PROJECT 3: ADVANCED COMBUSTION SYSTEMS USING DIESEL AND NATURAL GAS BLENDS FOR INTERNAL COMBUSTION ENGINES APPLICATIONS MINIMIZING METHANE SLIP

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Research Centre for Gas Innovation

cleaner energy for a sustainable future

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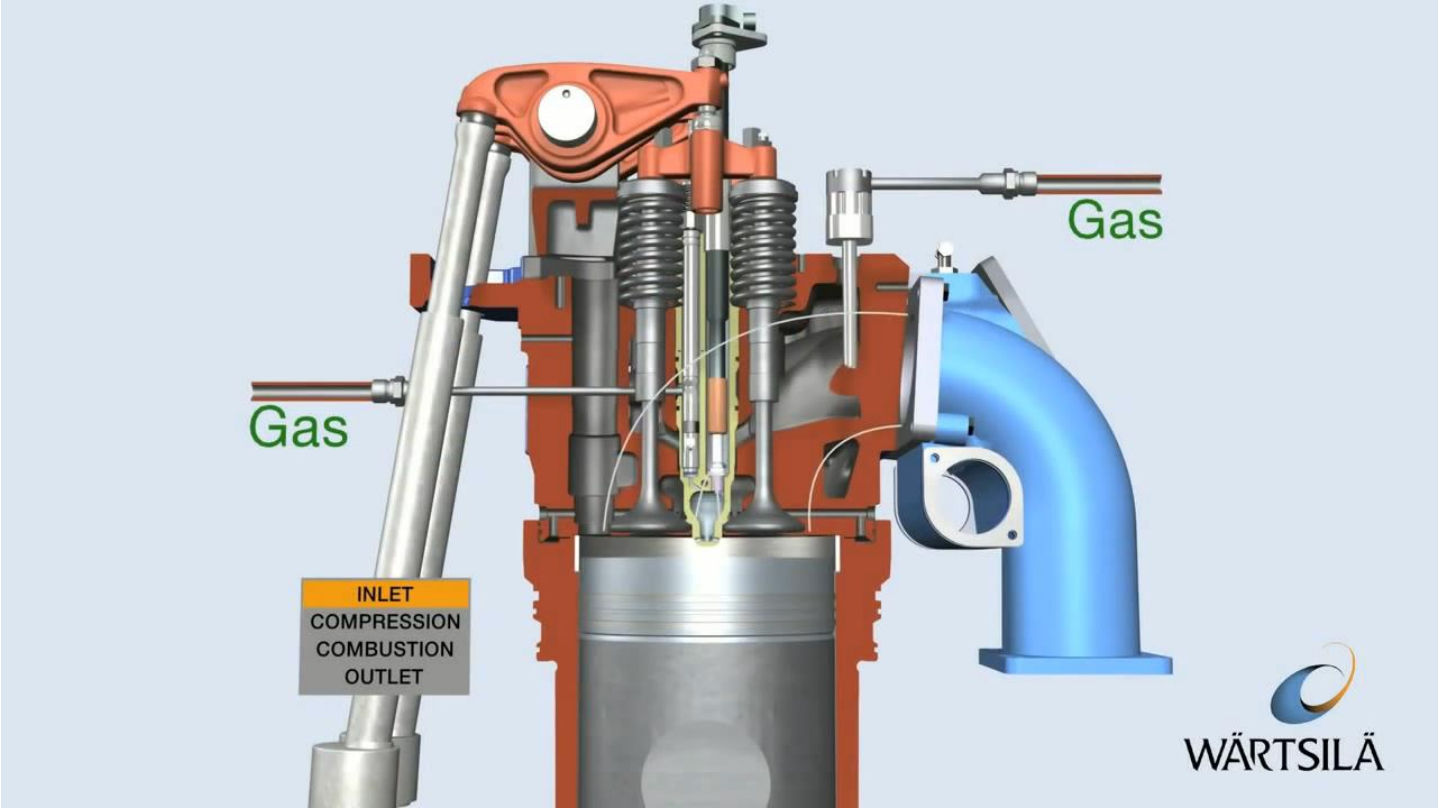
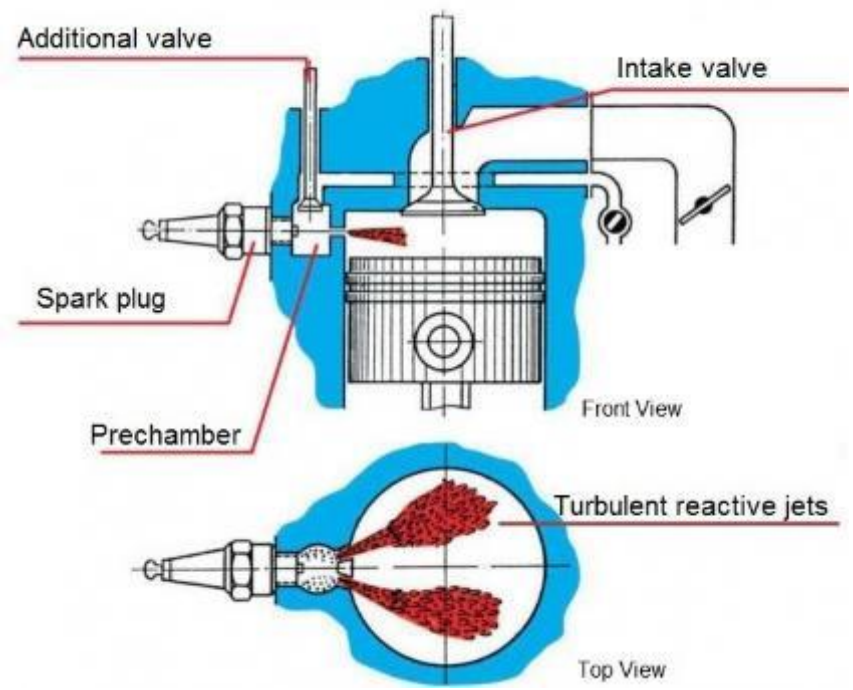
Motivation: Methane Slip

