Capacity Area A2 Topic 2.2 Milestone 2

Detailed experimental and modelling understanding of dual-fuel combustion strategies with different liquid-gas fuel shares and premixed or diffusion combustion model

Recent assessment studies converge to the insight that in order to successfully "defossilize" the transport sector within a few decades three powertrain technology pillars are necessary, namely:

a) Efficiency increase of ICE-based powertrains
b) Electrification through BEV's and/or FCEV's
c) Optimization of ICEs fed with renewable energy carriers (biofuels, e-fuels, solar-thermochemical fuels

The proposed work contributes to stable ignition, efficient combustion and low-pollutant emissions in small, high-speed but, in particular, large, low-to medium-speed engines. Complete understanding of multi-mode combustion based on experiments and validated modeling for dual-fuel and pre-chamber ignition systems for optimal combustion initiation has been (almost) fully achieved. This applies so far to conventional fuels (diesel-like higher hydrocarbons and methane as basic constituent of natural gas). Therefore, the next step can be taken to expand this basis towards understanding and optimizing such multi-mode combustion processes involving renewable (hydrogen-enhanced) methane for gas engine combustion and higher synthetic hydrocarbons (paraffinic and/or oxygenated), for Diesel engine combustion.

Experiments have been completed in a rapid-compression-expansion-machine (RCEM) to visualize mixture formation, ignition, flame propagation and gas entrainment in the burnt zone for dual-fuel combustion with conventional fuels for a variety of liquid fuel quantities and gas-air equivalence ratios. Based on these data and additional measurements in a research engine in cooperation with IVK/University of Stuttgart (international FVV-project "Dieselverbrennung auf homogenem Grundgemisch", No. 6012192, its start being mentioned in 2016 report) a detailed CFD-model based on the tabulated FGM (flamelet generated manifolds) approach has been developed and fully validated (mentioned in 2018 monitoring list, "Output" section). Due to this activity, a fast, simplified but reasonable accurate predictive model for industrial product development purposes is currently under development.

Overall, our activities have shed light to complex reactive thermos-fluidic processes in dual-fuel IC engines for realistic pressures and temperatures and have advanced significantly the knowledge of the community in the field. Finally, several peer-reviewed publications have originated out of this work and a doctoral thesis on the subject has been successfully defended on 7 September 2018 (Ales Srna – "Experimental Characterization of Pilot-Fuel Ignition, Combustion, and Soot Formation in Dual-Fuel Combustion Systems").