EGR-Diluted NG combustion simulation in a high-performance SI engine

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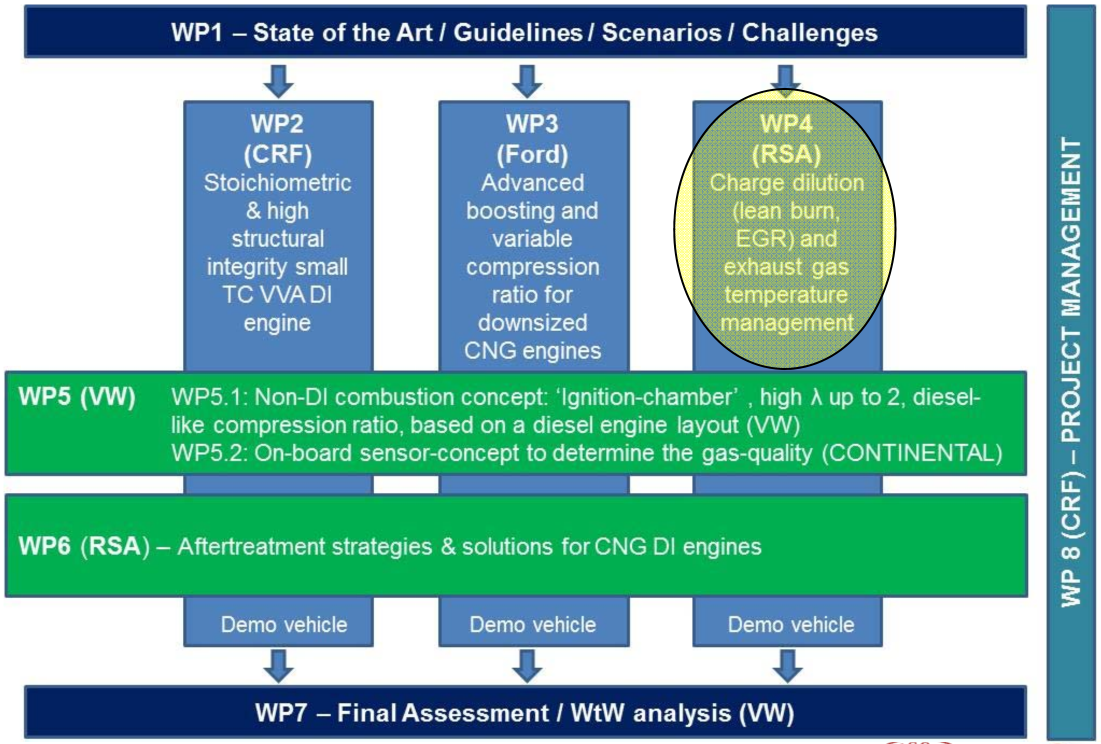
The GasOn research project (H2020)

