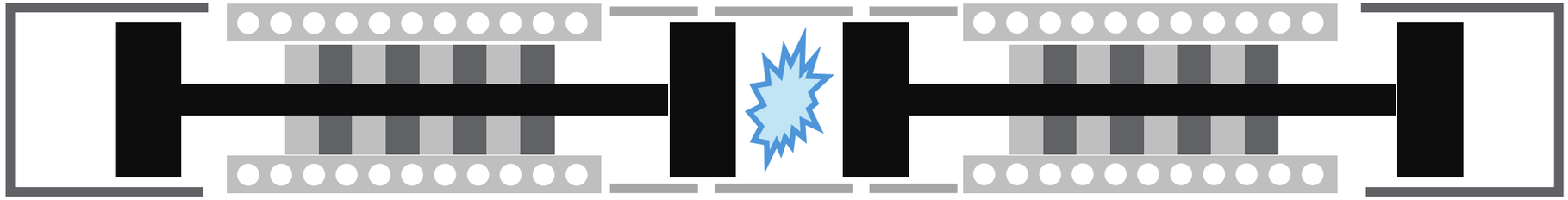
The Flex-Gen project

FPLG characterization and potential assessment via 1D modeling

Mirko Baratta – Politecnico di Torino

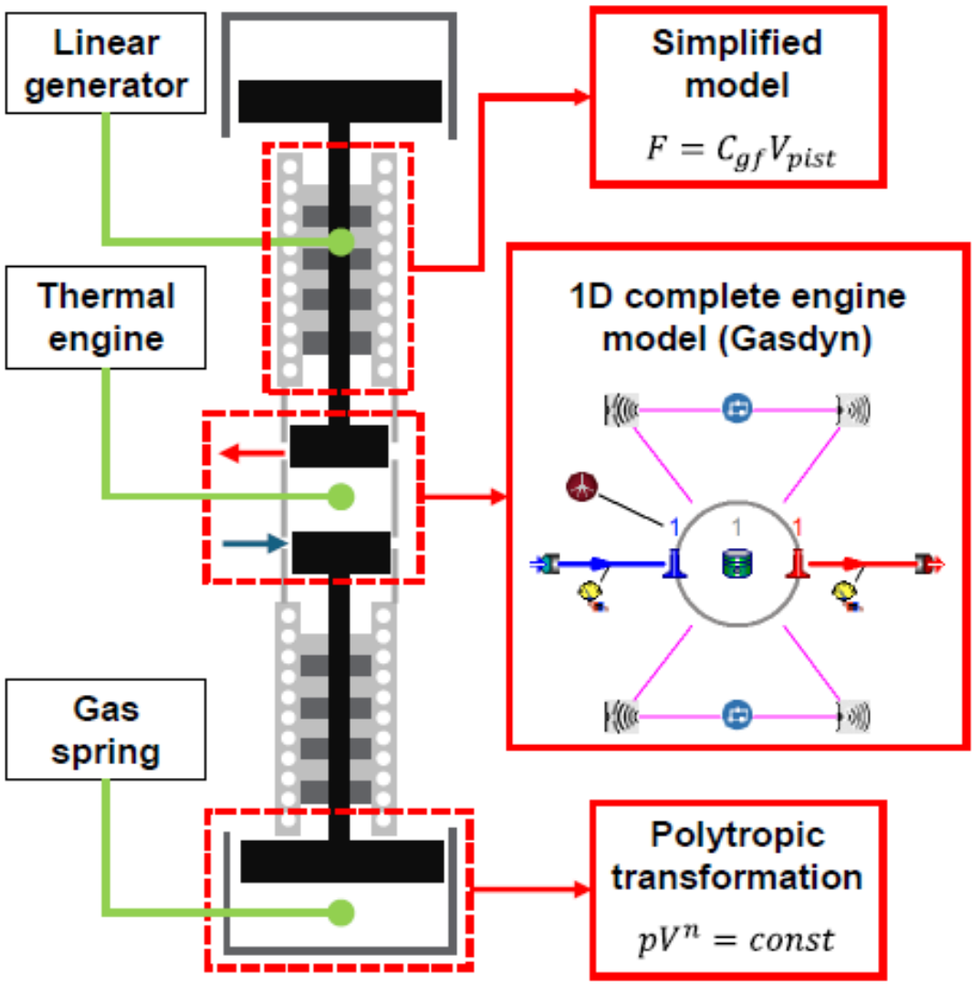


Acknowledgement

POLITO team

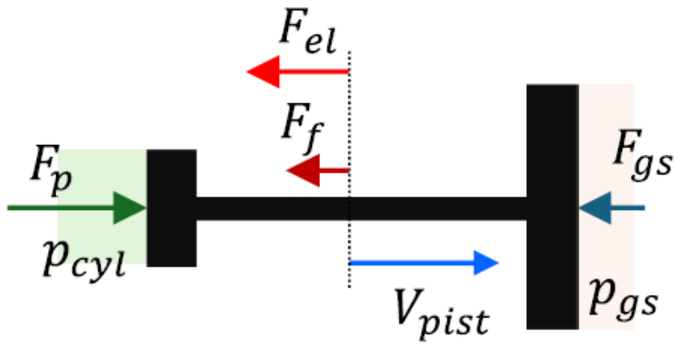
- Mirko Baratta
- Daniela Misul
- Alex Scopelliti
- Fabrizio Santonocito
- Antonella Accardo

