Karlsruhe Institute of Technology

HELMHOLTZ
RESEARCH FOR GRAND CHALLENGES

EMR / RU4 Feedstocks and Processes of the Future Carbon Cycle
Gasification

Spray Investigations for Entrained Flow Gasification

Pressurized Atomization Test Rig – PAT

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Objectives

Model based description for atomization of non Newtonian suspension fuels at high pressure, validated by experimental data.

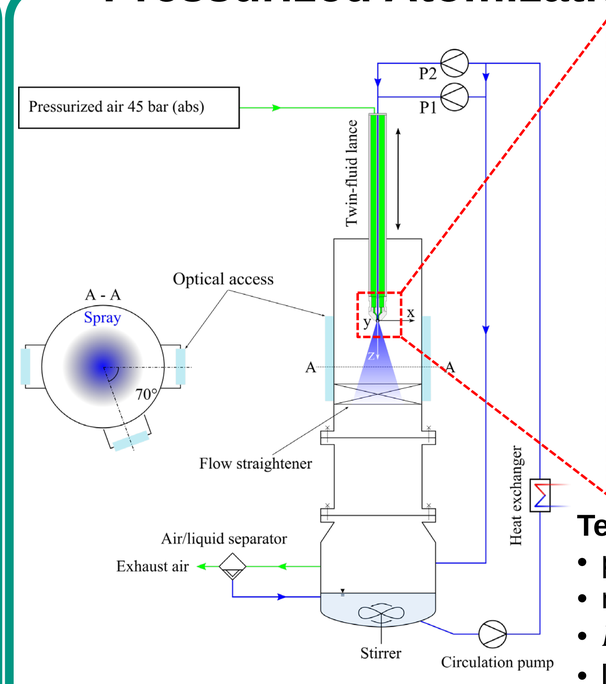
- Description of primary breakup (mode, α_{sp}, f_{prim})
- Measurement of local drop size distribution and velocity
- Input/validation data for numerical simulation of technical EFG

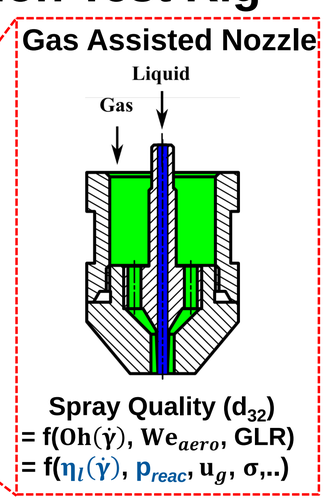
Challenges

Detailed experimental investigation of atomization process of high viscous non Newtonian suspension fuels at pressurized conditions.

- Adaption of measuring techniques to high pressure and high viscous fluids
- Atomization at high system pressure (PAT 21 bar (abs) | EFG 80 bar (abs))
- Atomization of high viscous fluids with complex rheological behavior

Pressurized Atomization Test Rig





Spray Quality (d_{32})
= f(Oh($\dot{\gamma}$), We_{aero}, GLR)
= f($\eta_l(\dot{\gamma})$, p_{reac}, u_g, σ,..)

Technical Data:
- p_{sys} = 1-21 bar (abs)
- $\eta_{liq,max}$ = 1000 mPa s
- $\dot{M}_{liq,max}$ = 200 kg h^{-1}
- liquid and suspensions
- process control system

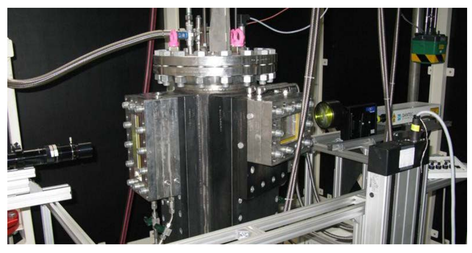
Complementary use of Measuring Technique

High-Speed Camera

System Properties:
- resolution: 1024 x 1024 Pixels
- frame rate: up to 500 kHz

Application:
- breakup Morphology / Spray Angle
- breakup Frequency / effective Visc.

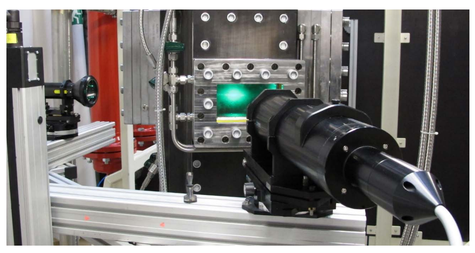
Shadow-Sizer



System Properties:
- resolution: 2048 x 2048 Pixels
- double frame rate: up to 12 Hz

Application:
- drop shape and size of large drops
- validation of PDA & SpraySpy-data

