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Editorial: Pressure Gain Combustion technologies for a Greener propulsion

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Editorial on the Research Topic

Pressure Gain Combustion technologies for a Greener propulsion

1 Introduction

This Research Topic was formulated to address some fundamental aspects of Rotating Detonation Combustor (RDC) performance and modelling strategies. Recently, great interest arose in developing novel cycles for gas turbines aimed at increasing overall efficiency and specific power. That effort is accompanied by the possibility of using hydrogen as fuel in Pressure Gain Combustion (PGC) cycles, thus decreasing the direct emission of CO₂ (although NO_x emissions are still an open topic) and exploiting its fast combustion properties. The actual performance of PGC-equipped gas turbines is highly debated, with the pressure rise in the combustor and the coupling with a turbine still under investigation by several research groups, including the ones to which the Editors of the Research Topic belong. The RDC exhibits complex aero-thermo-mechanical challenges that are difficult to evaluate experimentally due to the extremely high exhaust temperature, high Mach numbers and the high characteristic frequencies, preventing standard experimental approaches. A complete study of RDC performance is fundamental to appropriately design the turbine module, either subsonic or supersonic, aimed at fostering the manufacturing of enabling components for power generation or propulsion.

The present Research Topic addresses the impact of the injectors' geometry on mixing efficiency and the definition of strategies for their simulation. [Le Naour et al.](#) provide insights into some fundamental numerical and experimental aspects of RDC, with particular interest in the injection configurations. [Sato et al.](#) studied the impact of two different boundary conditions on the flow field development inside the RDC chamber using high-fidelity Computational Fluid Dynamics (CFD) compared to experimental findings. Finally, [Hellard et al.](#) apply a modeling strategy for the simulation of transitory injection in RDCs, thus providing information about the possibility of studying reactants mixing at low computational cost.

2 Papers in the Research Topic

Le Naour et al. describe fundamental and applied issues that affect the overall performance of an RDC. Concerning the injection process, the authors compare the Semi-Impinging (SI) element to the so-called Injection To Enhance Mixing (ITEM) solution in terms of mixing efficiency using Large Eddy Simulation (LES), thus demonstrating the superior performance of the newly-developed ITEM configuration (at least in a non-reactive environment). The Rotating Detonation (RD) propagation on a series of SI and ITEM elements is also studied using LES, considering both a linear and an annular configuration, thus confirming the higher mixing efficiency of the ITEM element for both cases. Finally, results from small-scale and large-scale test facilities provide fundamental information on the obtained thrust (small-scale) and the stability of the detonation regime when varying mass flow and total temperature (large-scale), also in comparison with numerical findings.

Sato et al. perform high-fidelity simulations of an experimental RDC considering a series of configurations with different feed-plenum pressures but with a constant equivalence ratio. Detailed chemical kinetics for the hydrogen/air system is also used. The authors point out that when increasing mass flow, a total pressure boundary condition for the numerical simulation fails to predict the axial pressure distribution correctly. On the contrary, simulations done by defining a prescribed mass-flow rate allow for confirming some experimental findings in terms of qualitative and quantitative trends. For example, non-uniform fuel-air mixing leads to variations in local equivalence ratio. Moreover, the fuel and oxidizer injectors experience backflow as the detonation wave passes over, further augmenting the inefficiencies in mixing. Finally, parasitic combustion in the mixing region extends the reaction zone across the wave, an unexpected and unwanted phenomenon.

Lastly, Hellard et al. apply a modelling strategy developed by ONERA to simulate the transitory injection to two existing RDCs and an RDC under development. First, a strategy for retrieving accurate boundary conditions to simulate burnt gas expansion in an RDC (also called “re-injection problem”) is presented. Then, numerical data allow for concluding that re-injection simulation can be used to help design an optimized injector providing efficient propellant mixing. However, the detonation speed computed from the mixture state in the re-injection simulation may differ from the experimental velocity. Therefore, more studies are needed to correctly predict the detonation speed from the heterogeneous mixture state by a reduced model.

3 Concluding remarks

Outcomes from the experimental and numerical campaigns presented in this Research Topic cover a relevant part of the open issues associated with studying the mixing performance associated with injectors’ geometry in RDCs. The information presented in the Research Topic about the limitations of numerical simulations in the study of both RDC injectors and the re-injection problem paves the way for a more accurate analysis of reactive flows, a detailed survey of pollutant emissions, and the design of more efficient injectors for RDCs.

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