energies

Editorial

Editorial Special Issue "Combustion and Propulsion"

Maria Grazia De Giorgi * and Antonio Ficarella

Department of Engineering for Innovation, University of Salento, 73100 Lecce, Italy; antonio.ficarella@unisalento.it

* Correspondence: mariagrazia.degiorgi@unisalento.it; Tel.: +39-0832-297759

Received: 17 April 2017; Accepted: 16 June 2017; Published: 18 June 2017

The increasing demand for socially and environmentally sustainable development requires appropriate use of energy resources, particularly in the transportation of people and goods. The main source of energy for propulsion is based on the use of fuels, mainly of fossil origin but increasingly produced from renewable sources. Therefore, combustion processes play a key role in the efficiency of energy use and for the environmental impact of transportation systems.

The most relevant topic of recent scientific and technological research is the control of the fundamental processes, down to the molecular level, affecting combustion. Therefore, research focuses on the production of fuels from renewable sources, on fuel injection and vaporization, by means of new concepts of atomizers in gas turbines, or by means of injection systems with electronic control and high pressure in internal combustion engines, on air–fuel mixing. Moreover, research focuses on the control of oxidation processes by lean combustion or by new combustion concepts, combustion instabilities, micro-scale combustion, control of turbulence and the boundary layer by means of active systems, and the development of new combustion concepts such as the homogeneous charge compression ignition.

Control and diagnostics are influenced by the peculiar characteristics of combustion in propulsion systems, with respect to stationary applications, because of the significant degree of unsteadiness of the operating conditions and the extremely high power density.

The present Special Issue focuses on experimental, theoretical, and computational investigations on the fundamentals of combustion in propulsion systems, and on the resulting lines of technological development. The articles cover a wide range of topics, such as combustion in gas turbines and internal combustion engines for aeronautical, automotive, naval and railway engines, chemical space propulsion, control and diagnostics of combustion, new and renewable fuels, alternative combustion-based propulsion systems, new combustion concepts, pollutants formation and control in propulsive systems.

Eleven papers have been approved for publication; most of them are related to the reduction and control of pollutants. The formation of pollutants from combustion systems is a topic that attracts considerable interest because of the negative impact on human health, air quality, and climate change. Numerous experimental and numerical efforts have been made in order to achieve a better understanding of the chemistry and physics involved in the pollutant formation process, with the aim of achieving low-emission combustion technologies.

In this context, the work of [1] was aimed at obtaining both quantitative and qualitative information of soot particles generated with a set of laminar partially-premixed co-flow flames characterized by different equivalence ratios by an improved version of the thermophoretic particle densitometry (TPD) method. Results also show that increasing the remixing has the initial effect of increasing particle concentration because of the increase of the radical pool promoted by the oxygen addition, while the competitive effect of increasing dilution prevails when the primary air is further increased so that the reduction of the particle volume fraction is measured

Aimed at achieving low exhaust emissions, lean-burn combustion systems, operating with a very lean air/fuel ratio are of great interest. However, in [2], it was shown that at very lean conditions the emissions of both particulate matter and CO were found to increase, most likely due to the occurrence of flame instabilities while the NO_x was observed to reduce. Furthermore, under very lean conditions, the stabilization of the flame is a main issue. In this context, the work of [3] investigates the effects of sinusoidal dielectric barrier discharge (DBD) on the stabilization of a lean inverse diffusive methane/air flame in a Bunsen-type burner. It was evident that the plasma flame enhancement was significantly influenced by the plasma discharges, particularly at high inner airflow rates. The flame structure changes drastically when the dissipated plasma power increases. The flame area decreases due to the enhancement of mixing and chemical reactions that lead to a more anchored flame on the quartz exit with a reduction of the flame length.