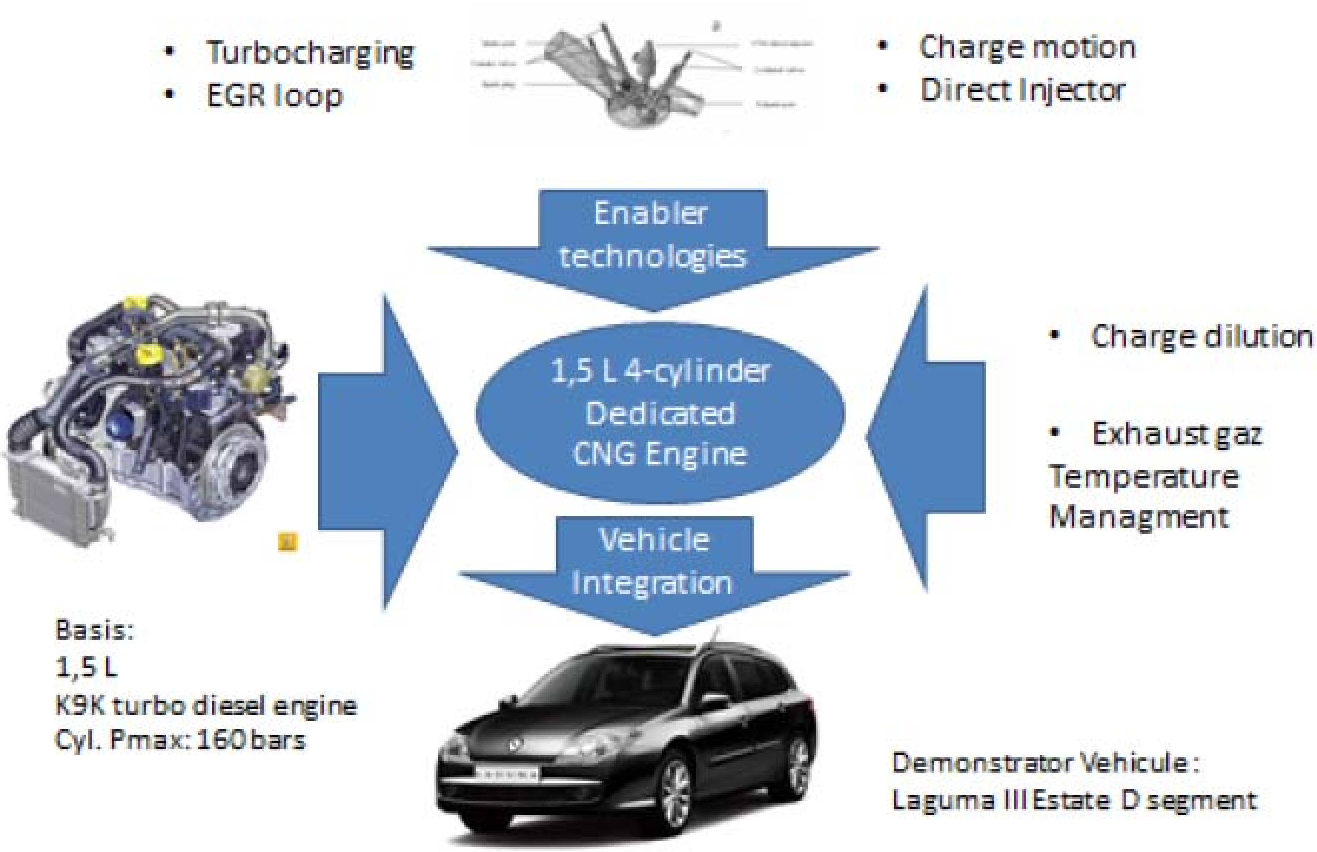


http://www.gason.eu/

The GasOn research project (H2020)

Technologies integration in WP4

(Charge Dilution and Exhaust-Gas Temperature Management for a CNG Direct Injection Engine)

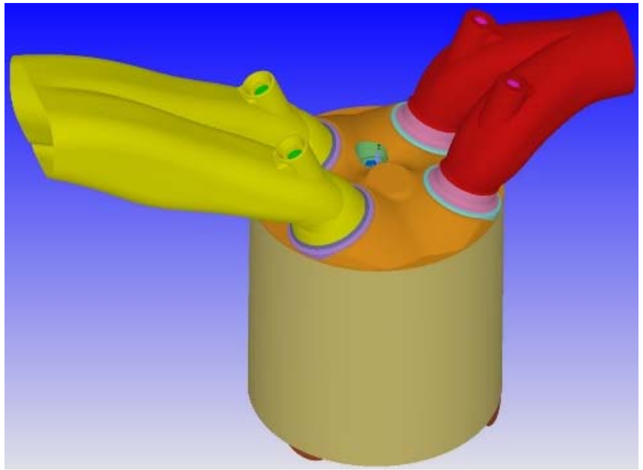


→ **Focus:**

Studying the impact of charge dilution on NG combustion speed/efficiency

http://www.gason.eu/

GasOn engine



Number of cylinders	4
Displacement	1.6 l
Number of valves / cylinders	4
Bore / stroke	80 mm / 80 mm
Compression ratio	13.5:1
Peak pressure	180 bar
Direct injection / Injection pressure	20 bar

- High C.R., increased PFP

  -> Diesel-based design
- Power target: 125 kW
- Revision of intake port geometry and intake/exhaust timing (VVT)

