Objectives of Work Package

WP Leaders: Dr. Johan Hult
Dr. Fridolin Unfug

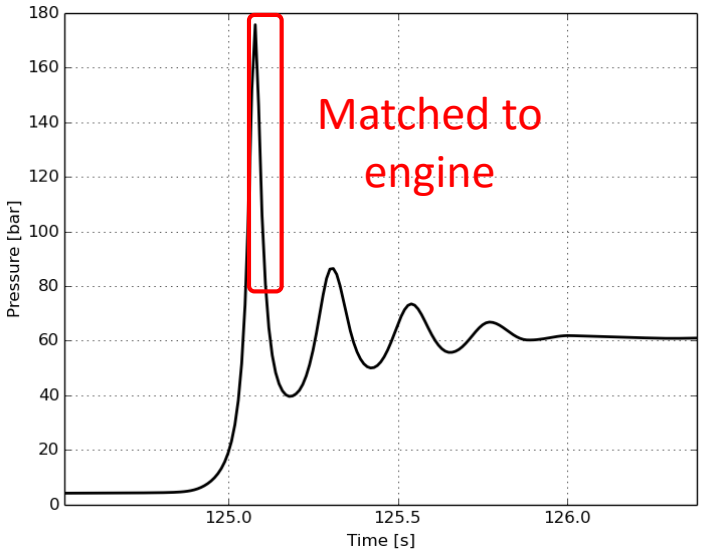
- Further improve fuel flexibility of marine engines
- Increase understanding of injection, ignition, combustion and emissions formation for novel and mixed fuels → efficient operation
- Develop experimental and numerical tools required to exploit alternative fuels in marine engines:
  - ➢ Experimental facilities with optical access
  - ➢ Development of numerical tools
  - ➢ Development of novel control strategies

Partners: MAN, Lund University, DTU, Technische Universität München

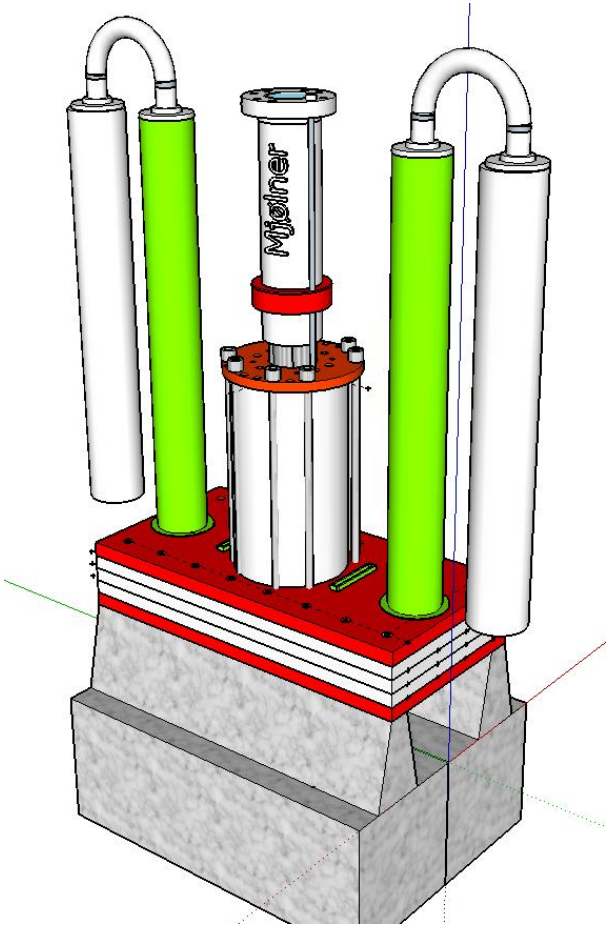
Progress update and results

2.1 Fuel-flexible test facility

- Concept evaluation → finished
- Design specifications → finished
- Building specifications → finished
- Detailed design work, purchasing & construction → reduced pace



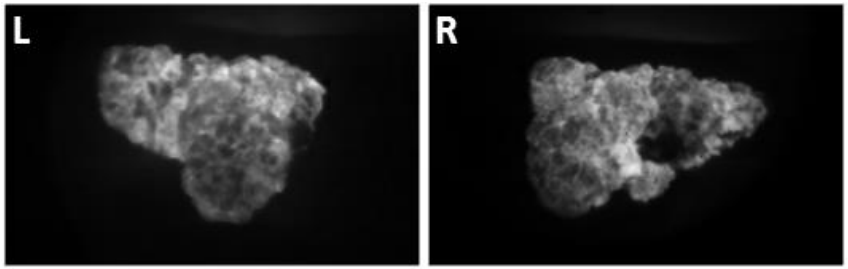
Simulated compression/expansion cycle



Proposed design for fuel-flexible test facility

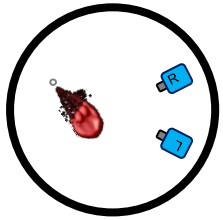
- Hydraulic drive
- Ø 500 mm
- Optical access
- Expansion
- P_{max}~200 bar