The work

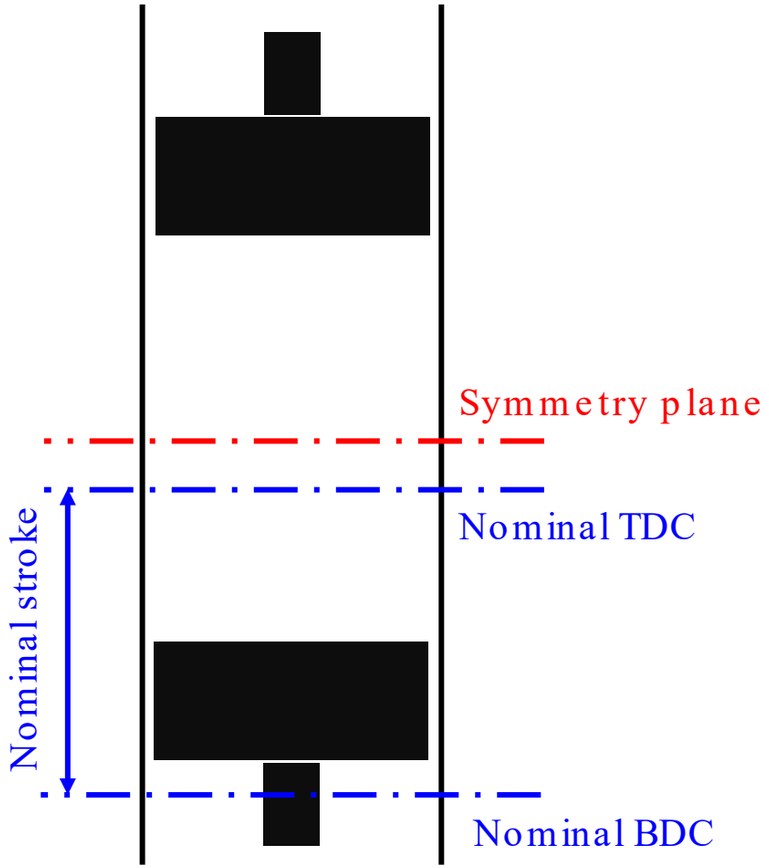


Integration of

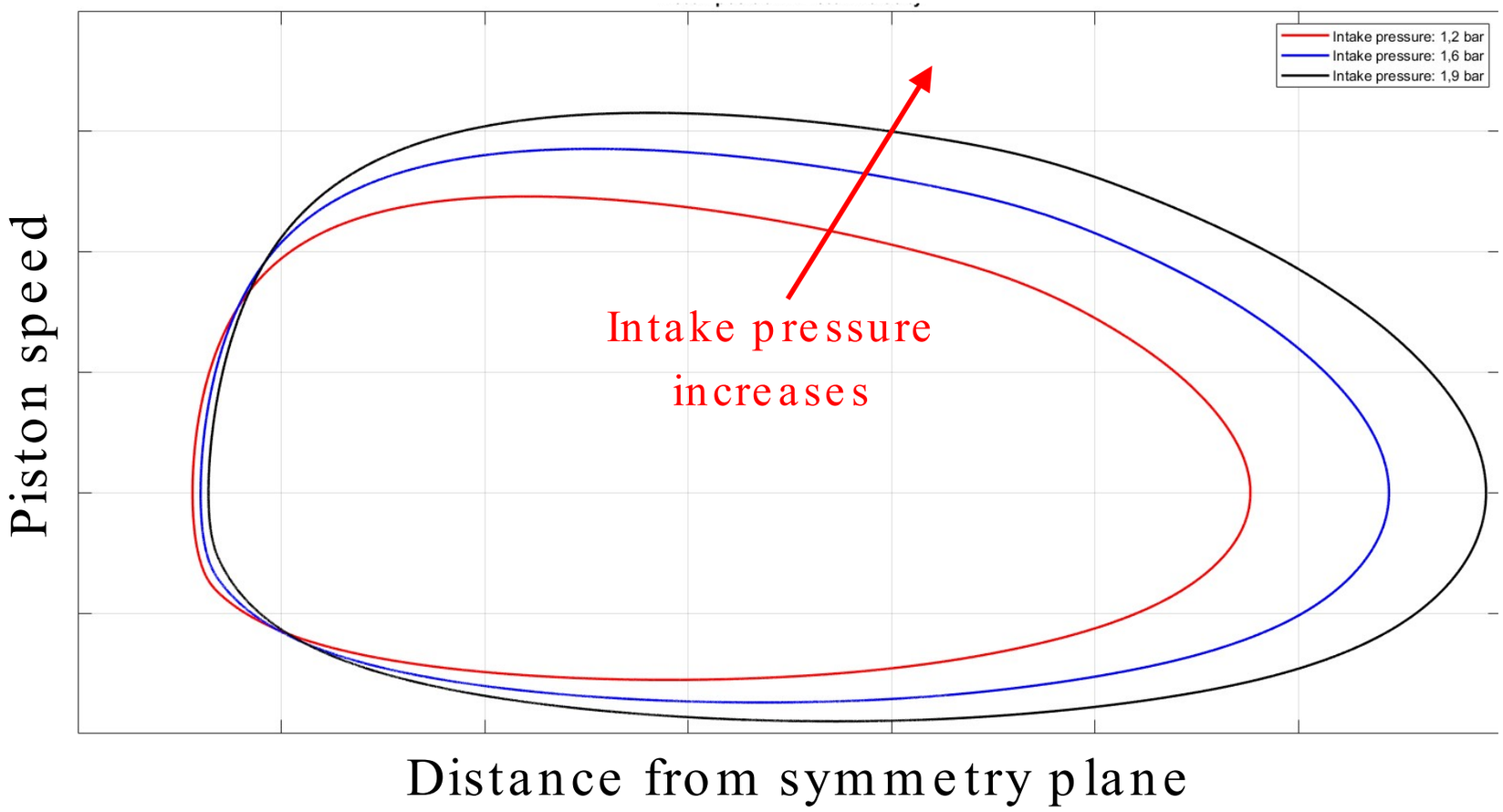
- 1-D modeling of intake/exhaust pipes and scavenging
- 0-D modeling of in-cylinder thermodynamics
- Piston dynamics



