International Conference on Numerical Combustion
Rome, Italy, October 14-17, 2025
www.icnc2025.com

Numerical analysis of nitrogen oxides production in a turbulent flame stabilized by Nanosecond Repetitively Pulsed discharges

Stéphane Q.E. Wang[1]*, Renaud Gablier[1], Yacine Bechane[2], Christophe O. Laux[1], Benoît Fiorina[1]

* Lead presenter: stephane.wang@centralesupelec.fr

[1] Université Paris-Saclay, CNRS, CentraleSupélec, Laboratoire EM2C – France

[2] Normandie Université, UNIROUEN, INSA Rouen, CNRS, CORIA – France

Addressing the challenge of climate change requires mitigating nitrogen oxides (NOx) emissions. One solution is to decrease the mixture equivalence ratio, limiting the temperature within the combustion chamber. While the lower temperature strongly reduces NOx production, it also leads to slower chemical reaction rates, often resulting in incomplete combustion and flame extinction. An emerging solution to enable flame stabilization in leaner regimes is to generate high-voltage plasma discharges at the flame basis, which interacts with combustion. Nanosecond Repetitively Pulsed (NRP) discharges are an energy-efficient and promising technique to stabilize lean premixed flames [1]. High-performance computing is a valuable complementary approach to experiments for exploring open questions regarding the influence of NRP discharges on flame pollutant emissions. This research aims to undertake a numerical investigation and analysis of the NOx production in a turbulent flame stabilized by nanosecond plasma discharges. To this end, Large-Eddy Simulations (LES) are performed by combining a low-CPU cost phenomenological plasma model with an analytical combustion mechanism. The retained experimental configuration is the Mini-PAC bluff-body burner with a lean premixed injection of methane-air [2]. The NRP discharge model of Castela et al. is employed [3]. The numerical results are compared against experimental data. Lastly, the flame dynamics and NOx chemical pathways are analyzed.

This research was supported by the European Research Council (ERC) under the European Union's Horizon 2020 program (GREENBLUE project, grant No. 101021538).

References

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