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CHEMILUMINESCENCE AND IR IMAGING OF PRE-CHAMBER JET PENETRATION, IGNITION, AND COMBUSTION IN A HD-NG ENGINE

IEA CLEAN AND EFFICIENT COMBUSTION TCP
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MOTIVATION & OBJECTIVES

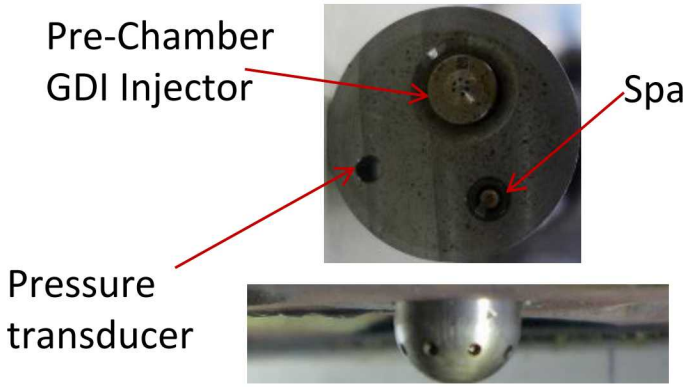
OBJECTIVES

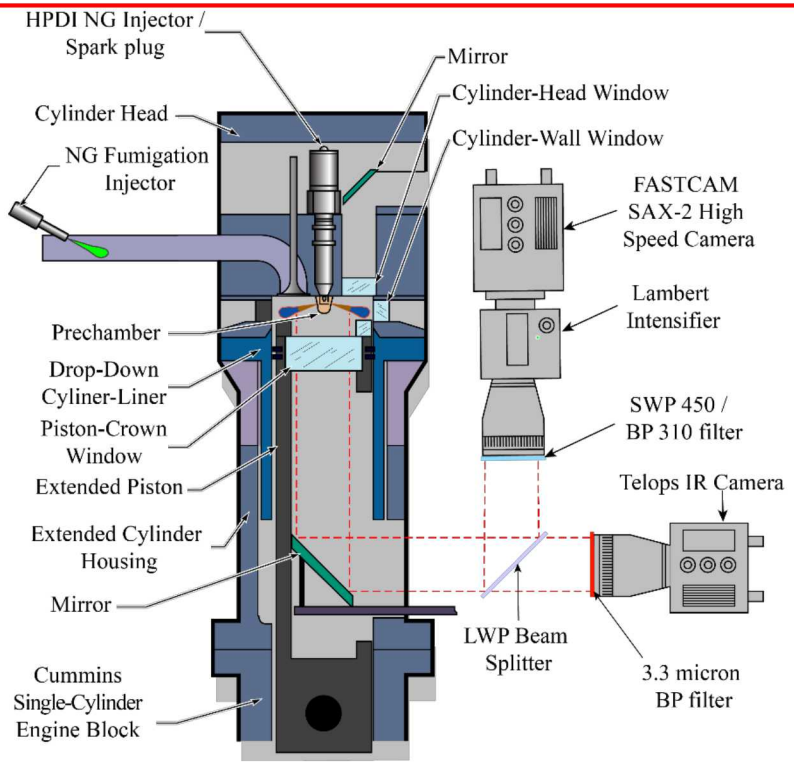
- Description of relevant events related to the pre-chamber gas ejection and premixed flame-front formation
- Evaluation of phenomena governing turbulent-jet ignition
  - Thermal conditions (i.e., hot jet emerging from pre-chamber)
  - Presence of chemically active species (e.g., radicals in pre-chamber jet)
  - Active combustion (i.e., flames emerging from pre-chamber)
- Development of conceptual models and validation of CFD code predictions
- Evaluation of IR visualization as a combustion diagnostic tool

EXPERIMENTAL FACILITY

SNL HD Optical Engine

- Engine/main-chamber geometry
  - TDC volume: 229 ml
- Pre-chamber geometry
  - Inner volume 4.67 ml (2%)
  - Number of holes: 8
  - Hole size: 1.6 mm
  - Included angle: 130°





- Diagnostics:
  - Pressure signal (both in main and pre-chamber)
  - High-speed OH*/broadband visible imaging
  - Low-speed IR imaging

OPERATING CONDITIONS

- Engine conditions
  - Speed 1200 rpm
  - Start of spark (SOS) = 343.0 CAD
  - Thermal conditions at SOS
    - P_{SOS} = 19.34 bar
    - T_{SOS} = 730 K
  - Constant injection pressure for both injectors
    - Pre-chamber: 100 bar
    - Fumigation: 7 bar
- Sweeps:
  - Constant dwell between pre-chamber end-of-injection and SOS

	λ_{main}	λ_{pre}
PRE-ONLY	∞ (air)	1.65 to 0.75
PASSIVE	1.5,1.65	1.5,1.65
ACTIVE	1.65 to 0.49 0.93	1.65 1.65 to 2.6

SAMPLE RESULTS

PRE-ONLY CASE

- Two observed regions:
  - Near-nozzle zone: Narrow chemically active jet (chemiluminescence)
  - Far-field: Wider gas jet, high temperature but absence of radicals
- IR imaging indicates spreading angle & penetration; more quantitative for non-reacting jets