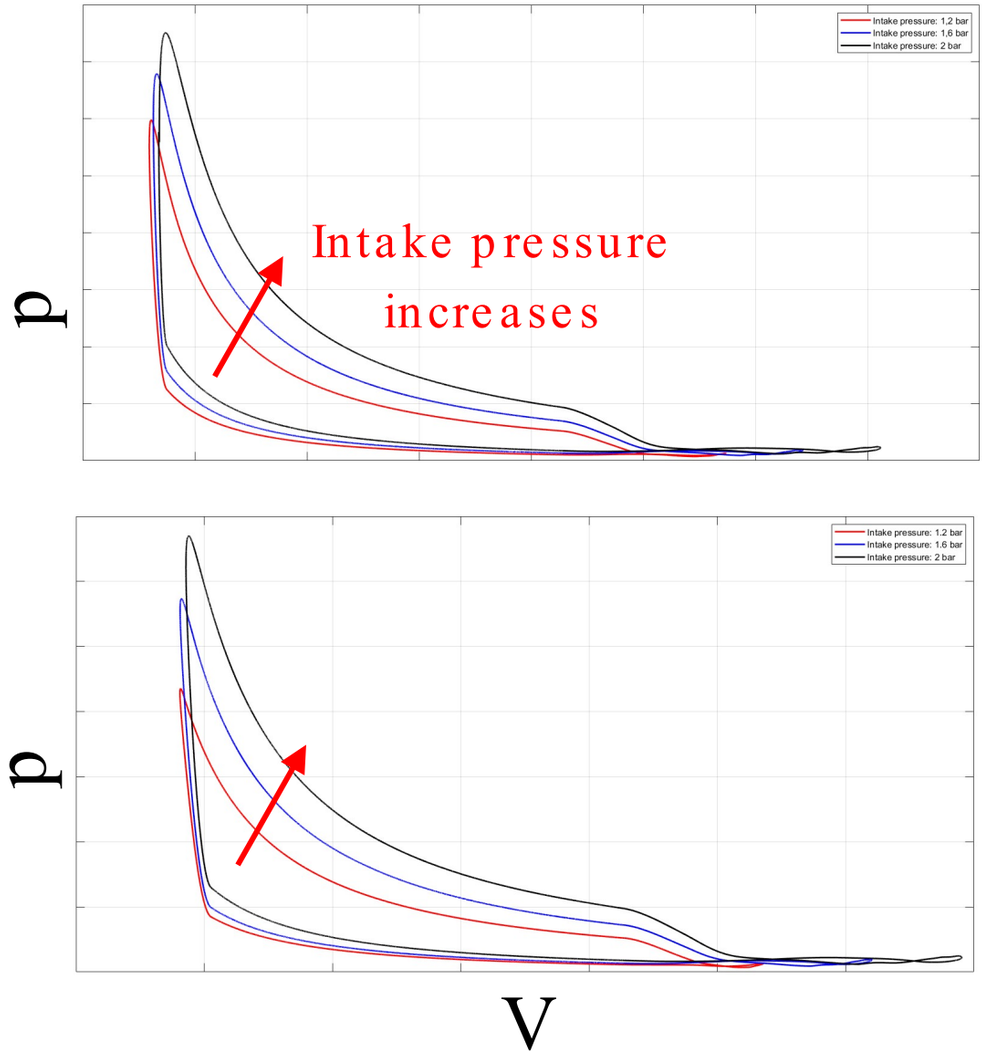
‘Free system’ behaviour



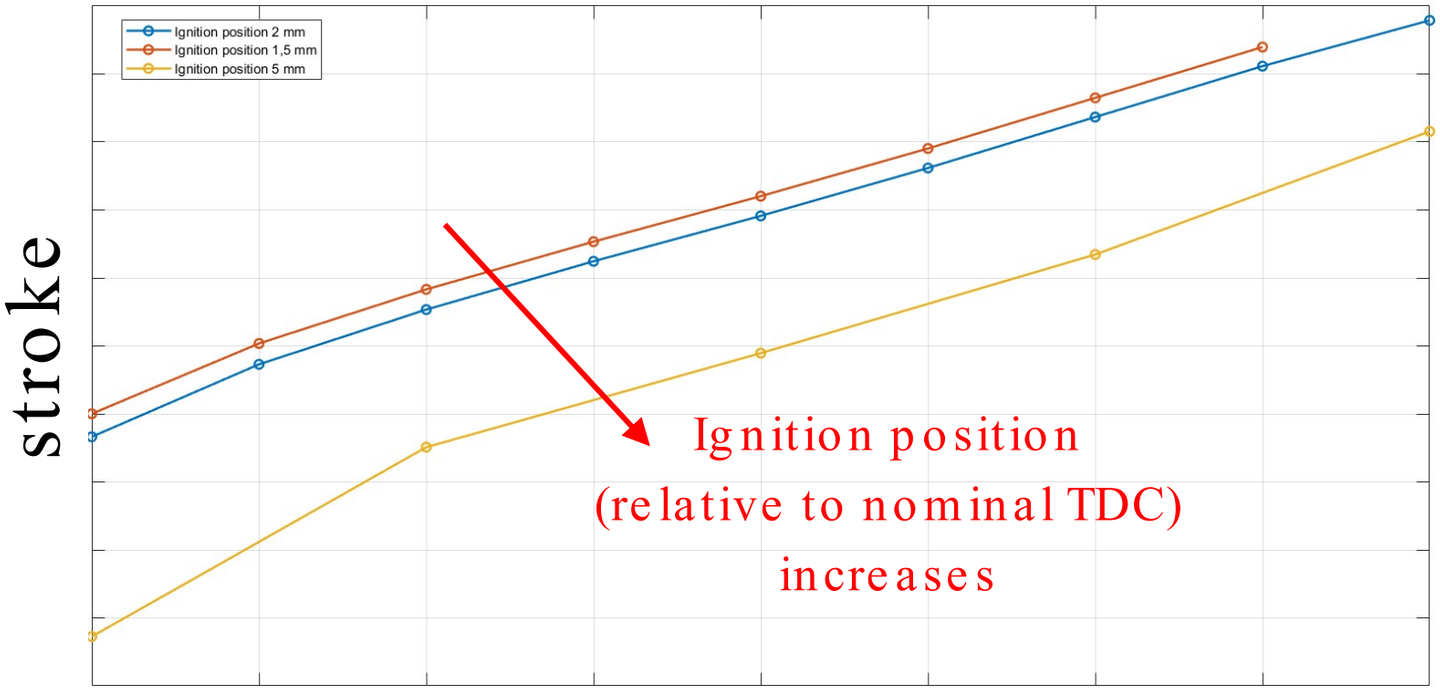
Effective TDC/BDC positions, stroke, CR, depend on operating variables!



