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Editorial

Renewable Fuels for Internal Combustion Engines

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Abstract: The continuous need for systematization and open dissemination of knowledge on Renewable Fuels intended for use in Internal Combustion Engines forms the premise of the presented Special Issue titled "Renewable Fuels for Internal Combustion". Experts in the field were encouraged to share their latest findings in the form of original research papers, case studies, or short reviews. Works targeting all aspects of the value chain were considered necessary, including the following: (liquid and gaseous) fuel production process, upgrading (catalytic and fractional blending), up to end, valorization in combustion engines (conventional and advanced concepts). Finally, techno-economic analyses aiming to valorize the value chain holistically were warmly encouraged to submit papers in this Special Issue of the Energies Journal. In this book, the reader will find successful submissions that present the latest findings from the discussed research field, encapsulated into nine chapters.

Keywords: alternative fuels; emission characteristics; engine performance; engine thermodynamics; additives for alternative fuels; innovative combustion concepts

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1. Introduction

The last decade has seen a stunning increase in the production of renewable fuels, growing at an average rate of 8% per year. However, this growth is only enough to cover half of the global increase in energy demand. Coupled with this growth in energy demand, combustion engines seem set to remain the prime mover for heavy-duty road and waterborne transport. Furthermore, their role in power generation, as fast-response peak-shaving plants for wind and solar-based future energetics, constantly increases.

Taking into account the above situation and the CO_2 reduction targets of the 2015 Paris Agreement, there is an immediate need for high-TRL renewable fuels that can be used in combustion engine technology. This development needs to be accompanied by intensified combustion research, exploring the full potential of new fuels in terms of efficiency and emission co-optimization. At the same, the fast phasing-in of renewable fuels requires efficient production methods and price-competitive feedstock. Finally, researchers, investors, legislators, and society need to have open access to well-organized, up-to-date, and relevant developments in the above fields in order to support the necessary transition of the fuel market. Nine articles have been successfully submitted to the Special Issue of Energies on the subject area of "Renewable Fuels for Internal Combustion Engines" [1–9]. All manuscripts present the results of original experiments in complementary sub-areas of this. A short summary of all individual contributions follows in this editorial.

2. Contributions in This Issue

Amongst the submitted works, three papers focus on emission characteristics from different alternatives [2,3,7]. Kuczyński et al. [2] demonstrated that the use of biofuels from waste animal fat allows for a significant reduction in the concentrations of the unburned hydrocarbons (UHC) and particulate matter (PM) when compared to diesel fuel operation.

Consequently, Shepel et al. [3] advertise the advantages of using complementary blends of Fatty Acid Methyl Esters (FAME) and Hydro-treated Vegetable Oils (HVO) on emissions. Note that the addition of HVO to FAME allows viscosity to be kept at bay while maintaining high cetane number, enabling lower net carbon monoxide (CO) and UHC emissions in a diesel engine. Elevated Nitrogen Oxide emissions remain an issue for oxygenated biofuels [2,3]. Finally, Kryshtopa et al. [7] demonstrates that the use of methanol conversion products might be an economically feasible solution to the issue.

The issues related to engine performance and engine thermodynamics on biofuels are additionally discussed in three papers [3,5,6]. Again, Shepel et al. [3] conclude that the use of animal fat biodiesel additives causes the earlier start of the combustion process. However, the additives present a negative effect on thermal efficiency and specific fuel consumption. Cisek et al. [5] test several commercial fuel additives affecting kinetic combustion rate, mitigating the formation of nitrogen oxides. Correspondingly, additives that support the diffusion phase of combustion may decrease the particulate matter formation. Pielecha et al. present the results of the combustion process analysis that confirms the combustion system using two injectors may have a significant impact on the combustion process of different diesel surrogates [6].

The results of the studies presented in three papers validate the alternative fuel additives [1,4,5]. Fabiś et al. [1] present the potential of dimethyl ether as fuel for SI engines. Paneerselvam et al. [4] evaluate peppermint bio-oil as an additive applied as a cetane improver. Cisek et al. [5] prove the synergy effect between examined additives which manifested in greater reduction in nitrogen oxides and particulate matter, while using both additives together compared to individual use.

One paper discusses in detail the properties of various alternative fuels. Górski et al. [8] examine the Physico-chemical properties of diethyl ether–linseed oil fuel blends in different proportions. Importantly, diethyl ether influences the viscosity, density, surface tension, and improves the low-temperature properties of the examined bio-oils.

Innovative combustion concepts for which alternative fuels are considered an enabler are presented by Karczewski et al. [9]. The authors focus on Reactivity Controlled Compression Ignition (RCCI) combustion while using a dual-fuel supply of hydrogen-enriched natural gas (HCNG) and HVO as a pilot dose. Such low-temperature combustion concepts promise superior efficiency for alternative fuels combustion; they exhibit issues related to controllability and are potentially more prone to emit N_2O. This component carries a GHG factor over 100 times greater than CO_2 and, together with methane slip, introduces further uncertainty about the climate impact of such advanced combustion concepts.

3. Conclusions

This special issue clearly shows that combustion engine fuels are an active research topic. Evidently, the mature renewable alternatives obtained from biomass/waste such as FAME and HVO currently receive the most attention. The research efforts focusing on upgrading these options steadily give room towards new-generation fuels based on renewable hydrogen production. The fast pace towards a hydrogen-supported, circular economy creates an immense opportunity for engine development towards advanced combustion systems such as RCCI. In order to grasp this opportunity fully, the paradigm of fuel and engine research needs to shift from separate roadmaps towards combined research efforts. Namely, the bulk of new fuel options emerging from hydrogen synthesis and waste material processing allows achieving tailored fuel properties either by immediate reforming, fractionation, or blending/addition. The valid research question is how superior fuel properties, achieved in an economically and environmentally sound manner, can support optimal efficiency and ultra-low emissions of future combustion platforms. The authors of this editorial commonly see as this tailored fuel and engine co-development an enabler for developing technology-neutral, optimum renewable powertrain alternatives.

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References

1. Fabiś, P.; Flekiewicz, B. Influence of LPG and DME Composition on Spark Ignition Engine Performance. *Energies* **2021**, *14*, 5583. [CrossRef]
2. Kurczyński, D.; Wcisło, G.; Łagowski, P. Experimental Study of Fuel Consumption and Exhaust Gas Composition of a Diesel Engine Powered by Biodiesel from Waste of Animal Origin. *Energies* **2021**, *14*, 3472. [CrossRef]
3. Shepel, O.; Matijošius, J.; Rimkus, A.; Duda, K.; Mikulski, M. Research of Parameters of a Compression Ignition Engine Using Various Fuel Mixtures of Hydrotreated Vegetable Oil (HVO) and Fatty Acid Esters (FAE). *Energies* **2021**, *14*, 3077. [CrossRef]
4. Paneerselvam, P.; Venkadesan, G.; Panithasan, M.S.; Alaganathan, G.; Wierzbicki, S.; Mikulski, M. Evaluating the Influence of Cetane Improver Additives on the Outcomes of a Diesel Engine Characteristics Fueled with Peppermint Oil Diesel Blend. *Energies* **2021**, *14*, 2786. [CrossRef]
5. Cisek, J.; Lesniak, S.; Stanik, W.; Przybylski, W. The Synergy of Two Biofuel Additives on Combustion Process to Simultaneously Reduce NOx and PM Emissions. *Energies* **2021**, *14*, 2784. [CrossRef]
6. Pielecha, I.; Wierzbicki, S.; Sidorowicz, M.; Pietras, D. Combustion Thermodynamics of Ethanol, n-Heptane, and n-Butanol in a Rapid Compression Machine with a Dual Direct Injection (DDI) Supply System. *Energies* **2021**, *14*, 2729. [CrossRef]
7. Kryshtopa, S.; Górski, K.; Longwic, R.; Smigins, R.; Kryshtopa, L. Increasing Parameters of Diesel Engines by Their Transformation for Methanol Conversion Products. *Energies* **2021**, *14*, 1710. [CrossRef]
8. Górski, K.; Smigins, R.; Longwic, R. Research on Physico-Chemical Properties of Diethyl Ether/Linseed Oil Blends for the Use as Fuel in Diesel Engines. *Energies* **2020**, *13*, 6564. [CrossRef]
9. Karczewski, M.; Chojnowski, J.; Szamrej, G. A Review of Low-CO2 Emission Fuels for a Dual-Fuel RCCI Engine. *Energies* **2021**, *14*, 5067. [CrossRef]