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Investigation of CH_4-H_2 combustion in a small scale micro Gas Turbine

Alessandro Piscopo[1,2,3]*, Farshid Y. Farrokhi[1,2,3], Ward De Paepe[3], Alessandro Parente[1,2,4]
*Alessandro Piscopo: Alessandro.Piscopo@ulb.be
[1] Université libre de Bruxelles, Aero-Thermo-Mechanics Laboratory, Belgium
[2] Brussels Institute for Thermal-Fluid Systems and Clean Energy (BRITE), Belgium
[3] University of Mons, Thermal Engineering & Combustion Unit, Belgium
[4] WEL Research Institute, Belgium.

The current energy sector has to adapt, in the context of the energy transition, to reduce harmful pollutant emissions such as carbon dioxide (CO_2) and nitrogen oxides (NO_x). The defossilization introduced a significant share of renewables in the European energy mix. Nevertheless, renewables are characterised by intermittency due to their dependency on uncontrolled and non-dispatchable sources such as wind and sun. An option to mitigate this effect is to decentralise energy production, mainly by using small-scale units with faster response times, thus offering higher flexibility. Micro gas turbines (mGTs) have a role to play in that aspect of heat and electricity production, as their flexibility can help in coping with the significant amount of variable renewable energy. mGTs burn mainly natural gas, resulting in CO_2 production. To reduce the CO_2 emissions, the carbon can be removed from the fuel, and a good candidate is hydrogen. The properties of natural gas (or methane) and hydrogen are, however, very different, mainly in terms of adiabatic flame temperature, lower heating value (LHV), and density. The switch from methane combustion to hydrogen combustion is not straightforward, and the impact of hydrogen addition on fuel should be investigated properly. To do so, this paper studies a 20 kW_{th} mGT combustor of a small 3.2 kW_e machine. The fuel enters the chamber through 14 injectors placed upstream of the 7-blade swirler, resulting in a partially premixed regime. Cooling and dilution holes are disposed of along the chamber to reduce pollutant emissions. The experiments were conducted in the UMONS laboratory and were used to validate the numerical methodology. Various operating set-points are available for methane combustion, while blends were burned only at full load, until the current official limit of the machine ($23\%_{vol} H_2$). Computational Fluid Dynamics (CFD) simulations with a Reynolds-Averaged Navier-Stokes (RANS) approach and detailed chemistry are performed with the commercial software ANSYS Fluent. The Partially Stirred Reactor (PaSR) combustion model, a robust model for predicting pollutant emissions with finite-rate chemistry, is retained for the closure of the reaction rate, with the realizable $k-\epsilon$ turbulence model. The hydrogen addition quickly affects the flame topology, from $5\%_{vol}$. After validation of the numerical approach, higher hydrogen contents are explored through CFD simulations for investigating the stability of the flame and the impact on pollutant emissions, as NO_x emissions rise with hydrogen addition.