- Emissions of methane that was not burned in the engine and escapes into the atmosphere.

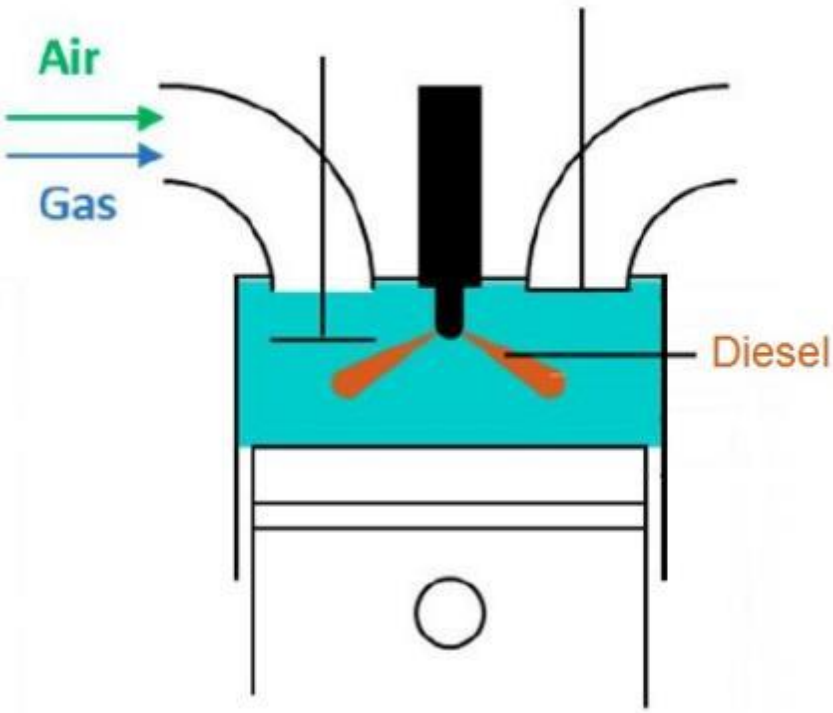


Options to Minimize Methane Slip

Prechamber (CH_4 only)

