Liekkipäivät 2012:
Optisia polttoainesuihkumittauksia
Optical Fuel Spray Measurements

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The predominance of internal combustion engines is due to their high overall efficiency, high reliability, low need for maintenance, and low manufacturing costs and the superior energy density of liquid fuels.

Intensive research and development work is being done on alternative powertrains, but in the near future these cannot compete with piston engines.

For the while, internal combustion engines have to be optimized for environmentally friendly operation and preparations need to be made for the end of the traditional oil era, which will lead to the use of various synthetic fuels instead of crude oil-based distillates.
Emission reduction

• Increasing awareness of health and environmental issues related to exhaust gas emissions has led to stringent legislation.
• The emissions of modern diesel engines are mostly related to spray combustion. In spray combustion there are local regions which tend to favour one of the main emission formation mechanisms.
  – If spray combustion was better understood, it would be possible to cut down emissions dramatically.
• There is still a lot to be discovered about fuel spray mixing and spray combustion.
Spray combustion

• The global diesel spray characteristics, the flow field inside the fuel spray and accumulation of droplets, and thus the mixing of air into the spray have a major effect on diesel combustion.

• Modern fuel injection technology enables the fuel injection pressure, duration, and timing to be controlled.
  – This helps to keep emissions low since the fuel injection parameters can easily be varied, depending on the engine load and selected operating scheme.

• To take full advantage of flexible fuel injection control, there is a need to have a better understanding of fuel spray dynamics and spray combustion.

• It is therefore essential to understand how the changing of the injection parameters affects the spray combustion itself.
Diesel Sprays

- John Dec, conceptual model based on laser sheet imaging
- Emission formation in spray combustion is very local

(Heywood, 1988)
Backlight imaging of fuel sprays

- Fuel injection tests of mainly both heavy duty and marine injectors
- Pressurized test chamber with optical access (100mm windows)
  - Ambien pressure in test chamber up to 32 bar, 35kg/m³
    - Density of gas is important for fuel jet formation; close matching to real engine
  - Fuel injection pressures 700 – 1500 bar
  - Transient fuel jets, from 1 to 5 ms duration
Fuel spray Particle Image Velocimetry (PIV)

- Double frame image with short time interval between consecutive frames. Visible shift of tracer particles (fuel droplets) is seen
- Local velocity can be calculated from particle shifts
- Laser sheet imaging of cut planes is realized simultaneously
Fuel spray PIV
Fuel spray structures

- Spray direction
- Longitudinal waves
- Droplets
- Eddies

Aalto-yliopisto
Local velocity in fuel sprays

- Droplet images, size estimates from flow dynamics
- Flow structure size
- Local velocities (PIV – measurements)
Concluding remarks

- Laser based PIV and backlight imaging system and pressurized test rigs showed to be good tools for fundamental spray research.
- Successful diesel spray PIV measurements in optically dense core of the spray were shown.
- Fuel spray PIV measurements in running optical large-bore medium-speed engine and heavy duty engine have been done, too.
- Diesel sprays and mixing as well as fuel spray penetration and tip velocity were studied.
- In diesel spray research it is important to understand the fundamental flow dynamics, to apply the measurement techniques to engine measurements, and to use experimental data to validate the results of fuel spray simulations.
Selected publications: