Analysis of the potential of the Partially Premixed Combustion (PPC) concept in a HSDI CI 2-stroke engine using gasoline as fuel

Master MCIA (Motores de combustión Interna Alternativos)

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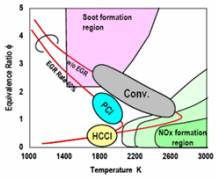
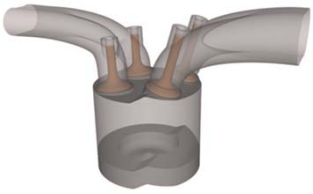
Introduction & objectives

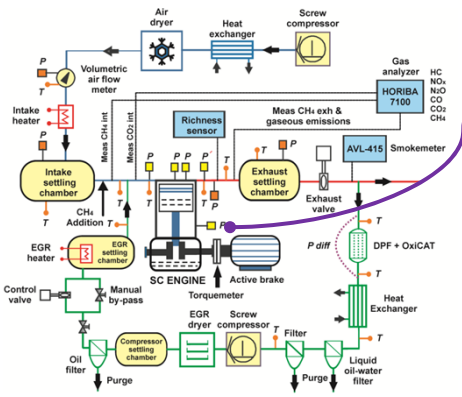


- Pollutant regulations are more exigent → necessity of new combustion processes to break the NO_x / soot trade-off keeping competitive fuel consumption
- Gasoline PPC concept allows low emissions while providing a good control over the combustion, and also keeping a high combustion efficiency
- The 2-stroke engine architecture is a promising alternative to extend the load range of the gasoline PPC concept toward the high and low loads



Methodology and Tools

Test bench configuration



POWERFUL Engine

Engine characteristics	
Engine type	Single cylinder, 2-Stroke, CI engine
Injection	Direct
Injector nozzle	148° - 8 holes - 90 µm
Distribution	4 valves, DOHC with VVT system
Bore x Stroke	76 mm x 80.5 mm
Displacement	365 cm^3
Compression ratio	17.6 : 1

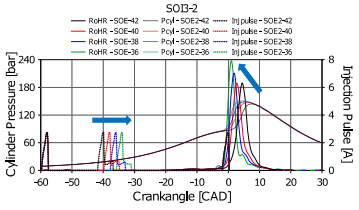
Main studies:

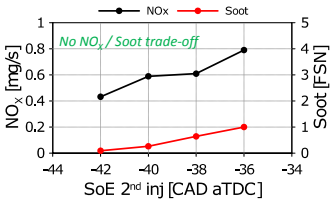
- Effects of injection timings over the combustion, and control of the combustion profile (RoHR shape) to control the emissions and noise levels
- Fuel consumption reduction through the optimization of the air management settings (Delta P, VVT…) and investigations to break the key trade-offs (NO_x / soot; noise / emissions / efficiencies…)
- Design of a new 2-Stroke long-stroke uniflow engine to improve the scavenge process and get better in-cylinder conditions for combustion development

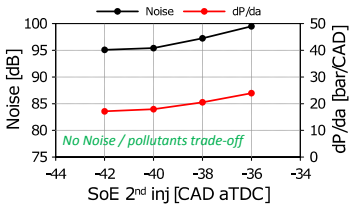
Models & Simulations

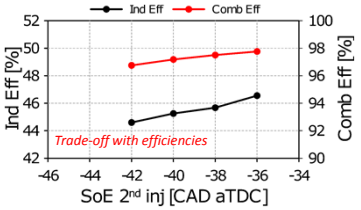
CONVERGE CFD SOFTWARE

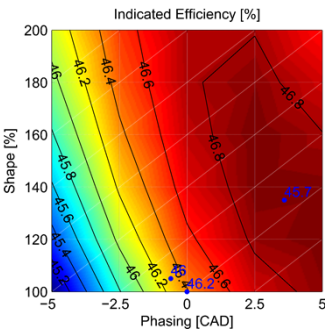
Results

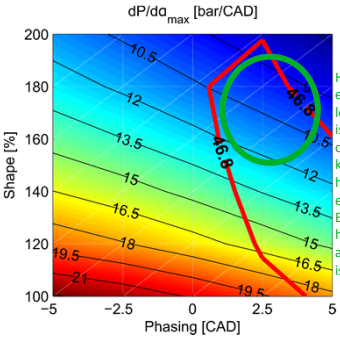






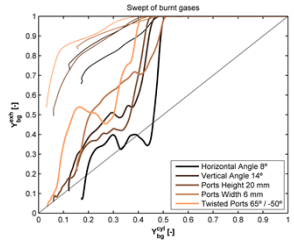


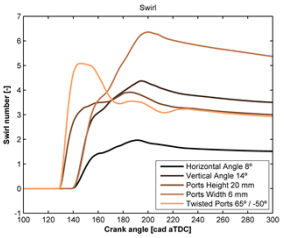




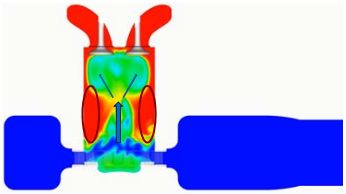
High ind eff and low noise is possible only keeping high comb eff → Engine hardware adaptation is critical

Improving the scavenge process: new engine design



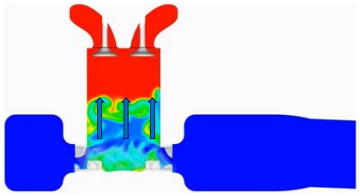


Straight ports, Horizontal angle 8°



- Fresh air flows to the center of the cylinder
- Burnt gas pockets get blocked → High IGR

Twisted ports, Top ang. 65°, Bottom ang. -50°



- Fresh air enters more slowly & uniformly
- "Pushes" the burnt gases evenly → Low IGR

	Trapping Ratio [%]	IGR Ratio [%]	Delivery Ratio [%]	Charging Coefficent [%]	TR @ 15 % of IGR [%]	TR @ 10 % of IGR [%]	IGR @ 95 % of TR [%]	IGR @ 90 % of TR [%]	Final Swirl ratio [-]
AngH8	66.4	17.3	146.9	97.6	-	-	44.1	39.9	1.5
65_-50	55.0	3.3	212.8	116.9	87.5	84.3	28.2	20.8	2.9

Conclusions

- The gasoline PPC concept implemented in a 2-Stroke engine shows promising results in terms of pollutant emissions and efficiency.
- However, new trade-offs have been identified (particularly between indicated efficiency and noise), that can be theoretically solved by controlling the combustion profile → Improving the engine design to reach sustainable in-cylinder conditions.
- The uniflow scavenge design provides better scavenge performance & in-cylinder conditions for combustion development than the poppet valves design.

Future work

- The long-stroke uniflow scavenge engine design is still under investigation, firstly for understanding/optimizing the scavenging process and then for evaluating the potential of the gasoline PPC concept → The encouraging results provided by the gasoline PPC concept in the poppet valves engine design need to be reproduced.
- The knowledge gained from the research work performed along the POWERFUL project will help to design the next stage of the REWARD project.

Benajes, J, Martín, J, Novella, R, Thein, K (2016). Understanding the performance of the multiple injection gasoline partially premixed combustion concept implemented in a 2-Stroke high speed direct injection compression ignition engine. *Applied Energy*, *161*, 465-475