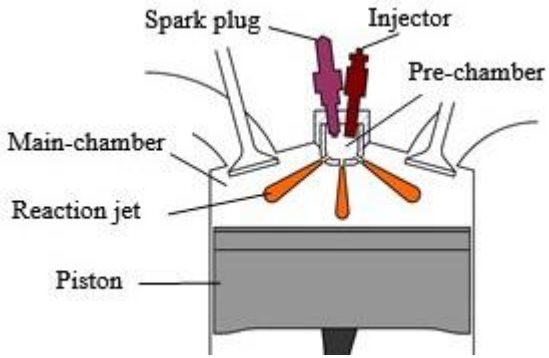


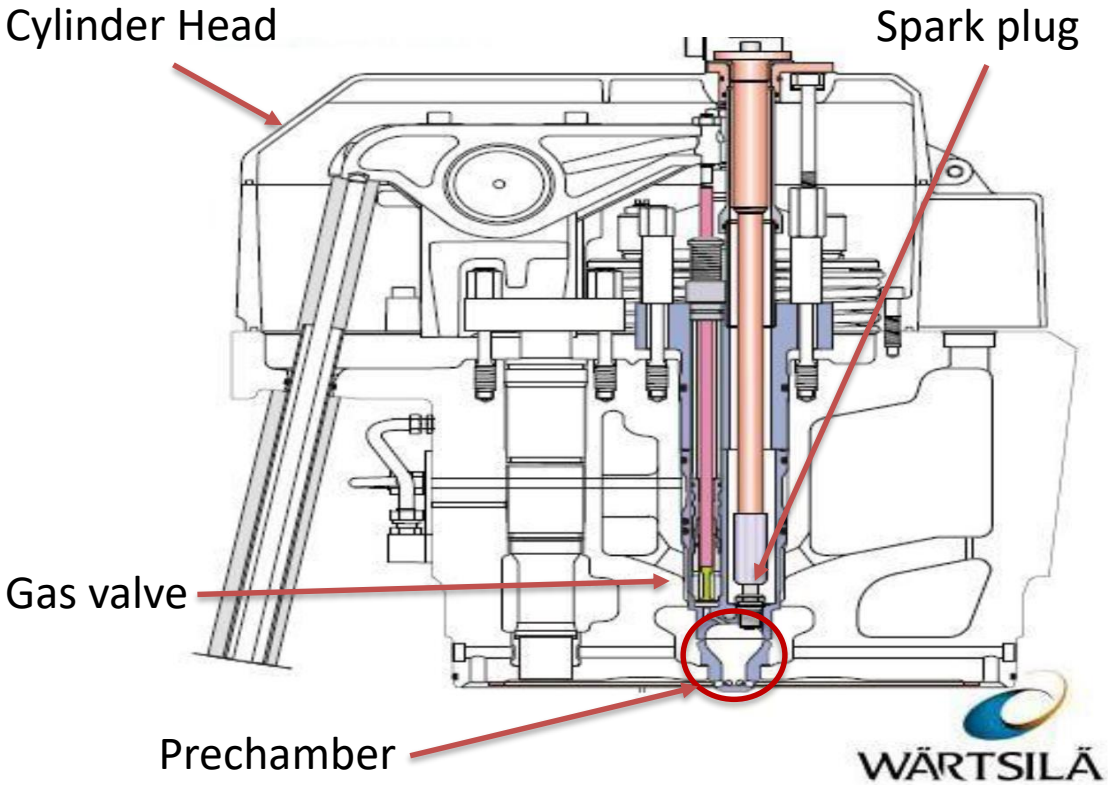
Diesel pilot fuel ignition



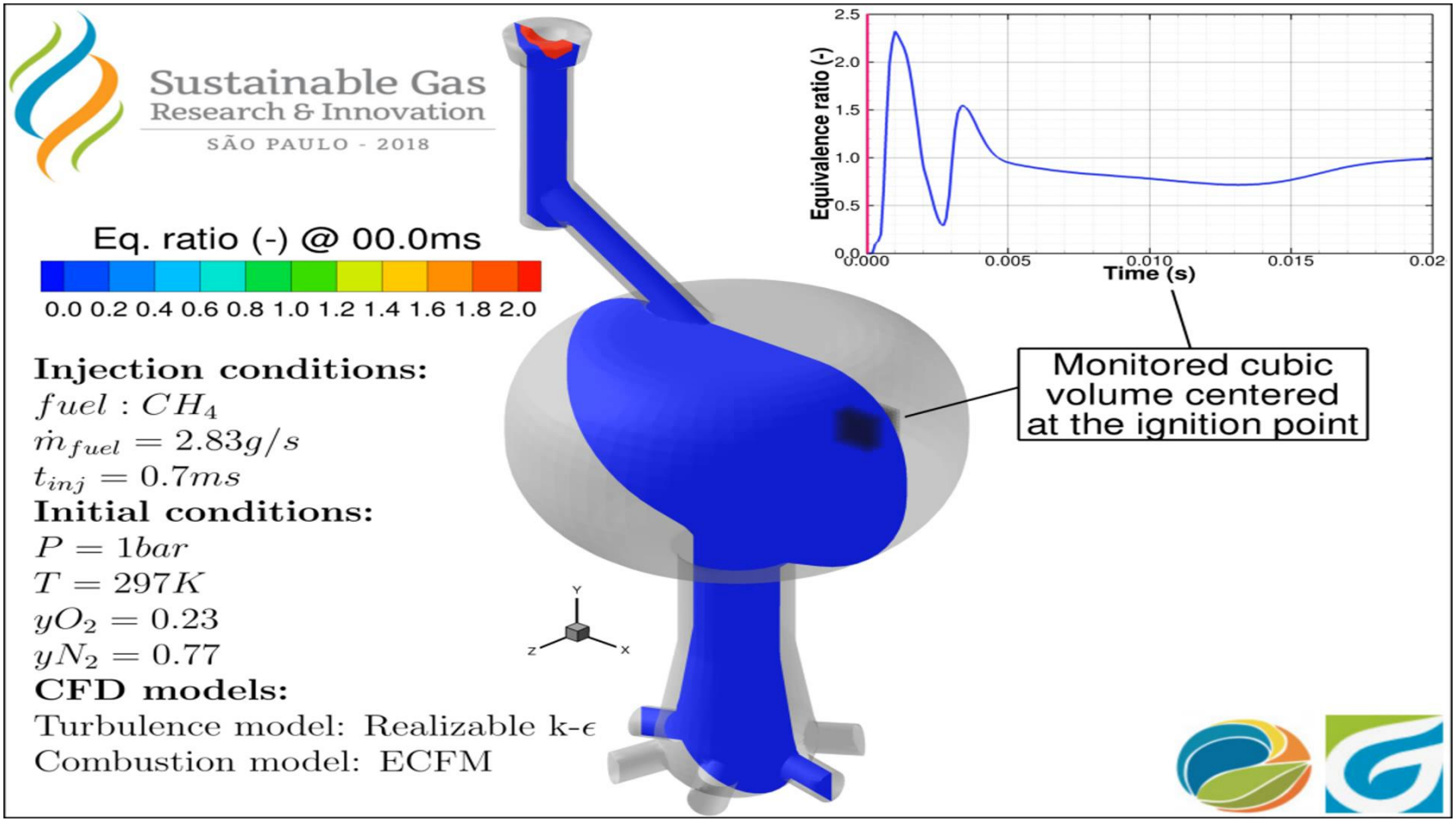
Prechamber

- Turbulent reactive jets leave the prechamber and ignites the natural gas in the main combustion chamber.