Progress update and results

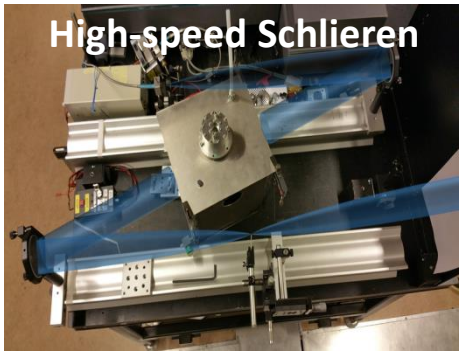


2.2 Injection and ignition characterization

- Ethane operation (2×HS) → finished
- Flame volume mapping NG (3×H) → Oct-Nov
- High-speed Schlieren imaging → prepared
- Seeding of lubrication oil → ongoing
- Improved engine optical access → ongoing

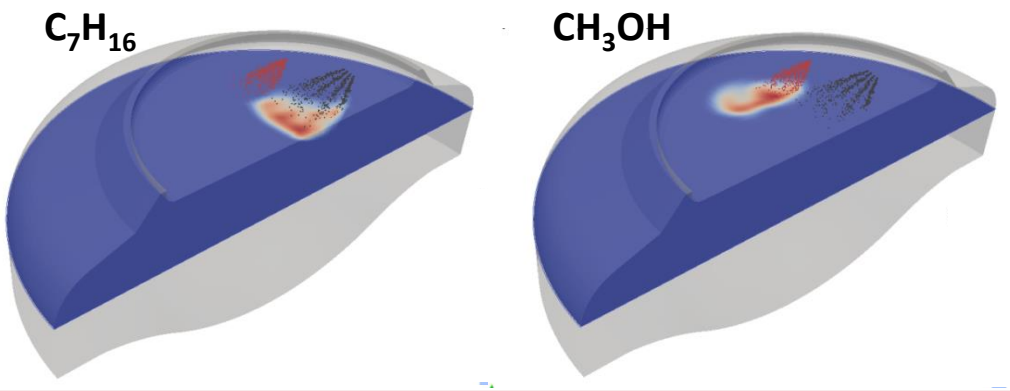


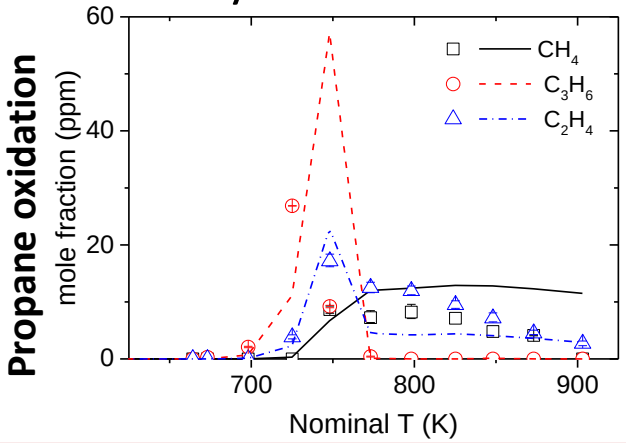
Ethane dual-camera test



2.3 Numerical studies of fuel and ignition

- Improved kinetic model for NG → finished
- Propane oxidation experiments → finished
- Model extended to propane → finished
- Tabulated chemistry for CFD → tested

