12th International ERCOFTAC
Symposium on Engineering Turbulence Modelling and Measurements

26–28 September 2018, Montpellier, France

NUMERICAL MODELLING AND VALIDATION EXPERIMENTS OF NEAR WALL REACTIVE FLOWS

A. SADIKI*, A. DREIZLER† AND J. JANICKA*

*Institute for Energy and Power Plant Technology, Dept of Mechanical Engineering,
Technische Universitaet Darmstadt
Otto-Berndt-Straße 3, 64287 Darmstadt
sadiki@ekt.tu-darmstadt.de; janicka@ekt.tu-darmstadt.de
† Institute for reactive flows and diagnostics, Dept of Mechanical Engineering,
Technische Universitaet Darmstadt
Otto-Berndt-Straße 3, 64287 Darmstadt
dreizler@rsm.tu-darmstadt.de

Keywords: *Numerical Modelling, Near-Wall reactive flows, Validation experiments*

Content:

In many combustion systems, the presence of walls strongly influences combustion processes. For the sake of increasing the energy density and improving the compactness, a downsizing trend is observed in modern combustion technologies. Thereby, the flame-wall interaction (FWI) becomes a limiting factor, as it may lead to important modifications of the flame and the wall dynamics. Experimental observations show that the flame strength is reduced near cold wall surfaces, leading to possible (partial or total) quenching, while the gas-solid heat flux takes peak values at flame contact. The evaluation of such wall heat fluxes is a key issue in design process of cooling devices and in determining the lifetime of combustion systems [1].

Furthermore, excess emissions of unburned hydrocarbons in combustion engines have long been attributed to the presence of cool walls. Indeed, the presence of the wall may cause an increase in the pollutant emissions and a degradation of the energy performances. Together with the pollutant emissions, turbulent fuel-air temperature mixing, flame extinction and wall surface heat transfer are relevant processes to be understood. Therefore the FWI appears as one of the essential issues in modeling not only turbulent combustion processes in engines but also wall heat transfer during combustion in combustion systems [1, 2].

The fluid thermal and combustion boundary layer thicknesses at the wall could be in order of mm. Very few experimental studies are available for numerical validation, while unsteady simulation techniques like LES (Large Eddy Simulation) remain challenging in this special situation due to the thickness of flame which can be smaller than the LES mesh size [1, 2, 4].

In recent years, many efforts have also been devoted to combustion systems fired with liquid fuel (e.g. [3, 4]). In particular, the aspect of fuel spray interaction with walls of combustion chamber in diesel engines makes clear that flat-wall impingement causes diesel combustion to deteriorate when the liquid phase–wall interaction occurs, once compared with a free spray flame [3, 4]. In gasoline engines, researches are conducted mainly on the fuel injection and atomization in a spray-guided system [4]. In after-treatment units, investigations are carried out in IC engines in order to reduce exhaust emissions generated in the combustion chamber by means of Selective Catalytic Reaction (SCR) systems in which both evaporating spray/wall-interaction (SWI), heat transfer and thermal decomposition of urea-water solution are exploited [4].

Both the FWI and SWI are currently not fully understood and experimental data are very scarce. This mini-symposium aims at providing an opportunity for researchers and interested workers to discuss new challenges and developments, and exchange ideas in the areas of Near-Wall Reactive Flows. Since advances in various engineering and process applications necessitate better understanding of underlying FWI and/or SWI, recent results related to these processes including material deposition, film growth and surface reactions, their coupling with chemically reacting flows - all together with the presence of conjugated processes of heat and mass transfer - will be addressed. In addition to reliable modelling approaches for numerically simulating near-wall processes in combustion systems, appropriate experimental techniques and well-designed experiments for generation of experimental data for model validation will be presented.

The mini-symposium will also give to participants the possibility to develop and initiate new collaborations in this field.

References:

[1] Pantangi, P., Sadiki, A., Janicka, J., Mann, M., Dreizler, A.: LES of Premixed Methane Flame Impinging on the Wall Using Non-adiabatic Flamelet Generated Manifold (FGM) Approach, Flow, Turbulence and combustion, Vol. 92 (4) pp 805–836, 2014
[2] Dreizler, A. and Böhm, B: Advanced laser diagnostics for an improved understanding of premixed flame-wall interactions, Proceedings of the Comb. Inst. 35 (1), 37-64, 2016
[3] Li, K., Nishida, K., Ogata, Y., Shi, B: Effect of flat-wall impingement on diesel spray combustion, Proceedings of the Inst. of Mech. Engineers, Part D: J. of Automobile Engineering, Volume 229, Issue 5, April 2015
[4] Sadiki, A., Di Mare, F., Hasse, C. et al.: Best Practices in Combustion CFD: IC-Engines, in ERCOFTACS BPG Book Series- CFD of Turbulent Combustion, Ed. L. Vervisch and D. Rockaerts, 2016

List of potential Speakers:

[1]Dreizler, A. et al.: Institute for reactive flows and diagnostics, TU Darmstadt, Germany
[2]Fiorina, B. et al.: CentraleSupélec, EM2C laboratory, France
[3]Deutschmann, O. et al.: KIT, Karlsruhe, Germany
[4]Magagnato, B. Frohnapfel, et al.: KIT, Karlsruhe, Germany
[5] Sadiki, A. et al.: Institute of Energy and PowerPlant Technology, TU Darmstadt, Germany
[6] Atul Dhar et al.: School of Engineering, Indian Institute of Technology Mandi, India