CFD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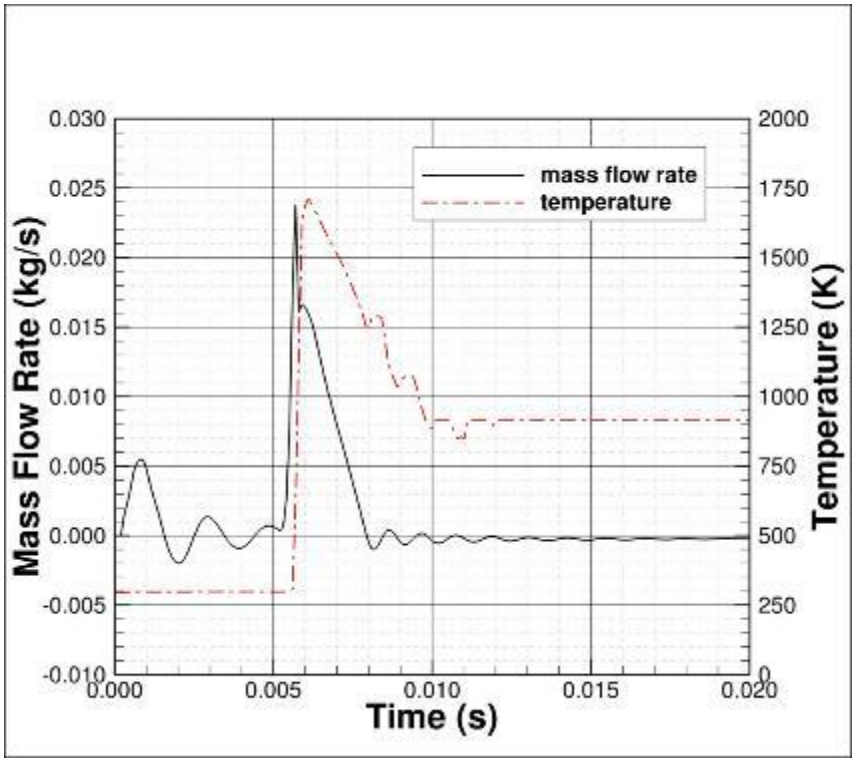
Eq. ratio (-) @ 00.0ms
0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0
Injection conditions:
$fuel : CH_4$
$\dot{m}_{fuel} = 2.83g/s$
$t_{inj} = 0.7ms$
Initial conditions:
$P = 1bar$
$T = 297K$
$yO_2 = 0.23$
$yN_2 = 0.77$
CFD models:
Turbulence model: Realizable k-ϵ
Combustion model: ECFM
Equivalence ratio (-)
Time (s)
0.0
0.5
1.0
1.5
2.0
2.5
0.000
0.005
0.010
0.015
0.02
Monitored cubic volume centered at the ignition point
Y
Z
X