‘Free system’ behaviour

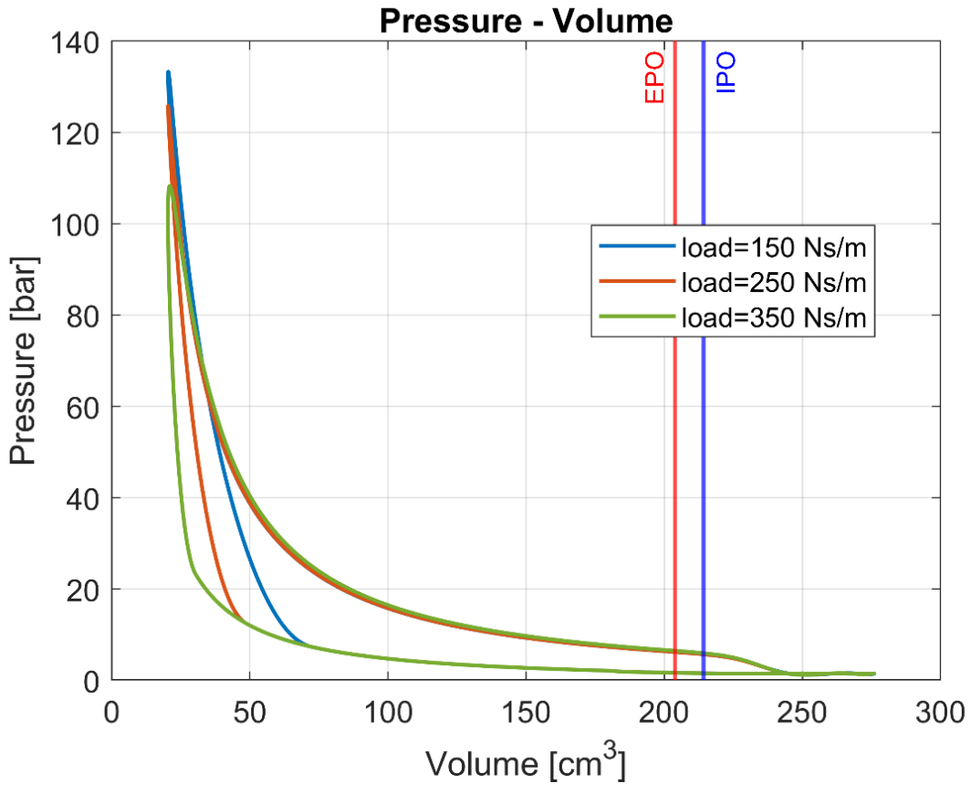


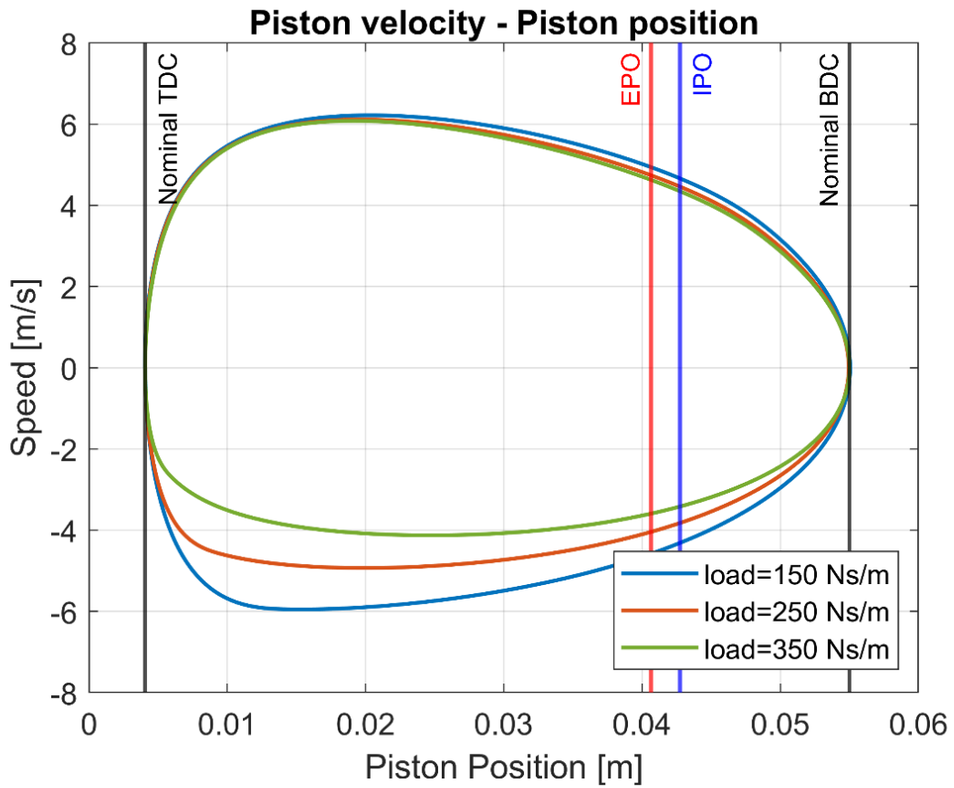
Effective TDC/BDC positions, stroke, CR, depend on operating variables!



