EFFICIENT ADDITIVATED GASOLINE LEAN ENGINE

GV-02-2016 – PROJECT 724084

SUREAL-23 FINAL EVENT - 10TH DECEMBER 2019

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 724084
CONTEXT AND OBJECTIVES

- GV-02-2016: Technologies for low emission light duty powertrains
  - Scope → Future combustion engines for electrified powertrains
  - New combustion processes, sensing, control and after treatment systems
  - Future ambitious energy and emission targets
  - Special attention should be given to the assessment and reduction of particle emissions below 23 nm

- Research and Innovation Action

- Objectives
  - Long term fleet target of 50 g/km CO₂ (WLTP)
  - Peak brake thermal efficiency of 50%
  - Real driving €6 values with no conformity factor
CONSORTIUM

- 9 Partners from 4 countries
  - IFP Energies nouvelles (coordinator)
  - FEV Europe GmbH
  - Università degli Studi di Napoli Federico II
  - Renault SAS
  - Universitat Politècnica de Valencia
  - RWTH Aachen
  - Saint-Gobain CREE
  - Continental Germany ➔ Vitesco Technologies
  - Continental France ➔ Vitesco Technologies
- Funding ≈ 6M€
- Effort ≈ 450 p-m.
- October 2016 - March 2020
ENGINE CONCEPT

- Overall concept
  - Breakthrough combustion system
    - Ultra-lean mixtures
  - H₂ boosting
  - Pre-chamber ignition system
  - Optimized intake ports
  - Smart coatings
  - Optimized NOx after-treatment systems
- Final demonstrator: multi-cylinder engine
  - Including turbocharging and EAT systems

Activities expected to focus on TRL 3-5
H₂ supplementation for lean burn SI engines already studied back in the 1970s
- EAGLE is extending the current knowledge with an up-to-date combustion system

- New context for H₂
  - Now seen as viable energy carrier
  - Why not for clean ICE?

- Minimal H₂ amount of 2-4 % vol. to achieve λ = 2

- Major and delicate challenge: efficient on-board production
  - Water electrolysis and fuel reforming seem compromised

Optimized conventional base engine
- Stroke/Bore, Compression ratio, Miller cycle

Advanced ignition system
- Volumetric ignition

Heat insulation
- Smart coatings

EATS
- Particulates and NOx

Optimized intake ports
- High charge motion

Hydrogen boosting
- Enhanced mixture

Ultra lean mixtures
- λ = 2
HYDROGEN SUPPLEMENTATION

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NOx reduction thanks to dilution, not to H₂

Towards high efficiency with high dilution rates, short burn durations and optimal combustion timings
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PRE-CHAMBER IGNITION

- Space ignition technology
  - To ignite a larger share of the combustible volume
  - To increase the energy transfer to fresh gases
  - To reduce the flame travel

- Active pre-chamber ignition system required for ultra-lean mixtures
  - Stoichiometric mixture in the pre-chamber
  - Homogeneous lean mixture in the main combustion chamber
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Short burn durations up to $\lambda = 2$ and above
Limited smoke emissions with near-stoichiometric mixtures in pre-chamber
Stable combustion process possible up to $\lambda = 3$ (excellent pre-conditions for calibration)
Compatible with different fuels (liquid or gaseous fuels)
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3000 rpm, 13 bar IMEP, $\lambda = 1.67$

PN created inside the pre-chamber (rich or inhomogeneous mixture), not oxidized in the main chamber because of low temperature
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**Optimized strategies can keep smoke / PN emissions low, even with liquid injection into the pre-chamber**

![Graph showing smoke number vs. pre-chamber fuel]
EAGLE MULTI-CYLINDER ENGINE

- Dual stage turbocharging system
  - Low Pressure Variable Nozzle Turbine
  - High Pressure E-charger
  - Combined with flexible valve actuation (VVT & VVL) to achieve $\lambda = 2$ over the complete engine map
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- Exhaust after-treatment
  - Oxidation catalyst
  - Gasoline Particulate Filter
  - Innovative NOx Storage Catalyst

Material selection and mini cat evaluation

Coating of a full size NSC demonstrator
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- Experimental assessment on-going
  - Expected maximal BTE higher than 48%
  - Final results to be published in 2020, including updated vehicle simulations for WLTC and RDC

Simulated brake thermal efficiency map (E-charger power not included)

< 50 gCO₂/km (WLTC)
Efficient Additivated Gasoline Lean Engine

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