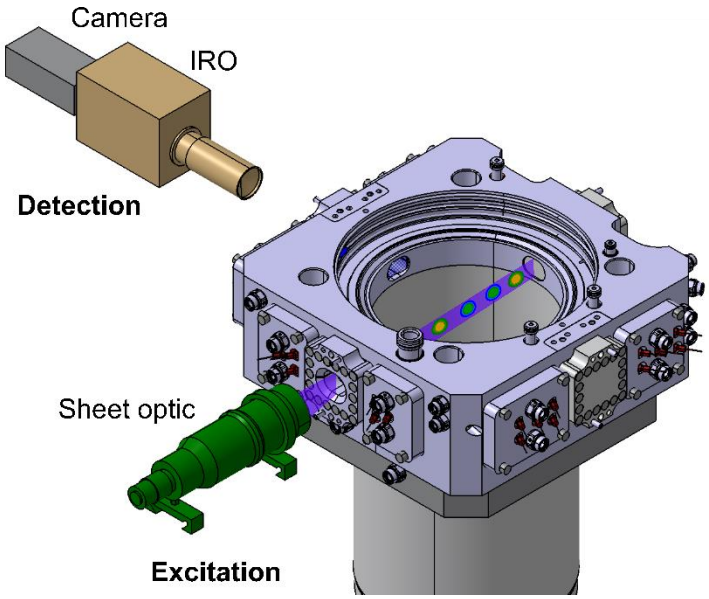




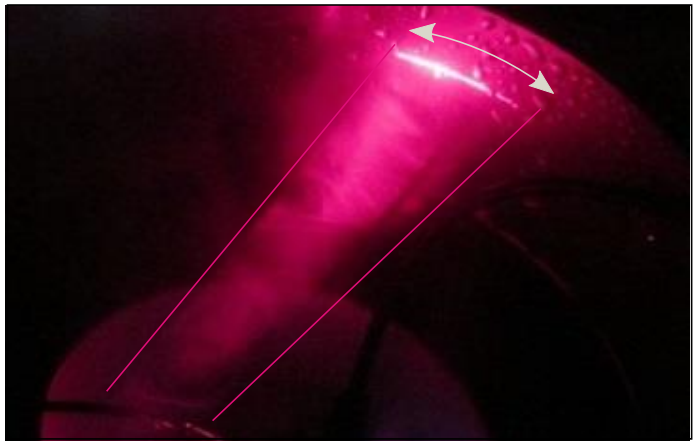
Progress update and results

2.4 In-cylinder mixture formation

- Lateral optical access design → finished
- Testing rig assembly → ongoing
- Design further optical access → ongoing
- Validation measurement technique → ongoing
- 3D CFD mixture formation → started



Design for measuring mixture distribution



Light-sheet test

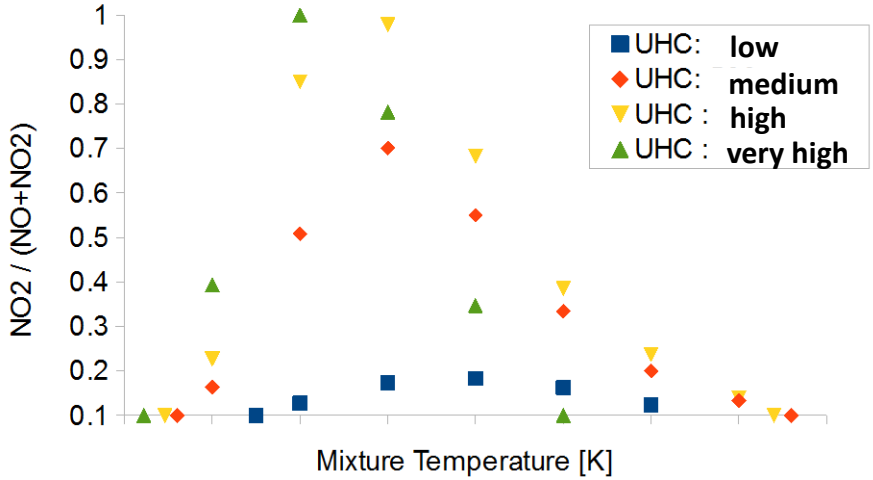
Progress update and results

2.5 Fuel-specific engine-control strategies

- First basic engine tests → finished 10/2015
- Single cylinder tests using advanced injection timings → 50% finished
- Preparation of spray chamber measurements for investigation of different fuels → finished
- Preparation of CFD model → finished

2.6 Low temperature NO_x formation

- Conversion of NO to NO2
- First calculations show promising results
- Thermodynamic conditions understood
- Modeling in CFD --> ongoing



Sensitivity Analysis of NO2 Formation Regarding Mixture Temperature and Unburned Fuel

Future work (2.1-2.3)

- Fuel-flexible test facility: design at reduced pace
- Optical engine tests: - *multi-camera flame mapping*
  - *high-speed Schlieren/shadowgraph*
  - *LPG*
- Design compact fuel-jet visualization units
- Lubrication oil seeding for imaging
- CFD: implementation of chemical mechanisms
- Detailed chemical kinetic model extended to butane (LPG)
- Experimental validation for butane
- Reduced mechanisms for ignition scenarios

Future work (2.4-2.6)

- Build up and test of 1st optic release of the optical engine
- Design and Procurement of 2nd optic release of the optical engine
- 1st test of optical measurement techniques at the optical engine
- Further improvement of optical measurement techniques
- Single cylinder engine tests with different fuels
- Spray Chamber measurements for investigation of fuels with different viscosity
- Validation of NO/NO_2 model with single cylinder engine data