WP1: Systems for increased fuel flexibility

Objectives / Expected results

WP Leader: Andreas Schmid
DWP leader: Kaj Portin

To develop **engines able to switch between fuels**, whilst operating in the most cost effective way and complying with the regulations in all sailing regions.

- Development of a fuel injection system for multi fuel purposes
- Demonstration of fuel flexible engine operation

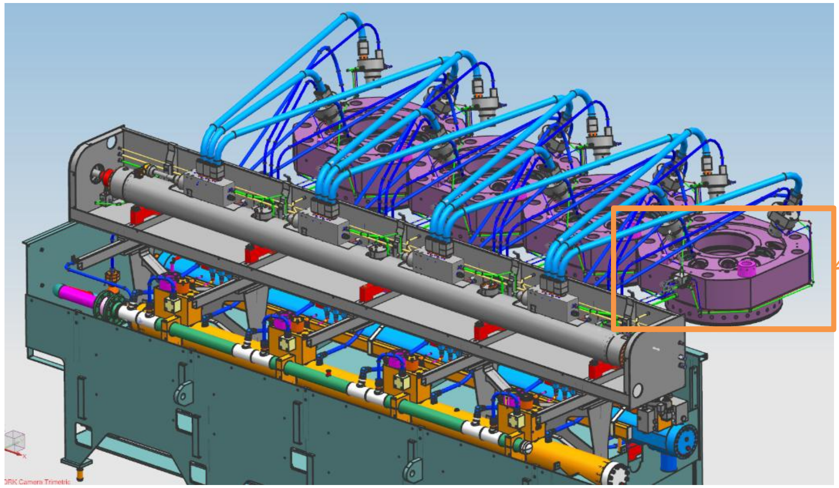
WP 1

1.1 Fuel flexible engine
Identify, design, manufacture, test, and validate systems for flexible engine operation

- 2-Stroke: Winterthur Gas & Diesel — Andreas Schmid
- 4-Stroke: Wärtsilä — Kaj Portin

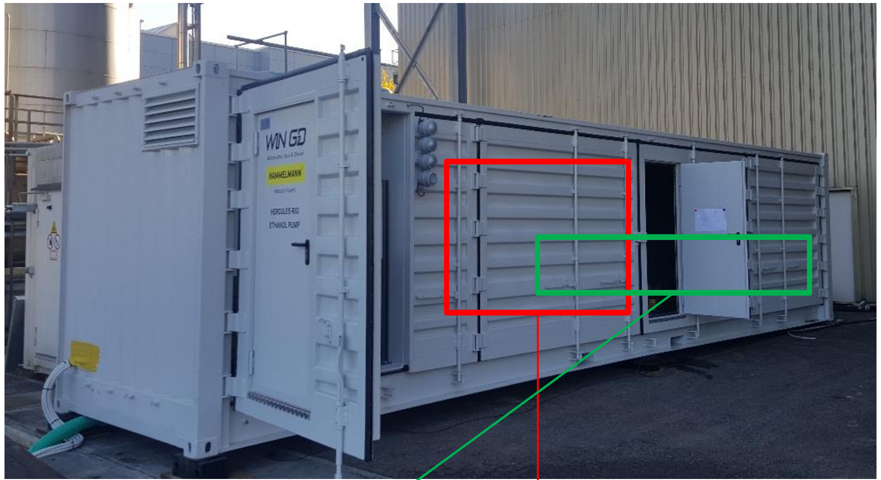
Results & Achievements of Past Period Month 25-32

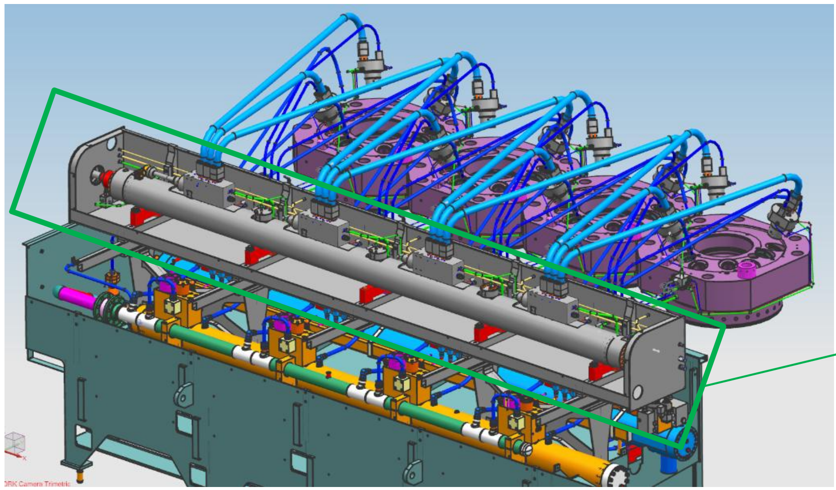
- External tank installed, fuel-fill station currently under construction
- Engine: Piston cover being machined and ready for new injectors.