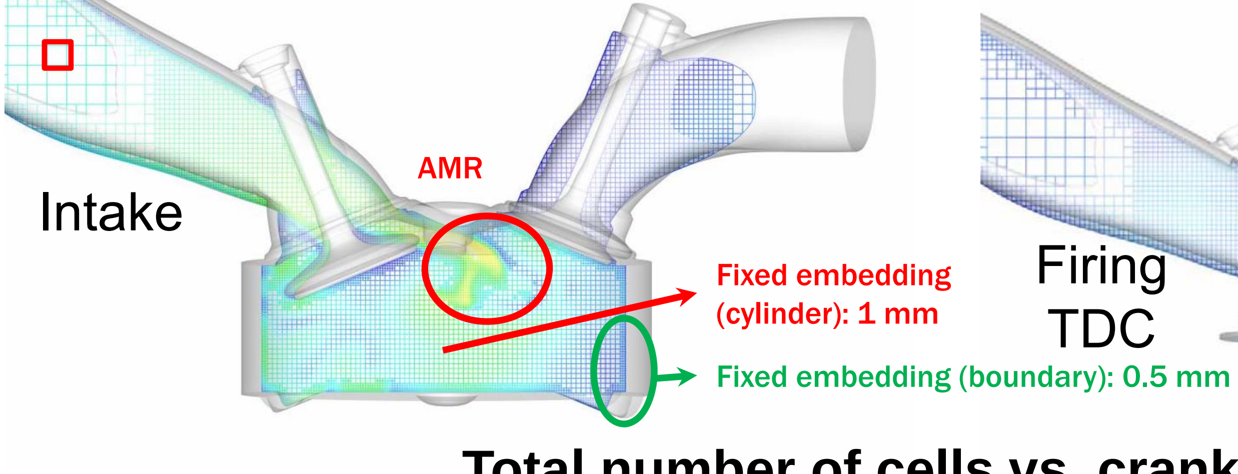
  -> scavenging

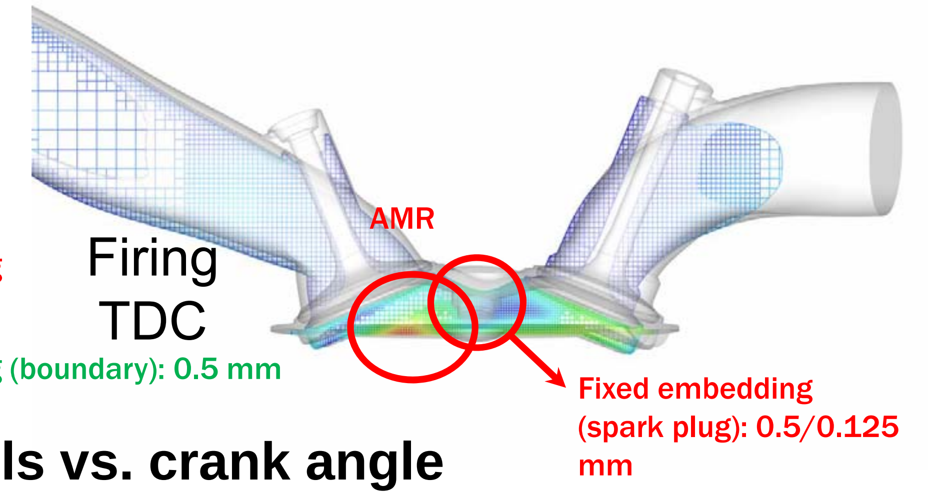
  -> increased tumble

Baratta, M., Goel, P., Laurenzano, D., Misul, D. et al. Experimental and numerical analysis of diluted combustion in a direct injection CNG engine featuring post- Euro-VI fuel consumption targets. Submitted to the SAE WCX 2018 Congress.