CFD

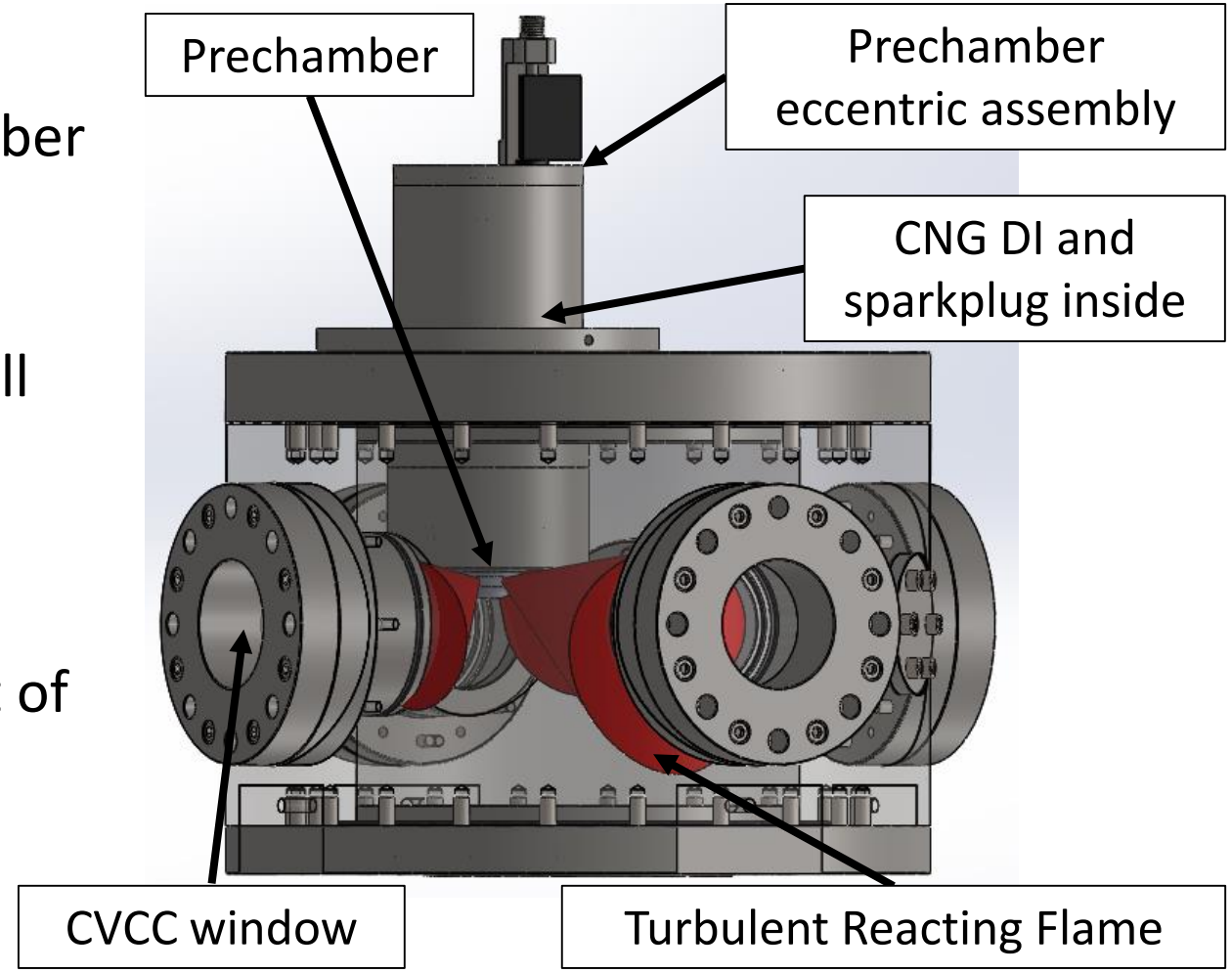
CFD answers:

- Injection time: 0.7 ms;
- Ignition time: 5 ms;
- Mass flow;
- Temperature.