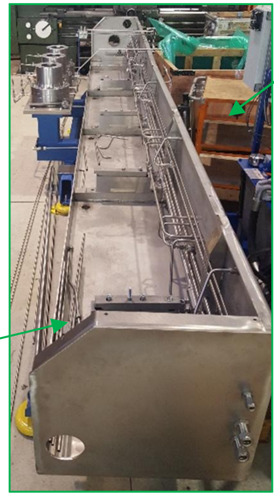


Results & Achievements of Past Period Month 25-32

- High pressure pump delivered and currently being connected
- The injectors are finished and tested at the partner's facilities (OMT, Turin).
- Rail finished, tested and ready to ship
- Rail unit box under construction







Future Work

- Commissioning of injector test rig (M31)
- Final assembly and testing of the injectors on test rig and on Spray Combustion Chamber (M32)
- Installation of new injection equipment on the test engine (M34)
- Commissioning and validation of engine with fuel flexible injection system (M35)

Objectives of Work Package

DWP Leader: Kaj Portin

- To develop **engines able to switch between fuels**, whilst operating in the most cost effective way and complying with the regulations in all sailing regions.

How

Measurement technology for intermediate combustion products formed inside the combustion chamber will be developed and tested.

The impact of switching between different fuels on possible after-treatment devices and engine components will be part of the investigations.

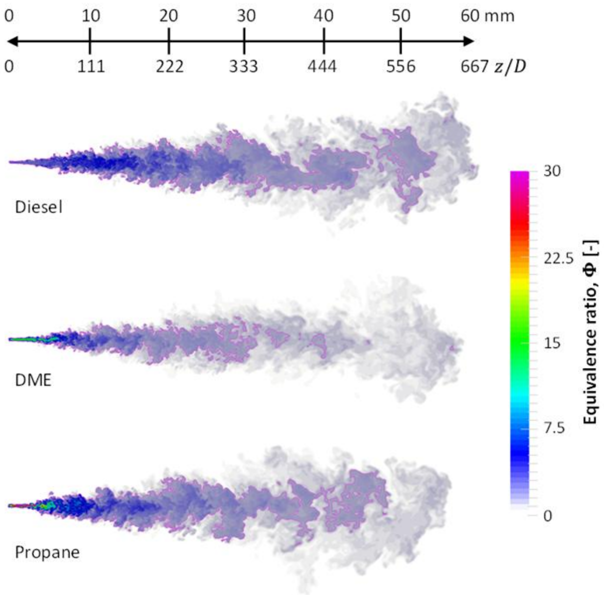
Expected Results

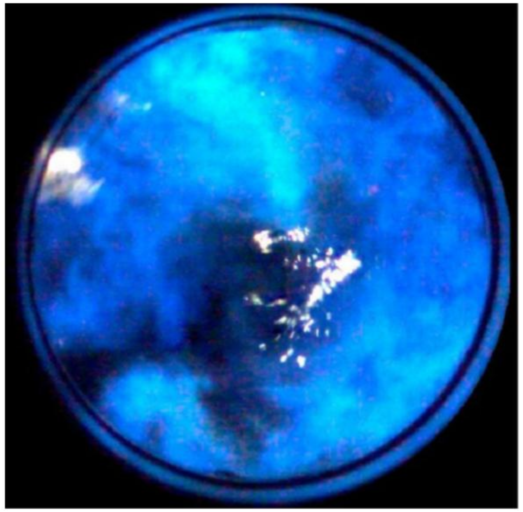
A fully fuel flexible optical injection and ignition test platform for low-speed Diesel engines will also be produced. A fully optical medium-speed multi-fuel engine will be developed and tested for the first time.

Partners: WÄRTSILÄ, Vaasan yliopisto UNIVERSITY OF VAASA, Aalto-yliopisto

Main results achieved during 2nd year

- Aalto University
- Large Eddy Simulation (LES) of evaporating fuels: Diesel, dimethyl ether (dme), and propane
- Optical Dual-Fuel (DF) combustion characterization of methane-diesel combustion



