PaREGEn

Particle Reduced, Efficient Gasoline Engines

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Written By	Andrew Lane (RIC) Phil Roberts (JLR) Helge Dagefoerde (BOSCH) Ludek Pohorelsky (HON) Jason Cleeton (JM)	2018-01-31
Checked by	David Richardson (JLR)	2018-02-19
Approved by	Simon Edwards (RIC) - Coordinator	2018-03-05
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Summary

The Particle Reduced Efficient Gasoline Engine (PaREGEn) project is a European Horizon 2020 project that has been created with a view to demonstrating a new generation of Gasoline Direct Injection (GDI) engines achieving a reduction in CO_2 emissions of 15% compared to the best equivalent engines in the market in 2016 and control of particle size down to 10nm in size through the adoption of new technologies. Jaguar Land Rover (JLR), in conjunction with Bosch (BOSCH), Johnson Matthey (JM), Ricardo (RIC) and Honeywell (HON) are to deliver a Jaguar XE vehicle in 2019 that will adopt dilute combustion (excess air, external Exhaust Gas Recirculation (EGR), internal exhaust residuals or a combination of all three) with a view to realising the fuel consumption saving equivalent to the CO_2 reduction mentioned above as well as ensuring the vehicle and engine they are applied to is compliant with EU6c emissions regulations with particulate control down to 10nm.

Deliverable 4.2 sets out the work completed in the design of new the hardware needed for the test bed and vehicle implementation phases. Specifically, the boosting system by HON, the base engine hardware by Jaguar Land Rover, the fuel injection equipment and aftertreatment urea dosing hardware by BOSCH, and the engine plus aftertreatment packaging by RIC. In addition, from WP2, JM have specified and procured the coated substrates for the aftertreatment system

The boosting system, comprising of a Honeywell Variable Nozzle Turbocharger Technology, VNT™, and an electrically driven compressor, eCharger unit, positioned downstream of the turbocharger, has been designed for WP4 PaREGEn vehicle demonstrator to provide required boost for diluted combustion technology with requirement on fast switch between stoichiometric and lean combustion and aggressive low end performance. An additional wastegate valve has been integrated in the turbine housing to enhance catalyst light-off and optimize turbocharger performance for part load and lean burn operation. Computational Fluid Dynamics (CFD) analysis and Finite Element Analysis (FEA) have been completed to maximize the VNT performance at all openings and to minimize stress concentrations in the turbine housings.

To meet the PaREGEn targets of increased thermal efficiency and a reduction in fuel consumption, the PaREGEn engine has been designed by Jaguar Land Rover to operate with a new combustion system including an increased compression ratio as well as dilute combustion.

The updated fuel injection equipment (FIE) provided by Bosch comprises of multi-hole high pressure solenoid injectors, a high pressure fuel rail, a sensor and a pump. The injector is mounted centrally in each combustion chamber. The injection system runs with a working pressure of up to 35 MPa. Based on the computer aided design (CAD) data of the combustion chamber, injectors with three different spray patterns have been designed to support the mixture formation of the injected fuel with the air via the enhanced charge motion created by the new combustion system. For the urea system, most components will be carried over from a Jaguar Land Rover XE diesel vehicle, but the dosing control unit and the dosing module need to be modified for the specific application in this project. Those two parts will be supplied by Bosch. The interface between the engine control unit (ECU) and the urea sub-systems is the dosing control unit (DCU). The dosing module will be water-cooled to cope with the higher exhaust temperatures of a gasoline vehicle compared to a diesel.

As leaders of WP2 for the design and optimisation of the emissions aftertreatment system, JM have provided guidance and input on the catalyst technology and system architecture design for the JLR lean-burn gasoline vehicle concept and its successful integration onto the demonstrator vehicle, with the inherent limitations and challenges of packaging space and urea-dosing module design.

Ricardo has successfully packaged the above modifications to the boosting hardware, base engine and aftertreatment into a feasible solution for the WP4 demonstrator vehicle. The successful completion of these tasks now paves the way for the single and multi-cylinder engine development phases.

4 Risk Register

This risk register (Table 4-1) builds upon the relevant risks as identified in D4.1.

Table 4-1 Risk Register for WP4, updated at the conclusion of D4.2

Action Details	Responsible	Comments	Risk Level
Achieving 15% fuel consumption reduction from base vehicle	JLR	No change	MEDIUM
Emissions compliance; predominately engine out NOx emissions during lean operation	JLR/JM	No change - SCRE testing is currently on-going to assess low NOx lean combustion and whether engine-out NOx emissions can be mitigated with assumed aftertreatment system	MEDIUM
NOx aftertreatment efficiency	JLR/JM	No change - Initial SCR and LNT systems are being assessed on engine bench rigs	HIGH
CO_2 benefit of operating lean	JLR	No change - SCRE testing is currently on-going. MCE testing with hardware defined in D4.2 is due to start shortly	HIGH
Urea usage	JLR	No change - Further assessment following engine out NOx emissions and aftertreatment efficiency testing	LOW/MEDIUM
Torque transition/driveability when mode switching (lambda 1 to lean and vice versa)	JLR/Ricardo	No change - Hardware defined in D4.1 has been packaged successfully for assessment on MCE. Combination of CVVL, eCharger, VNT and waste gate functionality.	MEDIUM
Aftertreatment light-out	JLR/JM	Decrease - IEM deletion complete and introduction of eTWLNT	Low
N_2O production – does this offset the CO_2 benefit from operating lean?	JLR/JM	No change - To be assessed as part of MCE testing	MEDIUM
Mitigation of PN increase when operating lean	JLR/JM	No change - GPF and new combustion system specified and package successfully	LOW
Air handling – what is required to deliver additional air for lean operation?	JLR/Honeywell	Decrease - 48V eCharger has been specified and packaged. Conformation of performance from MCE testing	LOW/MEDIUM
Air handling for lambda1/lean transition	JLR/Honeywell	Decrease - 48V eCharger has been specified and packaged. Conformation of performance from MCE testing	LOW/MEDIUM
Emissions mitigation during transient operation	JLR/JM/Ricardo	No change - Oxygen storage capacity of TWLNT, NH_3 storage (risk of purging), SCR durability all to be assessed during MCE testing	MEDIUM
JLR OpenECU control strategy – for MCE development	JLR	Decrease - Full details in D4.3. Large amount of progress made in preparation for MCE testing on OpenECU.	MEDIUM
48V architecture integration for eCharger and eCAT	JLR/Ricardo	Decrease - Full details in D4.3. Large amount of progress made in system specification and procurement in preparation for MCE testing	MEDIUM