Experimental Bench - Prechamber

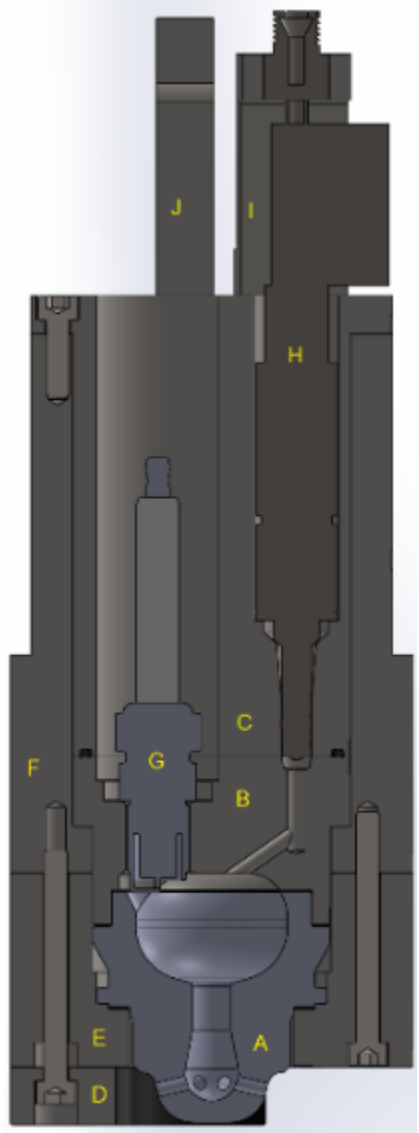
- Constant Volume Combustion Chamber (CVCC);
- Pressure vessel where the tests will be performed;
- CVCC and other experimental apparatus are part of Project 2.



Experimental Bench - Prechamber

- Experimental techniques:
  - Schlieren - flame shape to evaluate the turbulence;
  - Chemiluminescence for flame shape and radicals (OH*, CH*) – to evaluate the reactiveness;
  - Pressure measurements – Kistler sensors.

