energies

Editorial

Novel Combustion Techniques for Clean Energy

Jaroslaw Krzywanski [1,*], Wojciech Nowak [2] and Karol Sztekler [2]

1 Faculty of Science and Technology, Jan Dlugosz University in Czestochowa, Armii Krajowej 13/15, 42-200 Czestochowa, Poland
2 Faculty of Energy and Fuels, AGH University of Science and Technology, A. Mickiewicza 30, 30-059 Cracow, Poland; wnowak@agh.edu.pl (W.N.); sztekler@agh.edu.pl (K.S.)
* Correspondence: j.krzywanski@ujd.edu.pl

This Special Issue contains successful submissions as an answer to the invitation to bring together research on advances in design, modeling, and performance of novel combustion techniques for clean energy. The following keywords described this Special Issue: combustion energy policy, efficiency, emissions, pollutants, and modeling.

The Special Issue constitutes an answer to current climate and civilization challenges, such as increased energy demand, higher levels of atmospheric pollutants, and global warming. Since the world community currently depends mainly on nonrenewable fossil fuels, which are unfriendly to the environment, developing novel techniques for clean combustion is highly urgent [1–3]. That is why growing efficiency requirements and limitations of pollutant emissions lead to the emergence of advanced energy technologies. Some of them are oxyfuel combustion [4], chemical-looping combustion (CLC) [5], and moderate or intense low-oxygen dilution (MILD) flameless combustion [6].

The submitted papers covered several different combustion aspects. The combustion characteristics and kinetics of coal, RDF, and their blends were experimentally investigated in a micro-thermal gravimetric analyzer at four different heating rates by Azam et al. According to the obtained results, as the RDF in blends increases, the reactivity of the blends increases, resulting in lower ignition temperatures and a shift in peak and burnout temperatures to a lower temperature zone [7]. As an optimal thermochemical process for obtaining valuable products, such as char, oil, or gas from waste tires, pyrolysis was investigated by Cepic et al., The analysis of pyrolytic oil and char showed that these products can be used as fuel [8]. Various kinds of pilot burners and fuels to examine the effects of their geometry and their location relative to the main burner of a real size combustor were experimentally investigated by Lee et al. The obtained results revealed that not only pilot burner flame shape but also the vertical location of the pilot burner from the main burner combustor had a significant effect on combustor durability [9].

The paper by Zhao et al. deals with arsenic emission from coal combustion power plants due to its high toxicity [10]. The developed model of arsenic volatilization model based on the ash fusion temperature, coal type, and combustion temperature during coal combustion allows describing the complex mechanisms that occur during combustion. Artificial intelligence (AI) techniques for the optimization of a 660 MWe supercritical power plant performance were applied by Ashraf et al. Several AI techniques and algorithms were presented and incorporated to formulate the step-wise methodology in the spirit of industry 4.0-data analytics [11,12]. A comprehensive simulator of fluidized and moving bed equipment (CeSFaMB) for modeling a fluidized bed CLC combustion process was applied by Zylka et al. Coal and biomass as fuels were considered in the study. On the other hand, ilmenite, i.e., a natural mineral, as an oxygen carrier was selected, which is an important issue considering safety and environmental reasons [13]. The model's validation showed that the maximum relative errors between simulations and experiment results did not exceed 10% [14]. A study of visualization experiment on the influence of injector nozzle diameter on diesel engine spray ignition and combustion characteristics was presented by

Citation: Krzywanski, J.; Nowak, W.; Sztekler, K. Novel Combustion Techniques for Clean Energy. *Energies* **2022**, *15*, 4649. https://doi.org/10.3390/en15134649

Received: 23 May 2022
Accepted: 23 June 2022
Published: 24 June 2022

Tang et al. [15]. The authors examined three injectors with different nozzle orifice diameters to study the diesel spray, ignition, and flame-wall impingement visualization experiment. The authors obtained several exciting results. Among others, by processing the spray and combustion flame images, indicators like the numerical value well represented the fuel-air mixture quality and the total soot generation level under different experiment conditions [15].

All these activities are concise with the global scientific modeling trend, allowing better description and recognition of complex systems [16–19].

The concepts shown in this Special Issue do not cover all the possibilities of modern combustion techniques. However, they significantly contribute to developing and disseminating these technologies.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. McLennan, M.; Group, S. *The Global Risks Report 2021*, 16th ed.; World Economic Forum: Cologny, Switzerland, 2021.
2. Global Energy Review: CO_2 Emissions in 2021–Analysis. Available online: https://www.iea.org/reports/global-energy-review-co2-emissions-in-2021-2 (accessed on 11 March 2022).
3. Krzywanski, J.; Ashraf, W.M.; Czakiert, T.; Sosnowski, M.; Grabowska, K.; Zylka, A.; Kulakowska, A.; Skrobek, D.; Mistal, S.; Gao, Y. CO_2 Capture by Virgin Ivy Plants Growing Up on the External Covers of Houses as a Rapid Complementary Route to Achieve Global GHG Reduction Targets. *Energies* **2022**, *15*, 1683. [CrossRef]
4. Krzywanski, J.; Blaszczuk, A.; Czakiert, T.; Rajczyk, R.; Nowak, W. Artificial Intelligence Treatment of NOX Emissions from CFBC in Air and Oxy-Fuel Conditions. In Proceedings of the 11th International Conference on Fluidized Bed Technology (CFB-11), Beijing, China, 14–17 May 2014; pp. 619–624.
5. Zylka, A.; Krzywanski, J.; Czakiert, T.; Idziak, K.; Sosnowski, M.; Grabowska, K.; Prauzner, T.; Nowak, W. The 4th Generation of CeSFaMB in Numerical Simulations for CuO-Based Oxygen Carrier in CLC System. *Fuel* **2019**, *255*, 115776. [CrossRef]
6. Fortunato, V.; Giraldo, A.; Rouabah, M.; Nacereddine, R.; Delanaye, M.; Parente, A. Experimental and Numerical Investigation of a MILD Combustion Chamber for Micro Gas Turbine Applications. *Energies* **2018**, *11*, 3363. [CrossRef]
7. Azam, M.; Ashraf, A.; Setoodeh Jahromy, S.; Miran, S.; Raza, N.; Wesenauer, F.; Jordan, C.; Harasek, M.; Winter, F. Co-Combustion Studies of Low-Rank Coal and Refuse-Derived Fuel: Performance and Reaction Kinetics. *Energies* **2021**, *14*, 3796. [CrossRef]
8. Čepić, Z.; Mihajlović, V.; Đurić, S.; Milotić, M.; Stošić, M.; Stepanov, B.; Ilić Mićunović, M. Experimental Analysis of Temperature Influence on Waste Tire Pyrolysis. *Energies* **2021**, *14*, 5403. [CrossRef]
9. Lee, C.W.; Kim, I.S.; Hong, J.G. Experimental Investigation on the Effects of the Geometry of the Pilot Burner on Main Flame. *Energies* **2021**, *14*, 1115. [CrossRef]
10. Zhao, B.; Chen, G.; Xiong, Z.; Qin, L.; Chen, W.; Han, J. A Model for Predicting Arsenic Volatilization during Coal Combustion Based on the Ash Fusion Temperature and Coal Characteristic. *Energies* **2021**, *14*, 334. [CrossRef]
11. Muhammad Ashraf, W.; Moeen Uddin, G.; Muhammad Arafat, S.; Afghan, S.; Hassan Kamal, A.; Asim, M.; Haider Khan, M.; Waqas Rafique, M.; Naumann, U.; Niazi, S.G.; et al. Optimization of a 660 MWe Supercritical Power Plant Performance—A Case of Industry 4.0 in the Data-Driven Operational Management Part 1. Thermal Efficiency. *Energies* **2020**, *13*, 5592. [CrossRef]
12. Muhammad Ashraf, W.; Moeen Uddin, G.; Hassan Kamal, A.; Haider Khan, M.; Khan, A.A.; Afroze Ahmad, H.; Ahmed, F.; Hafeez, N.; Muhammad Zawar Sami, R.; Muhammad Arafat, S.; et al. Optimization of a 660 MWe Supercritical Power Plant Performance—A Case of Industry 4.0 in the Data-Driven Operational Management. Part 2. Power Generation. *Energies* **2020**, *13*, 5619. [CrossRef]
13. Idziak, K.; Czakiert, T.; Krzywanski, J.; Zylka, A.; Kozlowska, M.; Nowak, W. Safety and Environmental Reasons for the Use of Ni-, Co-, Cu-, Mn- and Fe-Based Oxygen Carriers in CLC/CLOU Applications: An Overview. *Fuel* **2020**, *268*, 117245. [CrossRef]
14. Zylka, A.; Krzywanski, J.; Czakiert, T.; Idziak, K.; Sosnowski, M.; de Souza-Santos, M.L.; Sztekler, K.; Nowak, W. Modeling of the Chemical Looping Combustion of Hard Coal and Biomass Using Ilmenite as the Oxygen Carrier. *Energies* **2020**, *13*, 5394. [CrossRef]
15. Tang, Y.; Lou, D.; Wang, C.; Tan, P.; Hu, Z.; Zhang, Y.; Fang, L. Study of Visualization Experiment on the Influence of Injector Nozzle Diameter on Diesel Engine Spray Ignition and Combustion Characteristics. *Energies* **2020**, *13*, 5337. [CrossRef]
16. Lund, H.; Arler, F.; Østergaard, P.A.; Hvelplund, F.; Connolly, D.; Mathiesen, B.V.; Karnøe, P. Simulation versus Optimisation: Theoretical Positions in Energy System Modelling. *Energies* **2017**, *10*, 840. [CrossRef]
17. Sosnowski, M.; Krzywanski, J.; Ščurek, R. Artificial Intelligence and Computational Methods in the Modeling of Complex Systems. *Entropy* **2021**, *23*, 586. [CrossRef] [PubMed]

18. Sosnowski, M.; Krzywanski, J.; Scurek, R. A Fuzzy Logic Approach for the Reduction of Mesh-Induced Error in CFD Analysis: A Case Study of an Impinging Jet. *Entropy* **2019**, *21*, 1047. [CrossRef]
19. Krzywanski, J. A General Approach in Optimization of Heat Exchangers by Bio-Inspired Artificial Intelligence Methods. *Energies* **2019**, *12*, 4441. [CrossRef]