The reduction of NO_x is a significant issue, especially in the transport sector. According to the third stage, harmful emission control regulations of the International Maritime Organization (IMO) (IMO Tier 3) newly built marine diesel engines operating in the Emission Control Areas (ECA) must apply in-cylinder control measures or after-treatment devices to satisfy the NO_x control requirements. Miller-cycle, exhaust gas recirculation (EGR), water injection or water-emulsified-oil, pre-injection, premixed charge compression ignition (PCCI) are effective methods to reduce the maximum combustion temperature and accordingly decrease NO_x emissions. Hence, in [4], the potential of in-cylinder control methods to meet the IMO Tier 3 NO_x emission standard was evaluated. It was shown that r with a combination of 2-stage turbo-charging, a mild Miller-cycle and 10% EGR rate, the NO_x emissions can be decreased by 48% without the increased Specific Fuel Oil Consumption (SFOC) penalties; with a medium Miller-cycle and 10% EGR, NO_x can be decreased by 56% with a slight increase of SFOC; with a medium Miller-cycle and 20% EGR, NO_x can be decreased by 77% and meet IMO Tier 3 standards, but at the high price of a considerable increase of SFOC.

In liquid fueled combustors, better atomization may also help in reducing fuel consumption and CO_2/NO_2 emissions. Recent developments have shown that the process of atomization can be affected by the introduction of acoustics. In [5], an experimental and theoretical study was conducted on the effects of an acoustic field induced by Hartmann resonance tube (HRT) on droplet deformation behavior. It was shown that the presence of acoustics can greatly enhance the oscillation process of the droplet, and the oscillation of the shape of the droplet has several modes at the same time; but the former oscillation modes have more significant influence on the deformation process. When the frequency of the acoustic field equals the resonance frequency of the droplet, the amplitude of the deformation reaches its maximum. This finding provides necessary information for optimizing atomization performance in real world atomizer design.

Regarding emissions, CO_2 is the most prevalent amongst greenhouse gases (e.g., CO_2, NO_x, SO_x, CH_4) that contribute to global warming. In order to capture CO_2, there are several available pre-combustion processes, in which the fuel is de-carbonized prior to combustion: oxy-fuel combustion, which uses pure oxygen obtained from cryogenic nitrogen separation from air; and post-combustion separation, which separates CO_2 from the flue gases using different approaches. However, these techniques are energy intensive, resulting in a significant decrease of the overall combustion efficiency and as a result in a price increase of the produced electricity. Considering all these factors, chemical-looping combustion (CLC) appears to have the potential for delivering the most efficient and low cost technology. In [6], experiments were performed to investigate the activity and regeneration ability of an iron-based oxygen carrier with high index facet during chemical looping combustion (CLC), suggesting that morphological control of the oxygen carrier is very rewarding.

In order to maintain the combustion process at the low-emission condition while satisfying the requirements for higher efficiency, performance, and reliability, not only are design efforts on engine operating conditions needed, but also reliable methods to measure system states, which are needed for the implementation of control strategies. However, the high-performance control of the dynamics of internal combustion engines is difficult to achieve due to unpredictable changes of load. For example, in order to obtain the desired balance between power output and fuel consumption in spark-ignition (SI) engines, the air/fuel ratio (AFR) must be maintained at the stoichiometric value also in transient operation.

However, the aging effect can often cause the AFR sensor fault in the feedback loop, and the AFR control performance will degrade consequently. In [7], a new control scheme on AFR with fault-tolerance is proposed by using an artificial neural network model based on fault detection and compensation, which can provide satisfactory AFR regulation performance at the stoichiometric value for the combustion process, given a certain level of misreading of the AFR sensor.

Aimed at the reduction of emissions and the improvement of efficiency of conventional engines, the potential advantage of a free-piston engine, free-piston gasoline engine linear generator FPGLG in lower NO_x emission has been investigated in [8]. The FPLG is a combination of free-piston engines and a linear generator. In [8], the combustion characteristics during the stable generating process of a FPGLG were presented using a numerical iteration method, which coupled a zero-dimensional piston dynamic model and a three-dimensional scavenging model with the combustion process simulation.

Some papers published in the present issue deal with potential alternative combustor technology.

In particular, the work of Azami et al. [9] has examined the feasibility and effectiveness of various alternative fuels under pulse detonation combustion conditions. The results indicate that alternative fuels require higher initial mass flux and temperature to detonate. The benefits of alternative fuels appear significant.