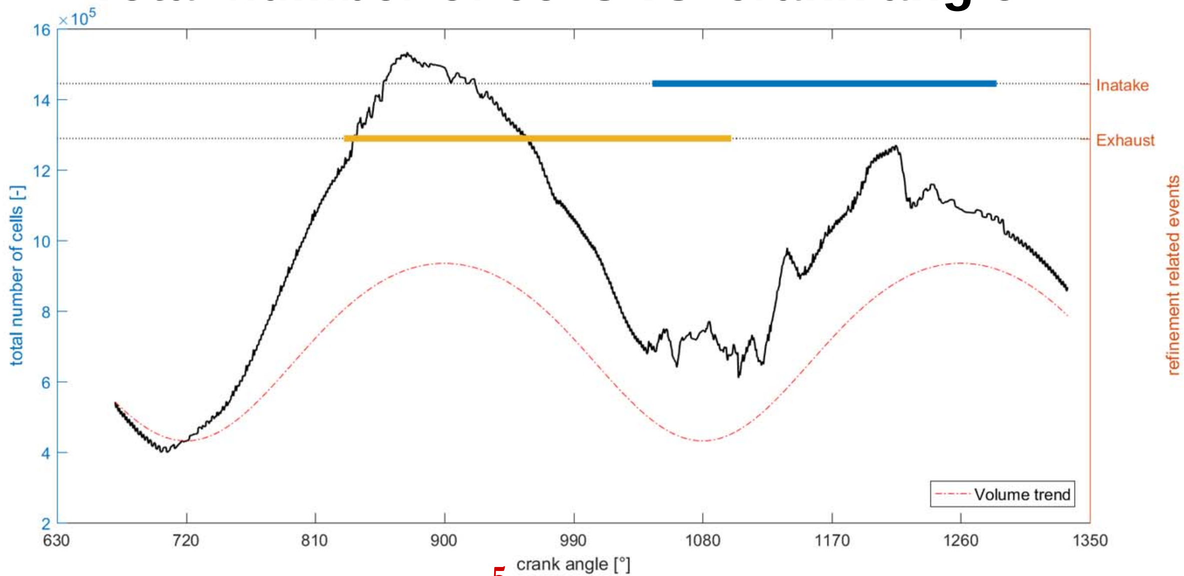
CFD engine model in CONVERGE

Computational mesh





Total number of cells vs. crank angle

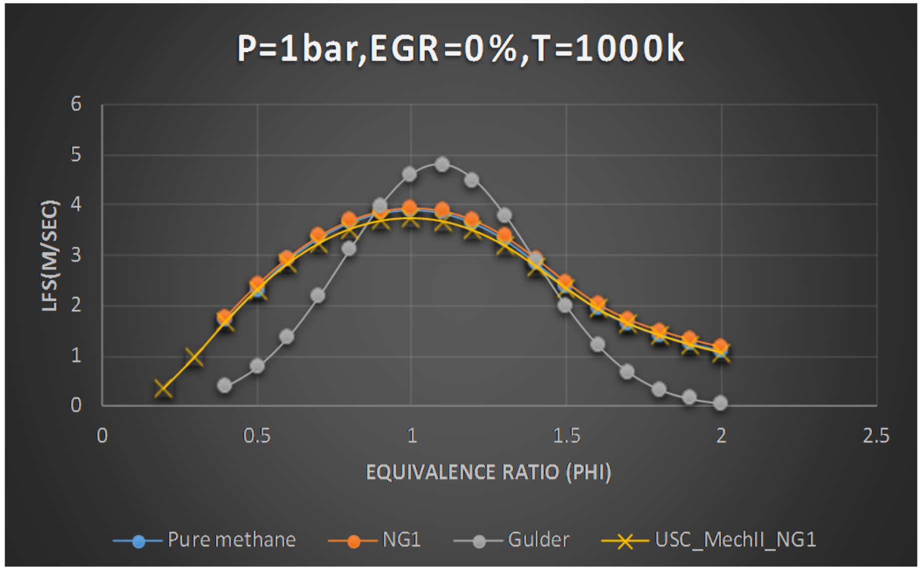


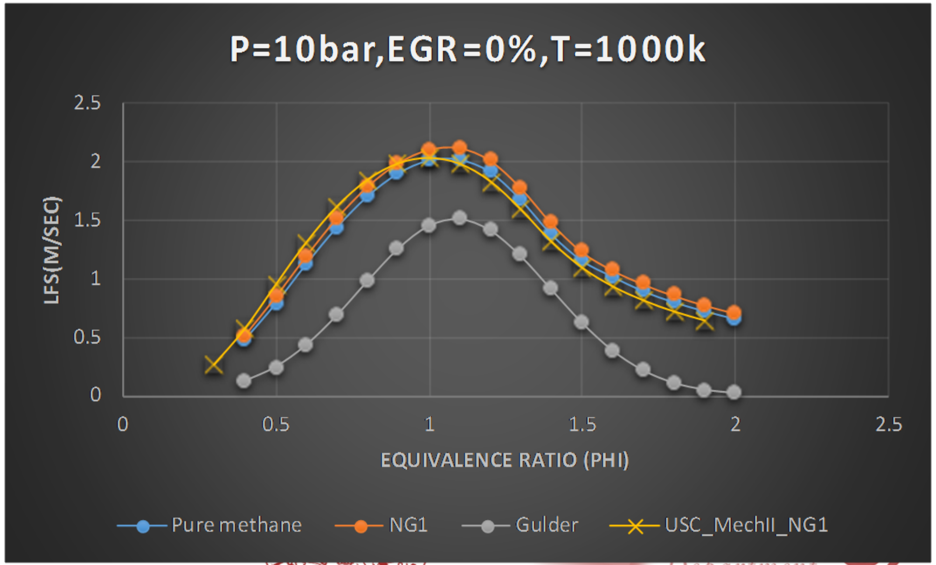
CFD engine model in CONVERGE

Flow	Compressible Flow
Gas Simulation	Redlich Kwong model
Numerical method	Implicit method
Turbulence model	RNG k-ε
Combustion model	ECFM
Heat transfer model	WF - Angelberger

LFS submodel from detailed chemistry developed and implemented via UDF

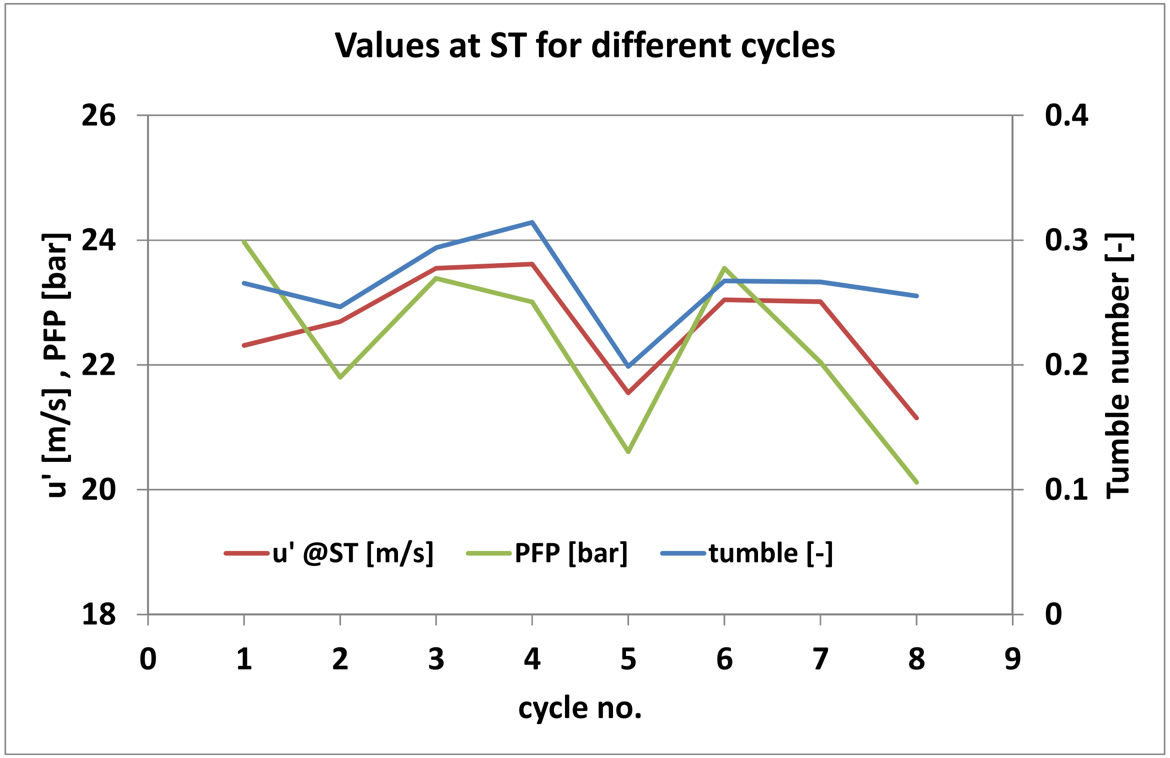
$$S_L = S_L\,(p, T, \lambda, EGR)$$





Cycle-to-cycle variations of results

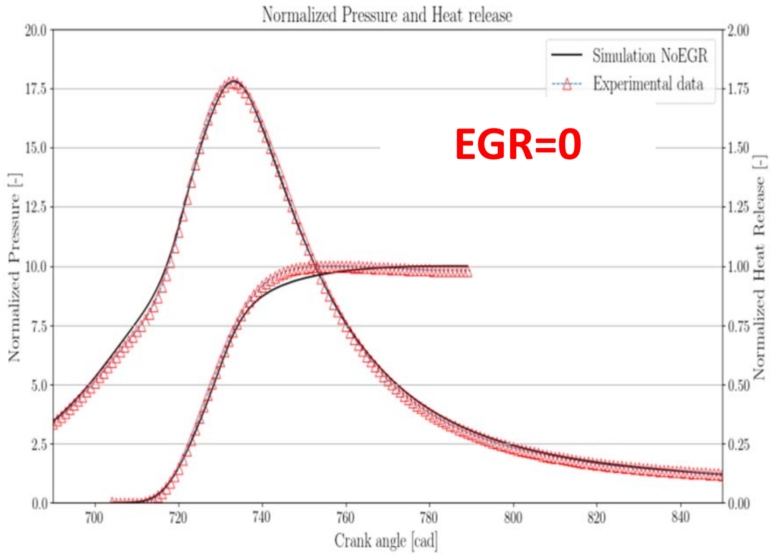
2000 rpm, imep = 3 bar

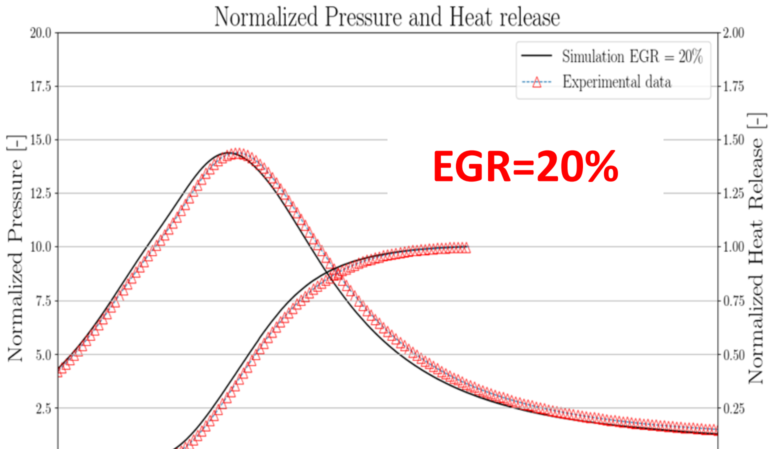


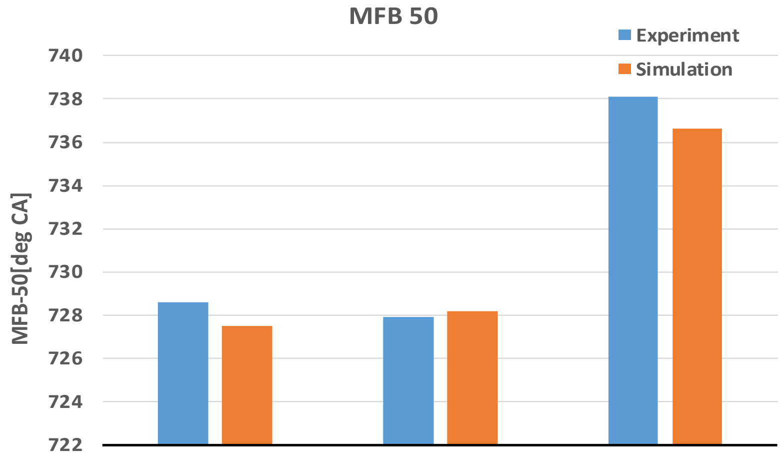
- In most of the operating points, with the present setup it was not possible to reach a ‘converged’ solution
- A clear correlation of the peak pressure with the turbulent flow features at ST was found
- Cycle-averaged results were considered from 2nd to 8th cycle
- Correlation of the simulated CoV with the engine variables were also analyzed

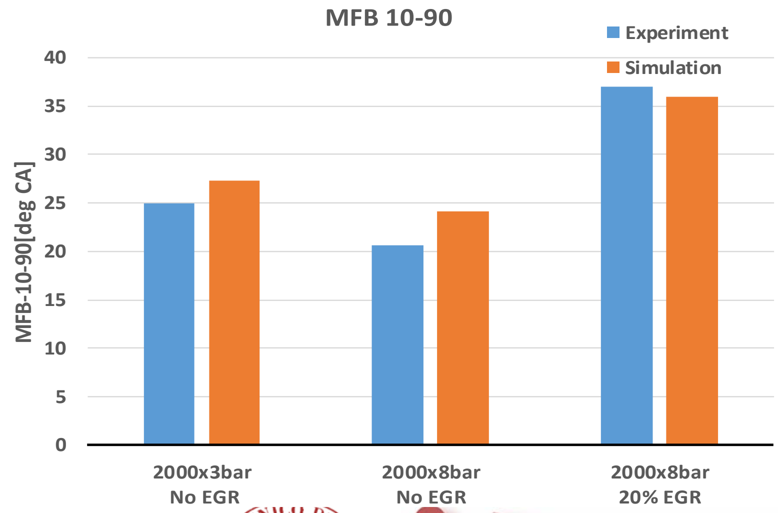
Model validation

2000 rpm, imep = 8 bar









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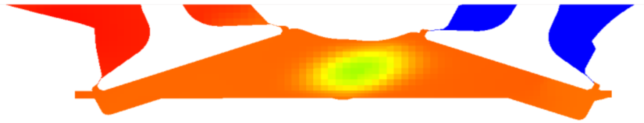
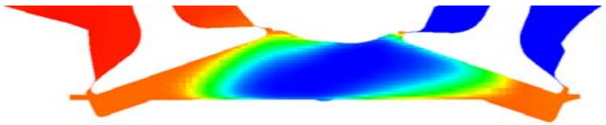
Combustion evolution – 2000x8, EGR=0

