Experimental study of plug formation in pipes

Master's project

Boris V. Balakin

Pavel G. Struchalin

Vegar Hovdenakk Øye

Fundamentals

Plug is bad ☹

https://www.pinterest.co.uk/pin/funnies--491666484296137721/

Background

Cut the cost

New method

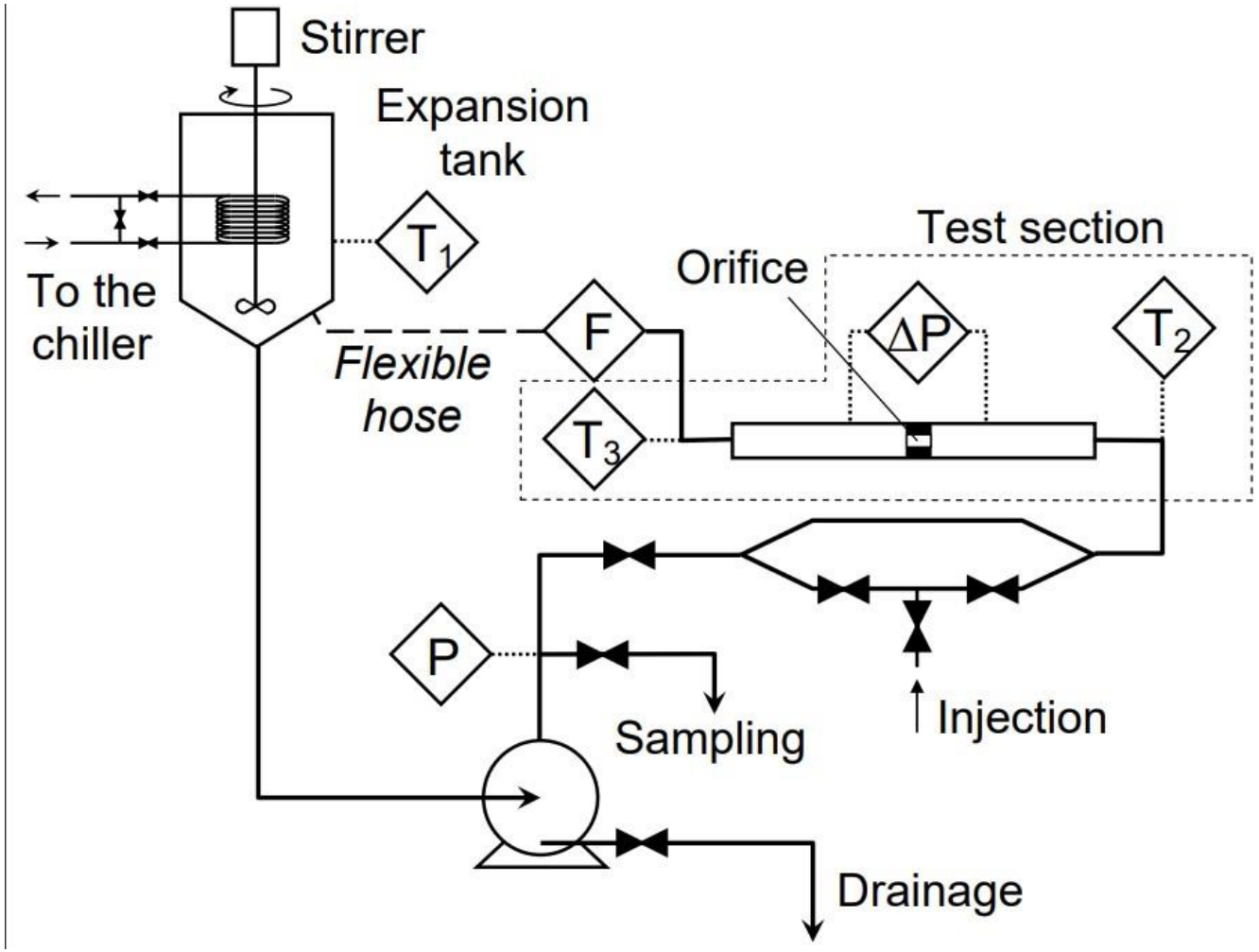