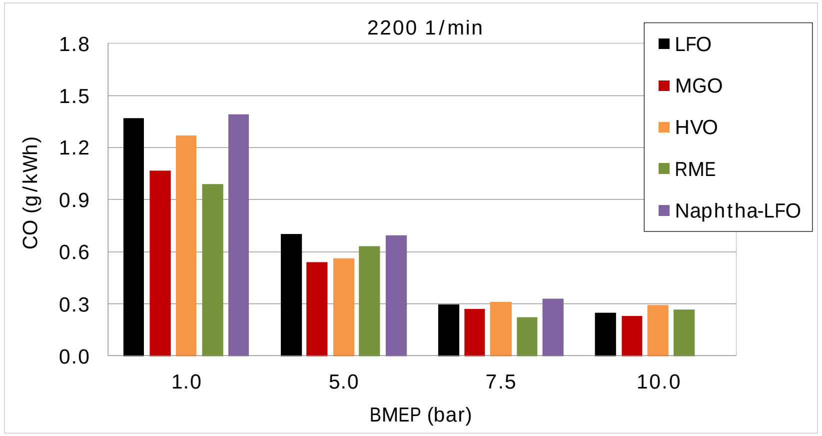


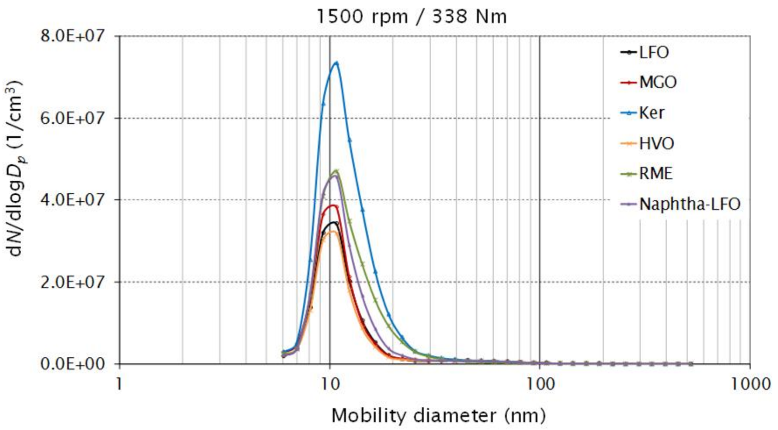
Main results achieved during 2nd year

- Wärtsilä Finland
- Gas online measurement equipment installed at Toftlund power plant.
- Data gathering started in October 2017

Main results achieved during 2nd year

- After the fuel ignition experiments in the combustion research unit, several fuels were tested in a high-speed non-road engine
- The fuels were LFO, circulation-origin MGO, Kerosene, HVO, RME and a blend of renewable naphtha and LFO
- Thorough performance and emissions measurements were conducted, also including the particulate numbers
- MGO and RME were favourable in terms of CO and HC emissions while NOx was the highest with RME
- Relative to LFO, kerosene and RME increased nucleation mode particles while RME reduced accumulation mode particles; HVO was especially favourable at low idle



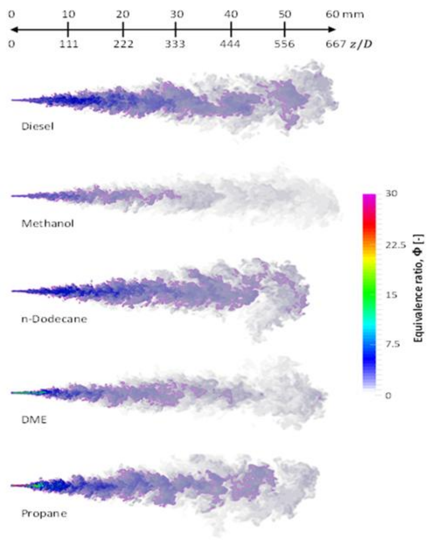


Deliverables

- Deliverable 1.5.

Fuel spray simulations

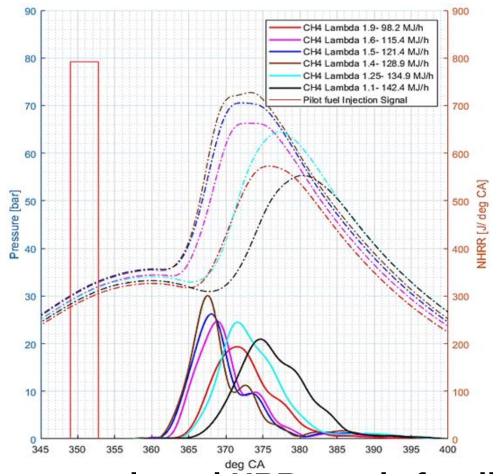
Detailed numerical fuel spray simulations were conducted in evaporative conditions for five different fuels: diesel, methanol, n-dodecane, dme, and propane. The observations indicate that there are large differences in the resulting liquid lengths between the fuels. Diesel has the highest liquid length while methanol and n-dodecane have somewhat shorter liquid length. On the other hand, dme and propane have much shorter liquid lengths compared to the other fuels. The study also indicates that produced equivalence ratio fields differ vastly between the fuels. While methanol gives the lowest equivalence ratio, diesel and n-dodecane yield the richest vapor fields.



Equivalence ratio (Φ) fields of the studied fuels at t = 1.5 ms

Optical imaging of dual fuel combustion

The optical DF combustion analysis shows that DF combustion is mainly governed by premixed flame front propagation with much longer ignition delays compared to the single fuel diesel combustion. DF combustion was always initiated close to the cylinder liner from a rather well mixed diesel-methane-air mixture. Lambda was established to be a very important parameter for DF combustion having an effect to both the ignition delay and the efficiency of the flame front propagation.



Cylinder pressure trends and HRR trends for different methane lambda cases at T_{TDC}=765 K

Future Work

- Methanol spray analysis:
  - spray penetration, opening angle and droplet sizes
- DF combustion characterization as a function of methane Lambda, intake temperature, and pilot ratio.
- The effect of diesel pilot cetane number on DF combustion
- Experimental RCCI combustion

- Gathering of data from Online gas quality measurement at Toftlund, Denmark

- In-cylinder combustion studies at VEBIC on a Wärtsilä 4L20 for Deliverable 1.8.

Aalto-yliopisto

WÄRTSILÄ

Vaasan yliopisto
UNIVERSITY OF VAASA