NG concentration contours

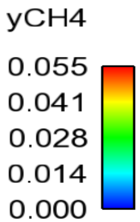
CA = 708 deg
(4 deg AST)

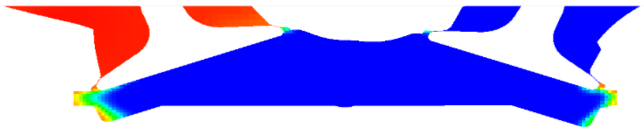


CA = 713 deg
(9 deg AST)



CA = 720 deg
(16 deg AST)





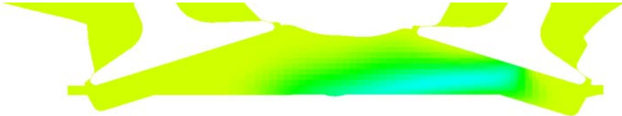
CA = 735 deg
(31 deg AST)

Combustion evolution – 2000x8, EGR=30%

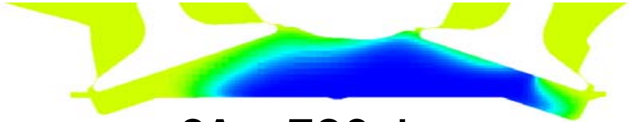
NG concentration contours

CA = 690 deg
(11 deg AST)

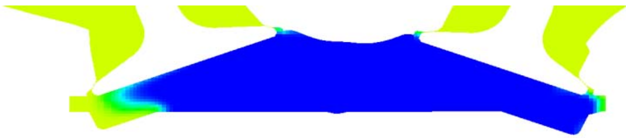
CA = 700 deg
(21 deg AST)



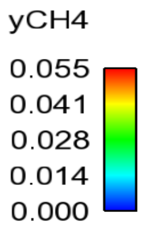
CA = 710 deg
(31 deg AST)



CA = 720 deg
(41 deg AST)