FPLG + controller

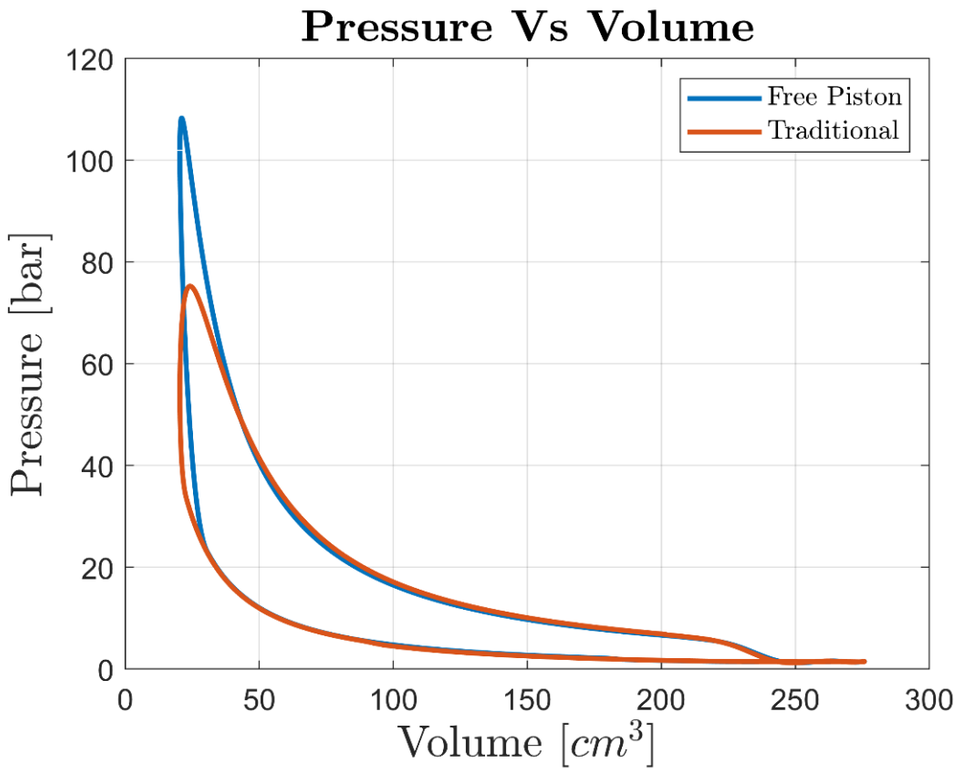
TDC and BDC positions controlled by acting on ignition position and gas spring pressure

