PaREGEn

Particle Reduced, Efficient Gasoline Engines

EUROPEAN COMMISSION
Horizon 2020 | GV-2-2016 | Technologies for low emission light duty powertrains
GA # 723954

Deliverable No.	PaREGEn D1.9	
Deliverable Title	Report on understanding of the cause and effect relationship (CER) for nanoparticle formation and identification of the in-cylinder soot formation process for different engine operating conditions.	
Deliverable Date	2019-08-31	
Deliverable Type	REPORT	
Dissemination level	Confidential – member only (CO)	CO
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Status	Final	2019-08-29

Publishable Summary

To achieve further reductions of particulate emissions from gasoline engines, an improved understanding of particle formation and the underlying interactions in the combustion chamber are necessary. From previous investigations, it is already known that particle formation correlates with locally fuel rich mixture zones in the combustion chamber. These zones arise for example from fuel mixture inhomogeneities in the gas phase, caused by late evaporating fuel wall films. Thus, the experimental determination of the wall-film thicknesses (WFT) is of importance, also because such quantitative data is needed for the validation of corresponding computational models that are further developed within WP1.

In addition to the fundamental cause and effect relationships (CER) investigations, the particle number (PN) emissions themselves have to be quantified down to 10 nm which poses significant challenges to the particle measurement system in the laboratory. The PN have to be measured under realistic engine conditions and require a sampling on a thermodynamic (metal) engine.

Therefore, this report is split into two parts: investigations on the optical single cylinder engine followed by investigations on the thermodynamic engine. It should be noted that the thermodynamic engine is also equipped with endoscopic access for in-depth analysis of the CER of particle formation.

In the first part of this report, in-depth investigations of mixture formation and soot precursor formation are presented and discussed. Laser-induced fluorescence (LIF) of a “tracer” is a very sensitive technique to image the in-cylinder fuel films but can be problematic in direct-injection gasoline engines. In particular, quantification of the measured film thickness has proven challenging. One issue is that the fluorescence signal intensity is sensitive to temperature. Here, we exploit the red-shift of the LIF signal from toluene via a two-color method to simultaneously image the thickness and the temperature of a fuel-film on the piston surface of an optically accessible engine. Fuel-film thicknesses and temperatures for different injection pressures were investigated in the motored engine. The results show that increasing injection pressure from 100 to 350 bar reduces the wall-film thickness. The film temperature was found to continuously increase over the compression stroke, with mean film temperatures between 70 and 110 °C. This proves that temperature has to be considered to quantitatively relate the fluorescence intensity from toluene to film thickness, since within this temperature range, the fluorescence intensity decreases by a factor of two to five with respect to room temperature.

In the second part of this report extensive parameter variations were carried out with the objective to evaluate the influences of load, speed, injection timing and injection pressure on the particle emissions and thus to better understand particle formation during engine operation. Within this sensitivity study, it can be seen that the particle emissions are significantly influenced by the quality of the mixture homogenization inside the combustion chamber. A high level of charge-motion in combination with an early and short injection influences the particle emissions in a positive manner. On the other hand, wetting surfaces inside the cylinder has a particularly unfavourable effect. It leads to a diffusive combustion, which produces high levels of soot and particles.

Appendix A – Acknowledgement

The author(s) would like to thank the partners in the project for their valuable comments on previous drafts and for performing the review.

Project partners:

#	Partner	Partner Full Name
1	RIC	RICARDO UK LIMITED
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18	Garrett	GARRETT MOTION CZECH REPUBLIC SRO

This project has received funding from the European Union's Horizon2020 research and innovation programme under Grant Agreement no. 723954.