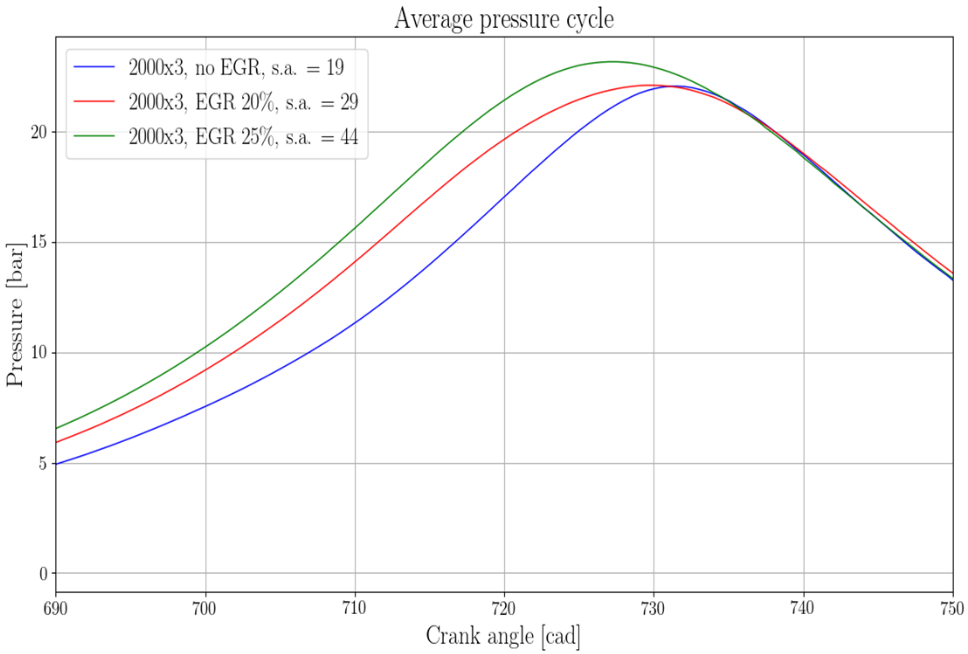


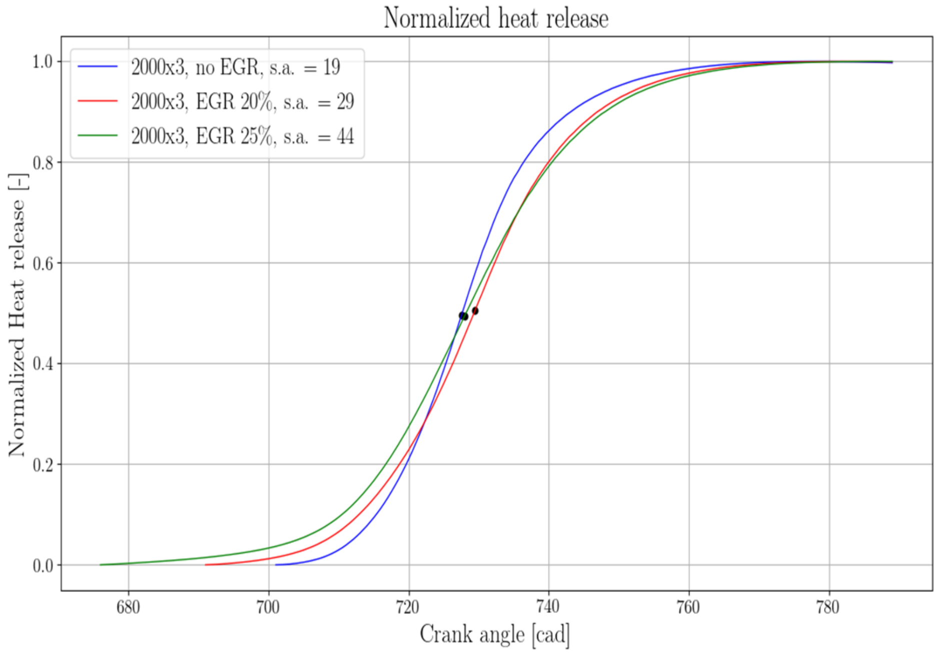
CA = 735 deg



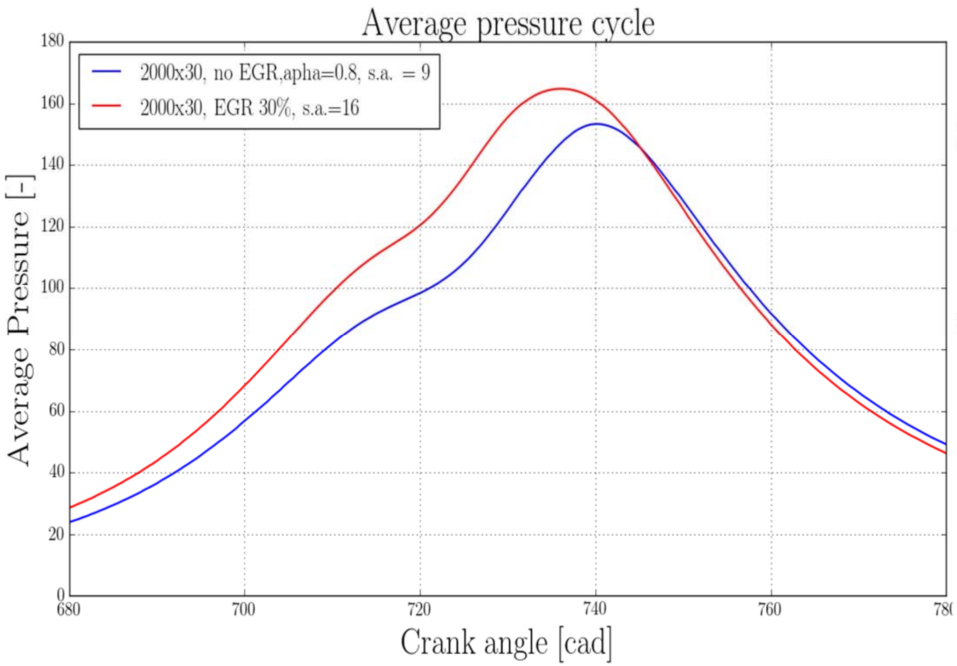
CA = 780 deg

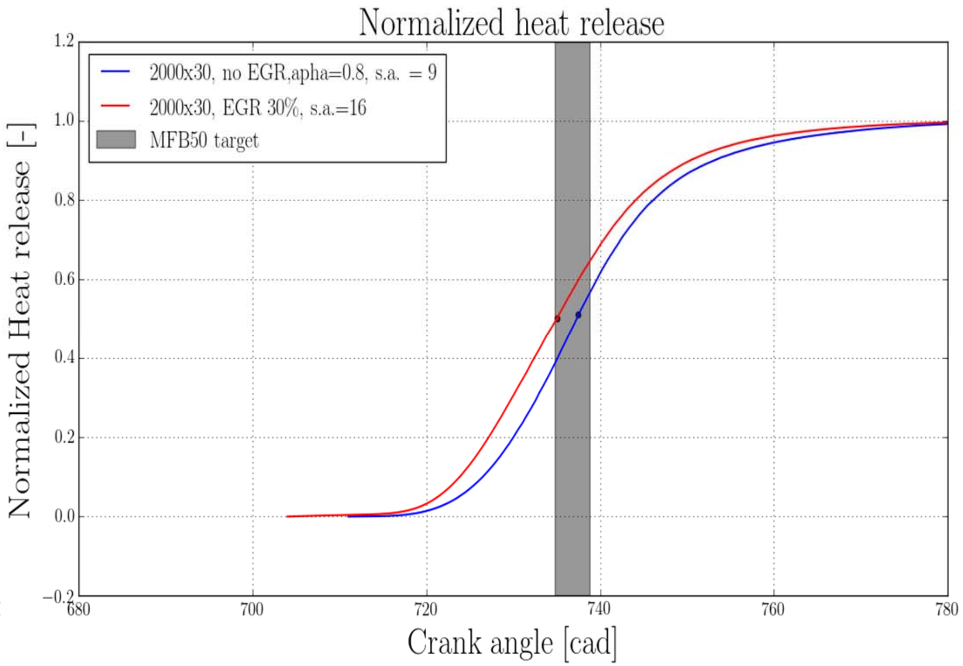
EGR sweep @2000x3



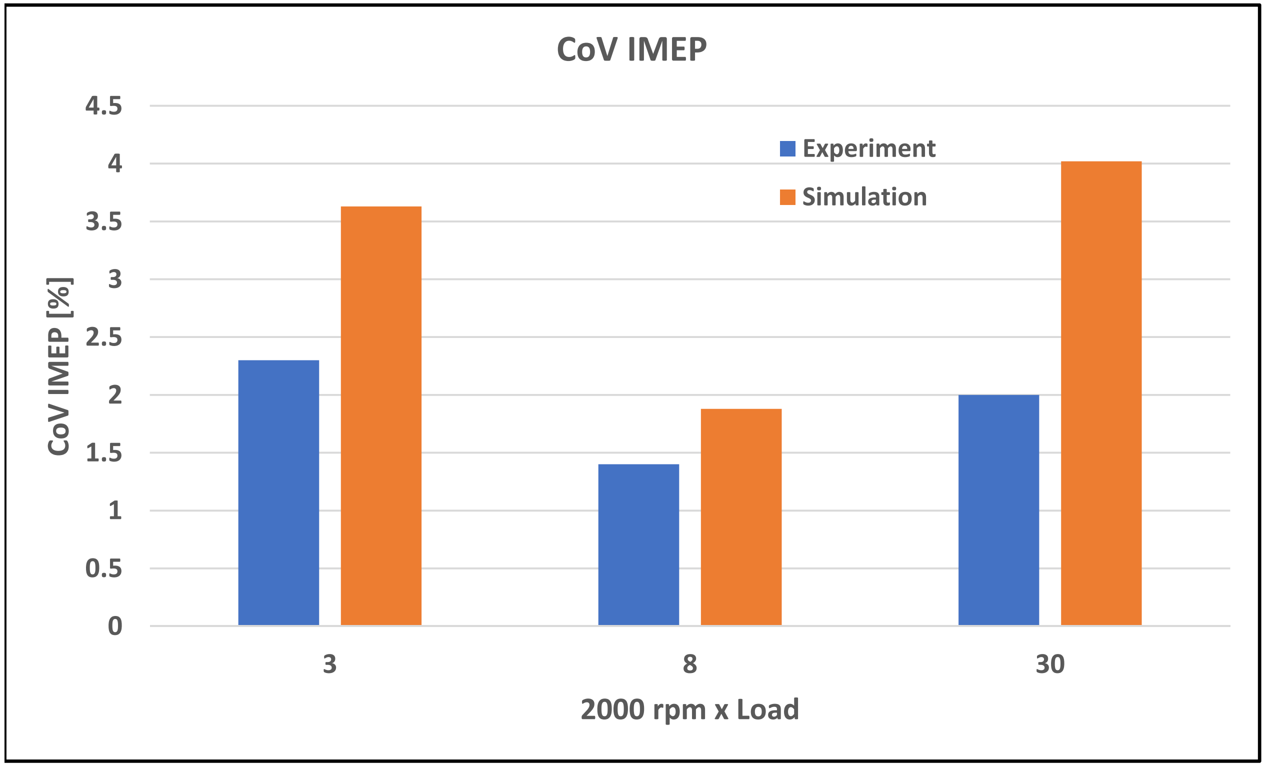


EGR sweep @2000x30



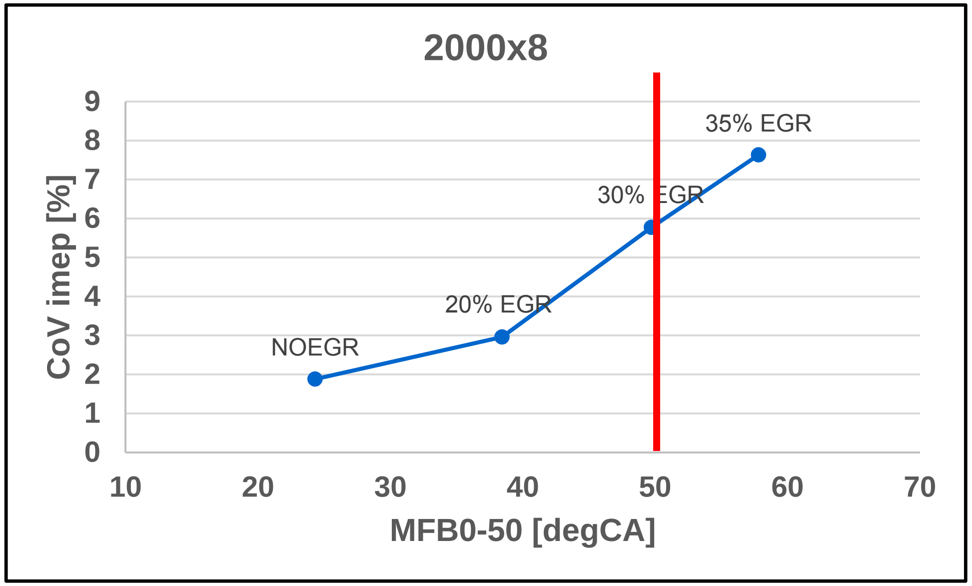


EGR sweep - cycle-to-cycle variations



- The simulated CoV is nearly twice the experimental one
- The trend is respected
- However, the quite low number of simulated cycles represents a limit for this analysis

Engine EGR tolerance



- The thorough analysis of results shows that the EGR limit is reached when the MFB0-50 gets higher than 50 deg.
- This also corresponds to an increase in the CoV imep up to 3-4 times the original value
- The exception is at full load where the CoV imep is mainly driven by the retarded ST and is nearly constant.

Thank you!