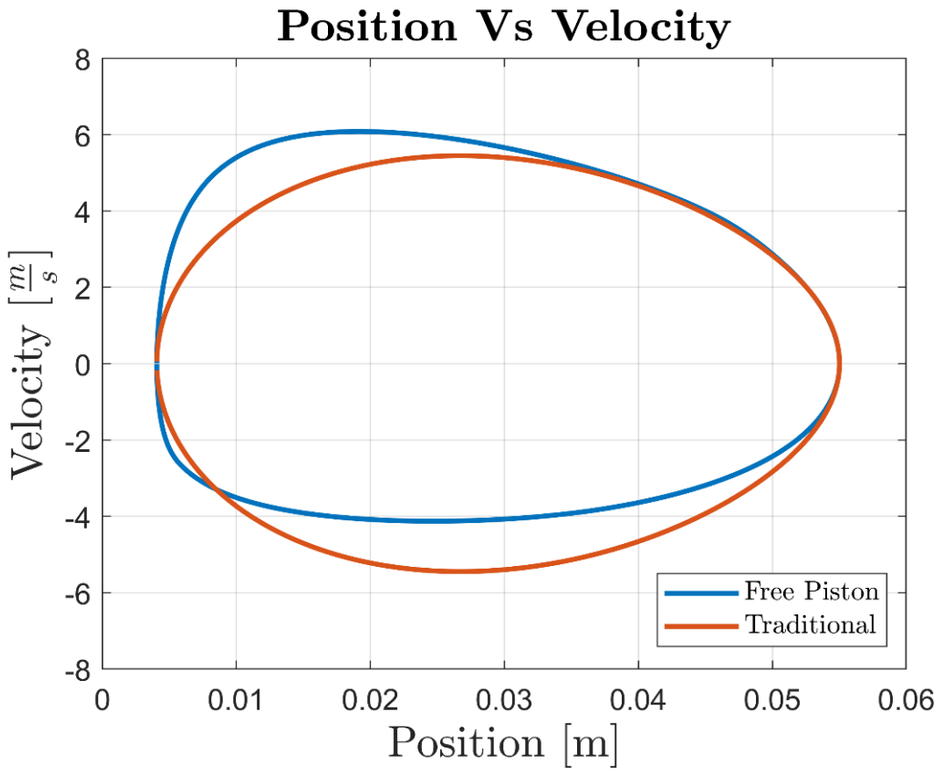




- Increase in the generating load coefficient improves efficiency

FPLG vs traditional SI engine

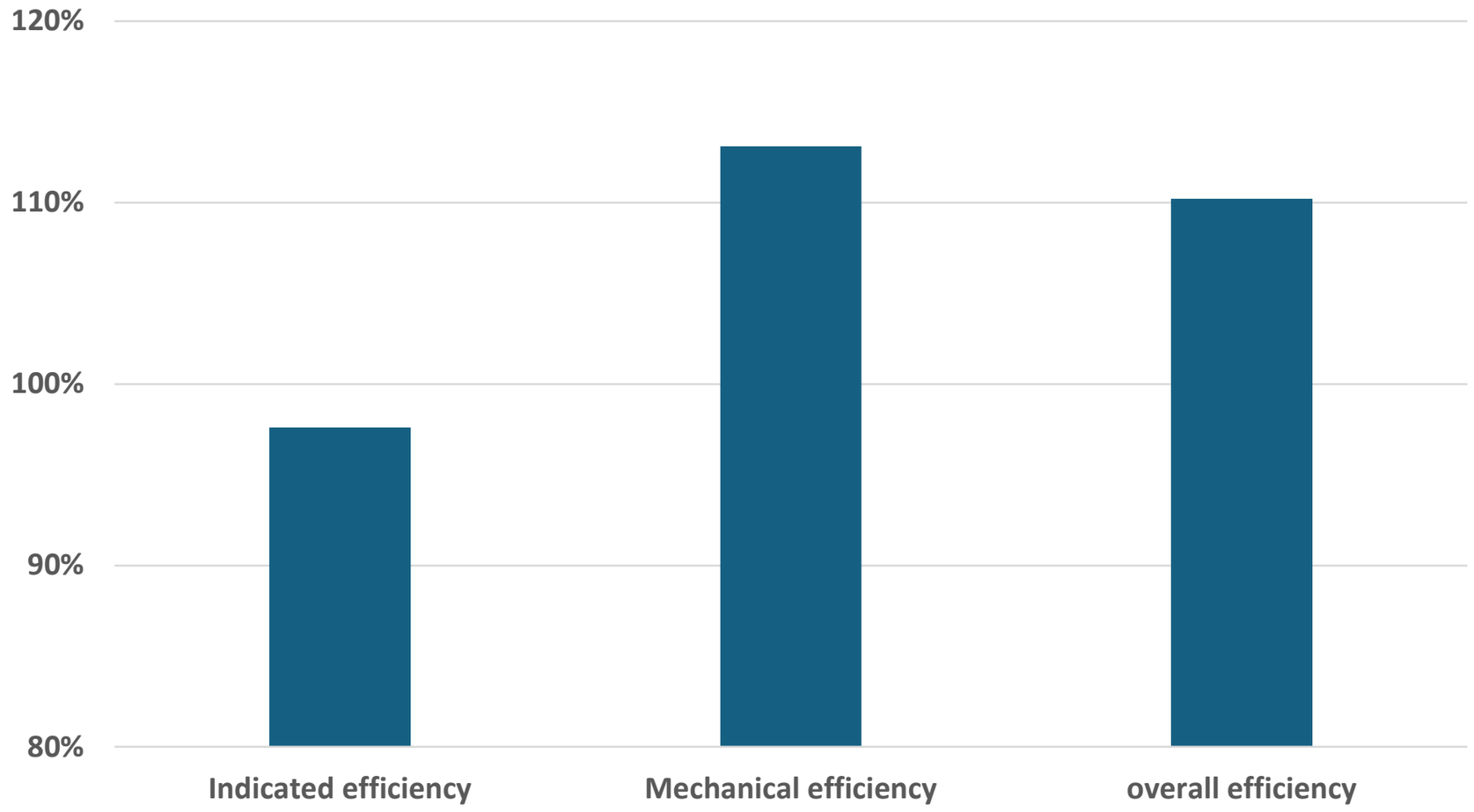




- Combustion timing:
  - Optimized for traditional engine (MBT)
  - Controls the engine CR for the free piston
- Faster expansion stroke in the FPLG, wrt compression

FPLG vs traditional SI engine

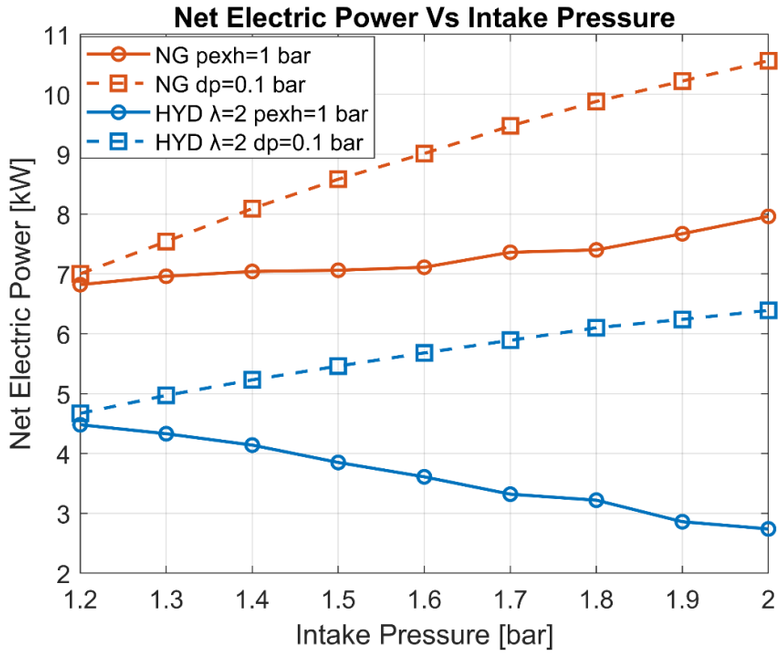
Efficiency comparison for NG fueling, $\lambda = 1$, CR=10

