PhD fellowship – PRISME (Orleans)

Aerodynamics and Combustion cycle to cycle analysis of a Spark Ignition ICE

Laboratory: Laboratoire Prisme, Orléans, France

Topic: In the context of the automotive industry, recent studies provided by the International Energy agency (AIE) [1] and La Plateforme Automobile (PFA) [2] agree that 77% of sold vehicles will be equipped with a spark-ignition engine (SIE) while only 12% will be all-electric vehicles by 2035. In OECD countries, the electrification of vehicles and the improvement of the efficiency of internal combustion engines (ICE) are the main levers to reduce greenhouse gas emissions. To meet such expectations, the SIE is seen as the most interesting ICE technology, due to its cost effectiveness and the relative simplicity and efficiency of its exhaust gas after-treatment systems. However technological challenges have to be tackled due to the diversification and complexity of hybrid applications (e.g. cold start, extreme operating conditions, restart in hybrid vehicles, coupling electrical and thermal engines). Designing and calibrating SIE to achieve optimal performance (high efficiency and low pollutant emissions) under real driving conditions requires better mastery of flow aerodynamics, mixing and combustion down to the individual engine cycle. Therefore, Large-Eddy Simulation (LES) studies are required for the accurate prediction of undesired events (e.g. knock) or to assess engine combustion stability for a wider range of operating conditions to meet real driving emissions (RDE) expectations [3]. One problematic aspect of such numerical tools is that it is difficult to prescribe boundary conditions able to replicate the fine perturbations observed in real systems. These perturbations, which are uncertain in an epistemic sense, may drive the evolution and the emergence of rare events which can in turn affect the global performance of the engine.
This PhD is integrated in the ANR-PRC-2020 project ALEKCIA. The goal of the project is to develop augmented numerical predictions and analysis of SIE engines. In that respect, a coupled experimental and numerical approach for LES in SIE engines will be carried out by the different partners (IFPEN, PRISME, PPRIME). The goal of this PhD is specifically to analyze internal aerodynamics and combustion in an optical access SIE using optical diagnostics in order to better understand the cycle to cycle fluctuations and to generate high accuracy data in order to improve LES models.

Objectives: The present PhD fellowship aims for characterizing in-cylinder and intake flows of an optical access SIE using highspeed PIV during stationary and transient mode simultaneously with the measurement of the intake flow using high speed PIV, pressure wave and mass flow. We will characterize both isooctane and hydrogen combustions by reconstructing, at high speed, both the flame volume and the internal flow in order to better analyze the cycle-to-cycle fluctuations of the flame propagation.
The data will be used to improve LES calculation and the development of Data Assimilation tools for the augmented prediction of ICE flows carried out by two other PhD student during the ALEKCIA project. Modern data analysis tools will be used to understand the in-cylinder flows and the combustion phase. Experiments will be able to detect rare events that can be responsible for large pollutant emissions and have to be discarded in production engines. The candidate will clearly benefit of a synergy work using both experimental and numerical data.

PhD supervisors: Pr. F. Foucher (PRISME), Pr J. Borée (PPRIME)

Profile: candidates for this PhD position will have skills in experimental measurement of turbulent flows and / or Internal combustion Engine. A Master's degree in these areas of expertise is required.
Additional information: the start date for the PhD fellowship is set to the 1st of October 2021 for a duration of three years. Applications (CV + motivation letter) should be sent via email to the PhD supervisors before the 1st of July 2021.

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References:
[1] "World Energy Outlook 2019", IEA, https://www.iea.org/reports/world-energy-outlook-2019 (2019).
[2] https://pfa-auto.fr/wp-content/uploads/2018/06/2018-Novembre-Note_technique_PFA.pdf (2018).