In [10], a new type of vortex combustor is proposed to increase the efficiency of the combustion of aluminum and steam, and a mathematical model of the two phases of reacting flow in this combustor is established.

Finally, there is also a growing interest in micro-combustion, to power microrobots, notebook computers, micro-aerial vehicles and other small-scale devices. Compared with traditional combustors, the heating area of a MEMS reactor is no more than 1% of the size of traditional combustors. However, in the micro-reactor, the surface-to-volume ratio (S/V) is high and the residence time of gas mixtures in the micro combustion chamber is lower, which results in high thermal losses and even flame-outs. Micro-tube reactors with inner wall protuberances are investigated in [11] as an effective way of reducing the heat losses and increasing the combustion stability in lean conditions.

We would also like to express our deep gratitude to all the reviewers, whose generous and anonymous contribution made this Special Issue possible.

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

References

1. De Falco, G.; Moggia, G.; Sirignano, M.; Commodo, M.; Minutolo, P.; D'Anna, A. Exploring Soot Particle Concentration and Emissivity by Transient Thermocouples Measurements in Laminar Partially Premixed Coflow Flames. *Energies* **2017**, *10*, 232. [CrossRef]
2. De Giorgi, M.; Campilongo, S.; Ficarella, A.; De Falco, G.; Commodo, M.; D'Anna, A. Pollutant Formation during the Occurrence of Flame Instabilities under Very-Lean Combustion Conditions in a Liquid-Fuel Burner. *Energies* **2017**, *10*, 352. [CrossRef]
3. De Giorgi, M.; Sciolti, A.; Campilongo, S.; Ficarella, A. Flame Structure and Chemiluminescence Emissions of Inverse Diffusion Flames under Sinusoidally Driven Plasma Discharges. *Energies* **2017**, *10*, 334. [CrossRef]
4. Feng, L.; Tian, J.; Long, W.; Gong, W.; Du, B.; Li, D.; Chen, L. Decreasing NO_x of a Low-Speed Two-Stroke Marine Diesel Engine by Using In-Cylinder Emission Control Measures. *Energies* **2016**, *9*, 304. [CrossRef]
5. Ruan, C.; Xing, F.; Huang, Y.; Yu, X.; Zhang, J.; Yao, Y. The Influence of Acoustic Field Induced by HRT on Oscillation Behavior of a Single Droplet. *Energies* **2017**, *10*, 48. [CrossRef]
6. Qin, W.; Lin, C.; Wang, J.; Xiao, X.; Dong, C.; Wei, L. Study on Reaction Characteristics of Chemical-Looping Combustion between Maize Stalk and High Index Facet Iron Oxide. *Energies* **2016**, *9*, 656. [CrossRef]
7. Zhai, Y.; Yu, D.; Qian, K.; Lee, S.; Theera-Umpon, N. A Soft Sensor-Based Fault-Tolerant Control on the Air Fuel Ratio of Spark-Ignition Engines. *Energies* **2017**, *10*, 131. [CrossRef]

8. Miao, Y.; Zuo, Z.; Feng, H.; Guo, C.; Song, Y.; Jia, B.; Guo, Y. Research on the Combustion Characteristics of a Free-Piston Gasoline Engine Linear Generator during the Stable Generating Process. *Energies* **2016**, *9*, 655. [CrossRef]
9. Azami, M.; Savill, M. Pulse Detonation Assessment for Alternative Fuels. *Energies* **2017**, *10*, 369. [CrossRef]
10. Chen, X.; Xia, Z.; Huang, L.; Ma, L. Numerical Simulation of a Vortex Combustor Based on Aluminum and Steam. *Energies* **2016**, *9*, 1072. [CrossRef]
11. Wang, R.; Ran, J.; Du, X.; Niu, J.; Qi, W. The Influence of Slight Protuberances in a Micro-Tube Reactor on Methane/Moist Air Catalytic Combustion. *Energies* **2016**, *9*, 421. [CrossRef]