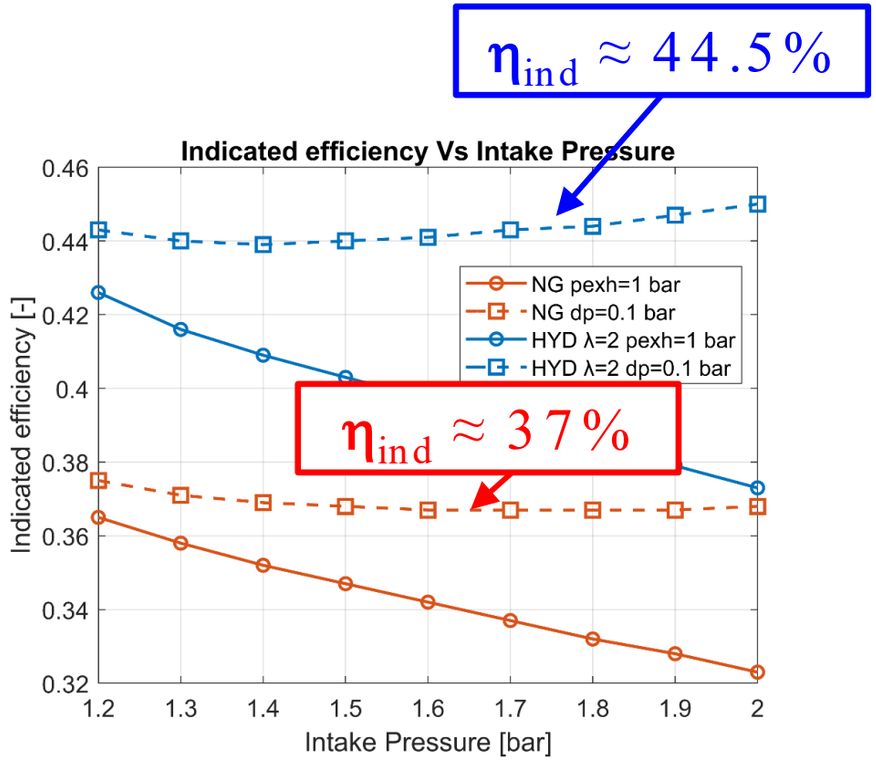


- FPLG indicated efficiency might be slightly lower, depending on combustion phasing
- Mechamical losses dramatically reduced (lack of forces normal to piston motion)

FPLG + controller

TDC and BDC positions controlled by acting on ignition position and gas spring pressure