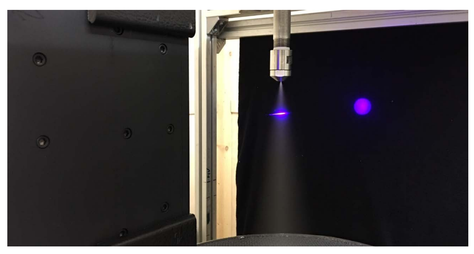
Phase-Doppler Analyzer



System Properties:
- measuring volume: ≤ 250 µm
- focal length: 1000 mm

Application:
- local drop size and velocity
- transparent liquids

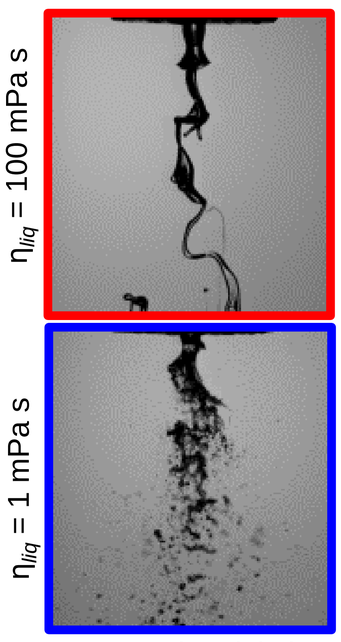
SpraySpy



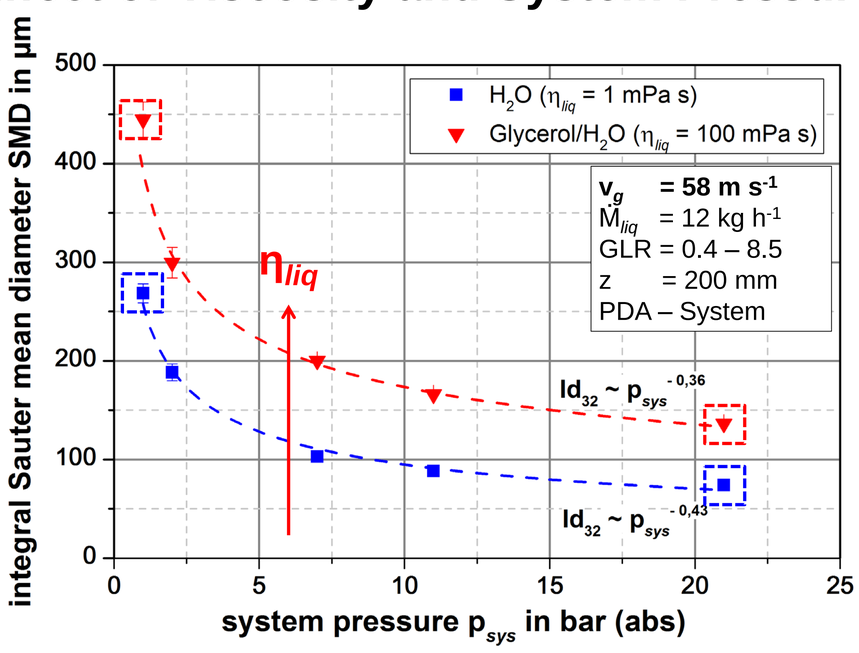
System Properties:
- measuring volume: ~ 100 µm
- focal length: 250 mm

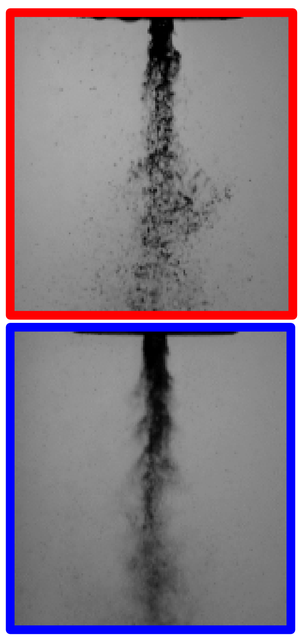
Application:
- local drop size and velocity
- all kinds of fluids & suspensions

Effect of Viscosity and System Pressure on Spray Quality (v_{gas} = const.)



p_{sys} = 1 bar (abs)





p_{sys} = 21 bar (abs)

Effect of System Pressure:
- p_{sys} ↑ → **drop size ↓ (u_{gas} = const.)**
- p_{sys} ↑ → **spray angle ↓**
- p_{sys} ↑ → **number density ↑**
- **Influence of p_{sys} less pronounced for p_{sys} > 11 bar**

Effect of Viscosity (Newtonian):
- η_{liq} ↑ → **drop size ↑**
- η_{liq} ↑ → **spray angle ↑**

Associated Publication: A. Sänger, T. Jakobs, N. Djordjevic, T. Kolb; Experimental Investigation on the Influence of Ambient Pressure on Twin-Fluid Atomization of Liquids with Various Viscosities, 13th ICLASS 2015, Taiwan

Ongoing Work

- **Pressure adopted nozzles / atomization of Suspensions**
- **Improved CFD-Modelling**
- **Data-based model atomization of viscous suspensions**

Future Work

- **Experimental investigation of different nozzle geometries**
- **Data based sub-models of atomization integrated in CFD**
  ➔ Virtual Spray Test Rig

Cooperations

HVI GAS TECH – Helmholtz Virtual Institute for Gasification Technology · IEVB Institute for Energy Process Engineering and Fuel Technology · DLR · JÜLICH FORSCHUNGSZENTRUM · RWTH AACHEN UNIVERSITY · Air Liquide Engineering & Construction · KTH Royal Institute of Technology · Luleå University of Technology · AOM Systems · DANTEC DYNAMICS · DAIMLER