engineering machinery, stationary power generation, etc., and are evolving towards the goal of higher efficiency and lower environmental impacts. In this Editorial, the role of IC engines for future transport and energy systems is discussed, and research directions for advancing IC engine and fuel technologies are recommended. Finally, we introduce the 14 technical papers collected for this Special Issue, which cover a wide range of research topics, including diesel spray characteristics, combustion technologies for low- and zero-carbon fuels, advanced combustion mode, fuel additive effects, engine operation under extreme conditions and advanced materials and manufacturing processes.

**Keywords:** internal combustion engine; fuel; renewable energy; carbon neutral; Special Issue

## 1. Introduction

Internal combustion (IC) engines have driven the development of human civilization and global economic growth, serving as a power device that is widely applied in the fields of transport, engineering machinery, stationary power generation, etc. The current global stock of passenger cars is around 1.19 billion, and the number of commercial vehicles totals 249 million, of which almost 99% are powered by IC engines, accounting for 81.3% of the oil demand in the transport sector [1]. Following that, maritime and aviation vehicles, which are also primarily powered by combustion engines, account for 7.9% and 7.1% of the transport oil demand, respectively [1]. Overall, the transport sector, including road, railway, aviation and shipping vehicles, accounts for 25.5% of global energy consumption [2] and contributes 16.2% of total global greenhouse gas (GHG) emissions as the fourth-largest source of emissions following industry (29.4%), agriculture, forestry and land use (18.4%) and construction (17.5%) [3]. Therefore, IC engines are a leading source of GHG emissions, and significant effort is needed to reduce their carbon footprint.

## 2. Current Status and Trends in IC Engine and Fuel Technologies

### 2.1. Progress in IC Engine Technologies

Since its conception in the late-19th century, the IC engine has undergone a continuous and rapid evolution and is now a complex assembly of numerous advanced technologies. To meet the ever-stringent emission regulations, tremendous effort has been dedicated to research and development aiming at an improvement in combustion efficiency and reduction in pollution emissions. The main harmful emissions generated from IC engine exhaust include particulate matter (PM), nitrogen oxide (NO<sub>x</sub>), carbon monoxide (CO) and unburnt hydrocarbon (UHC). Figure 1 presents the trends in the US federal emission limits on PM, NO<sub>x</sub> and non-methane organic gas (NMOG) emissions for light-duty fleet vehicles [4], which have been tightened significantly since their adoption in 1994. Over the past 40 years, including in the pre-regulation age, the emission levels of these harmful pollutants from IC engines have been effectively reduced by 100–1000 times. Taking the

**Citation:** Yue, Z.; Liu, H. Advanced Research on Internal Combustion Engines and Engine Fuels. *Energies* **2023**, *16*, 5940. <https://doi.org/10.3390/en16165940>

Received: 3 August 2023

Accepted: 9 August 2023

Published: 11 August 2023



**Copyright:** © 2023 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).