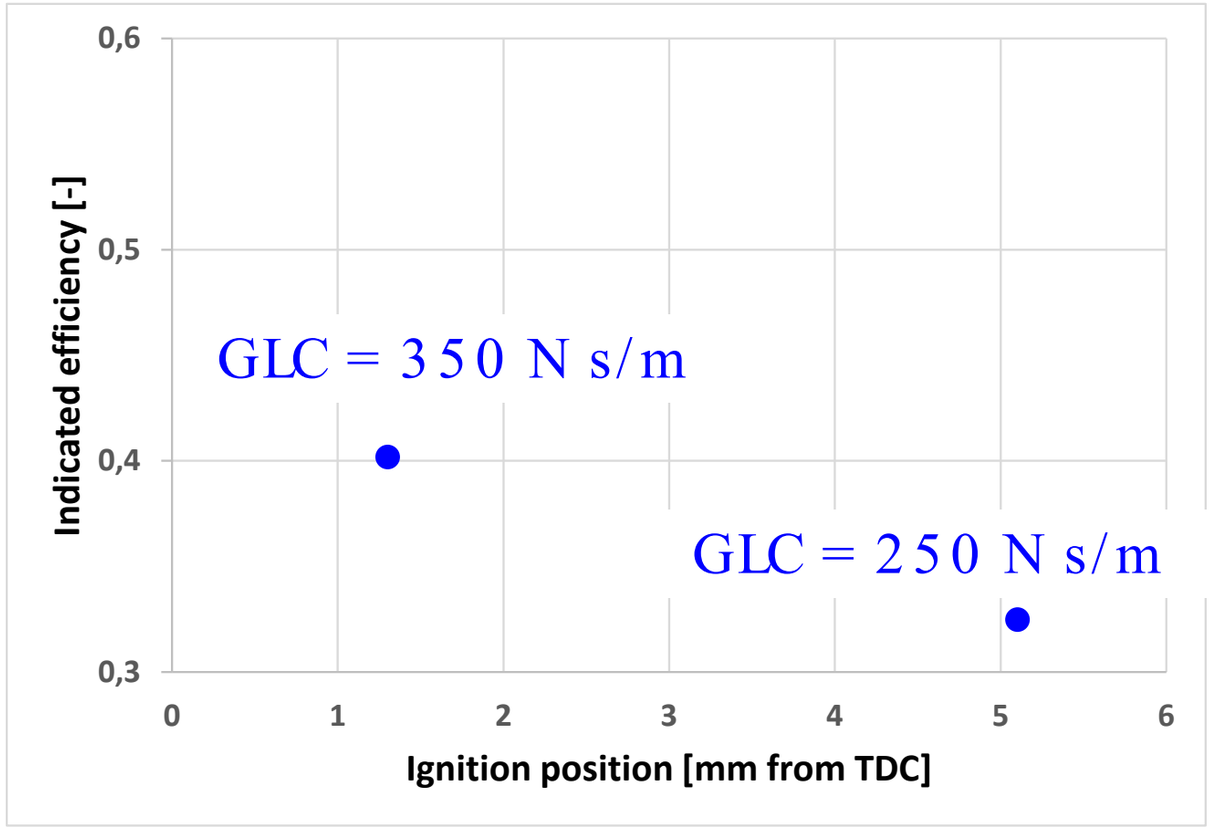


- Results for CR = 10
- GLC = 350 N s/m (NG, λ = 1), 250 N s/m (H2, λ = 2)

FPLG + controller

TDC and BDC positions controlled by acting on ignition position and gas spring pressure

Results for CR = 13 –NG - $\lambda = 1$

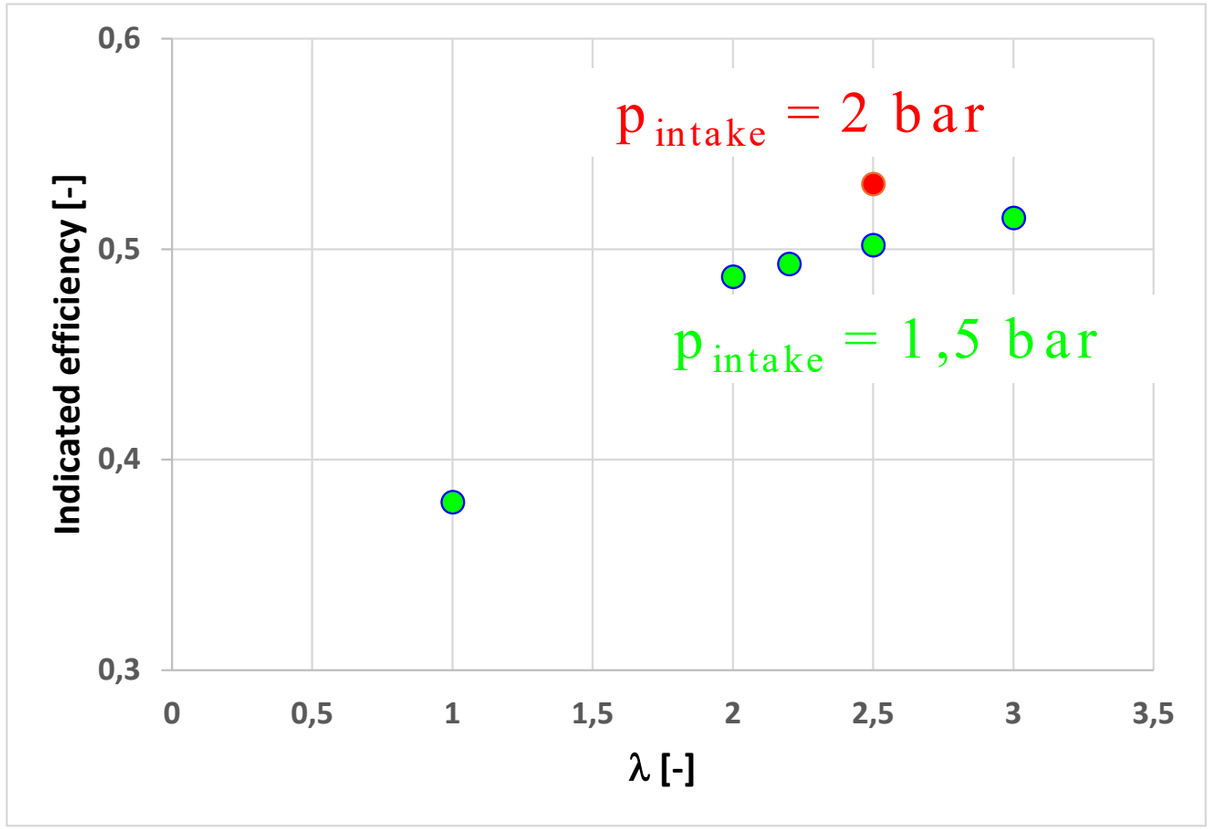


- Efficiency could be further increased by maximizing the load, so as to reduce the ignition position (optimal phasing)
- Lean mixtures also increase the efficiency due to reduced heat losses
- Higher PFP limits -> ground for CR increase for lean mixtures

FPLG + controller

TDC and BDC positions controlled by acting on ignition position and gas spring pressure

Results for CR = 13, H_2 fueling



- The efficiency is reported here for the maximum load at each lambda
- 53% of efficiency has been found for lambda = 2.5 and p_{intake} = 2 bar.

Conclusion and future perspectives

- The activity in the Flex-Gen project highlighted the peculiar behaviour of the FPLG concept
- Optimization process, workflow and independent variables had to be redefined
- The integrated dynamic/thermodynamic/gasdynamic approach represented a key factor within the new optimization process
- Further research work is necessary to consolidate and validate the approach -> prototype and experimental tests
- Lean combustion, HCCI or high-CR SI combustion represent the most promising technology ways for a very high efficiency

Thank you!

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