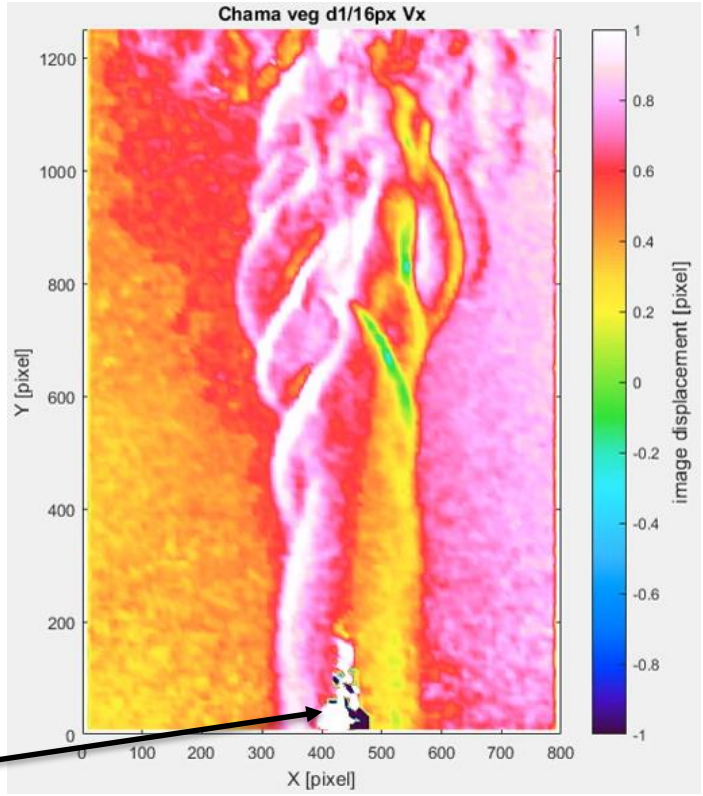
Prechamber assembly



Preliminary Test with BOS

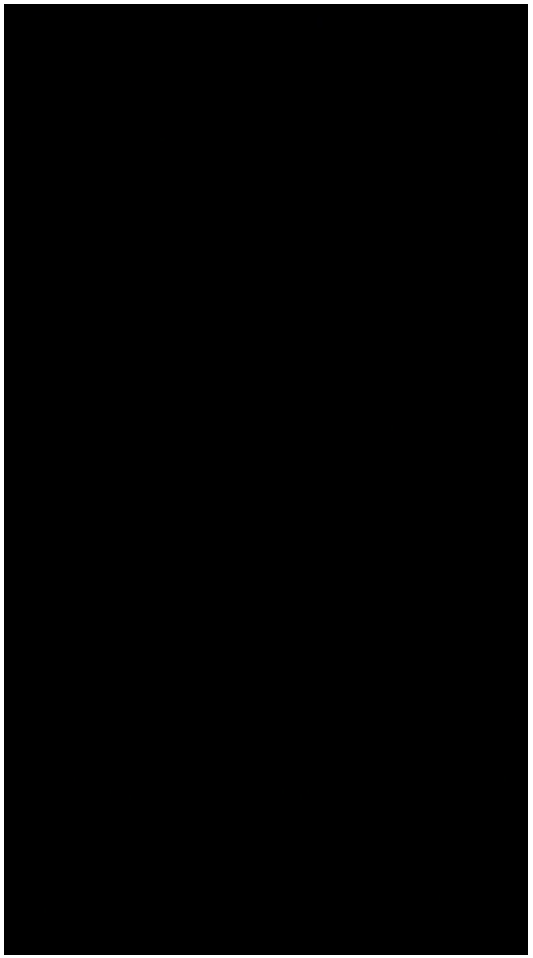
Background Oriented Schlieren (BOS) is a synthetic schlieren technique that do not require mirrors and can extract quantitative information about the fluid flow.

Yale flame



CVCC Previous Tests

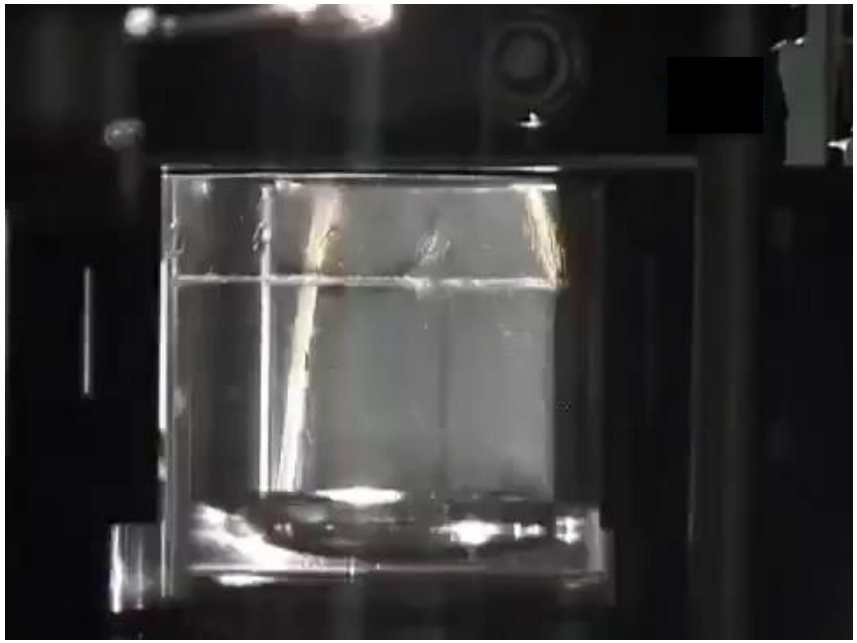
- CVCC pressure tests with ethanol and spark plug;
- Ethanol hollow cone injection;
- Two spark plugs.



Experimental Bench – Optical Engine

- Our Single Cylinder Research Engine (SCRE) is capable of running with diesel or diesel and natural gas;
- Preliminary tests were done in July at AVL (Austria);
- Commissioning: October 2018.

SCRE of University of Brighton



Bottom view

Frontal view

Future Work

Experimental

- August and September 2018: Tests with prechamber outside of CVCC;
- October 2018: Tests with prechamber inside CVCC;
- October and November 2018: Commissioning and first test of SCRE.

CFD

- LES simulation of mixture formation inside prechamber;
- Simulations of prechamber inside CVCC with different pressures.

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