Reduce risks

Project work

Flow loop

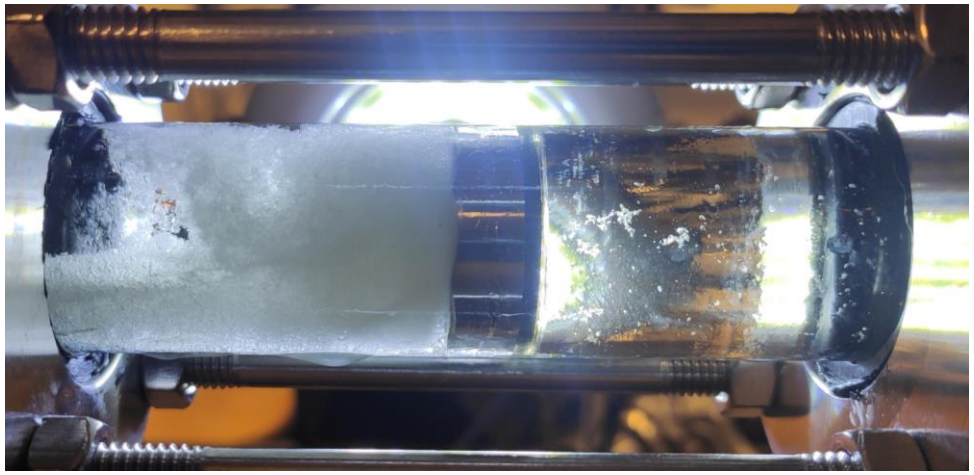
Plugging

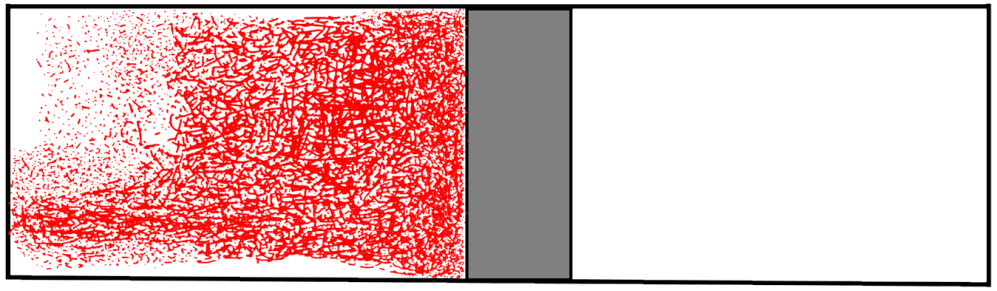
Flow loop scheme

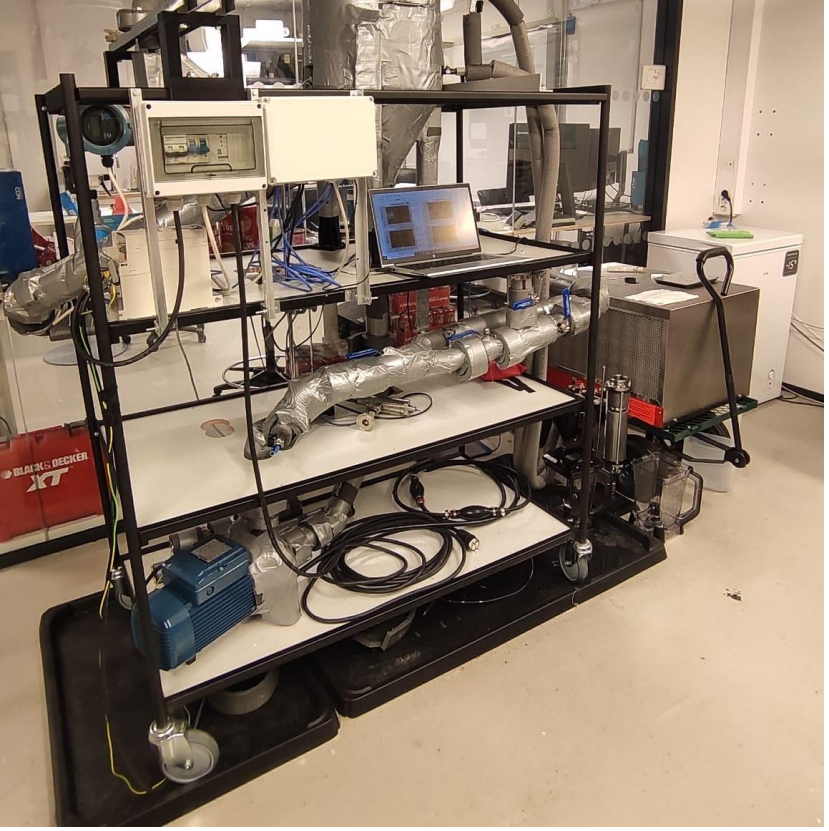


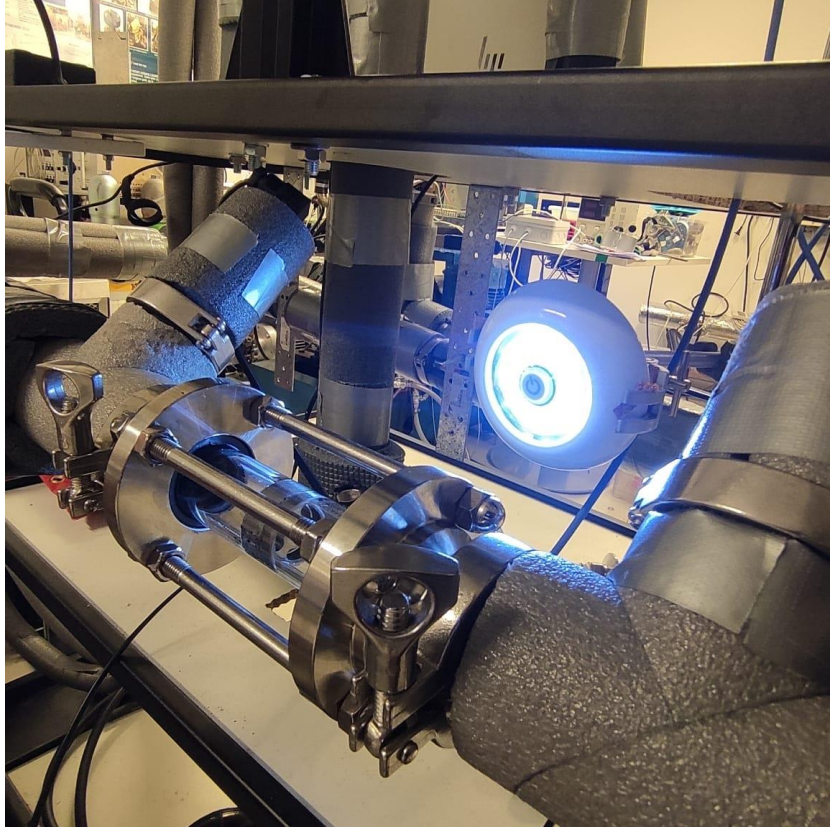
Overview experiments

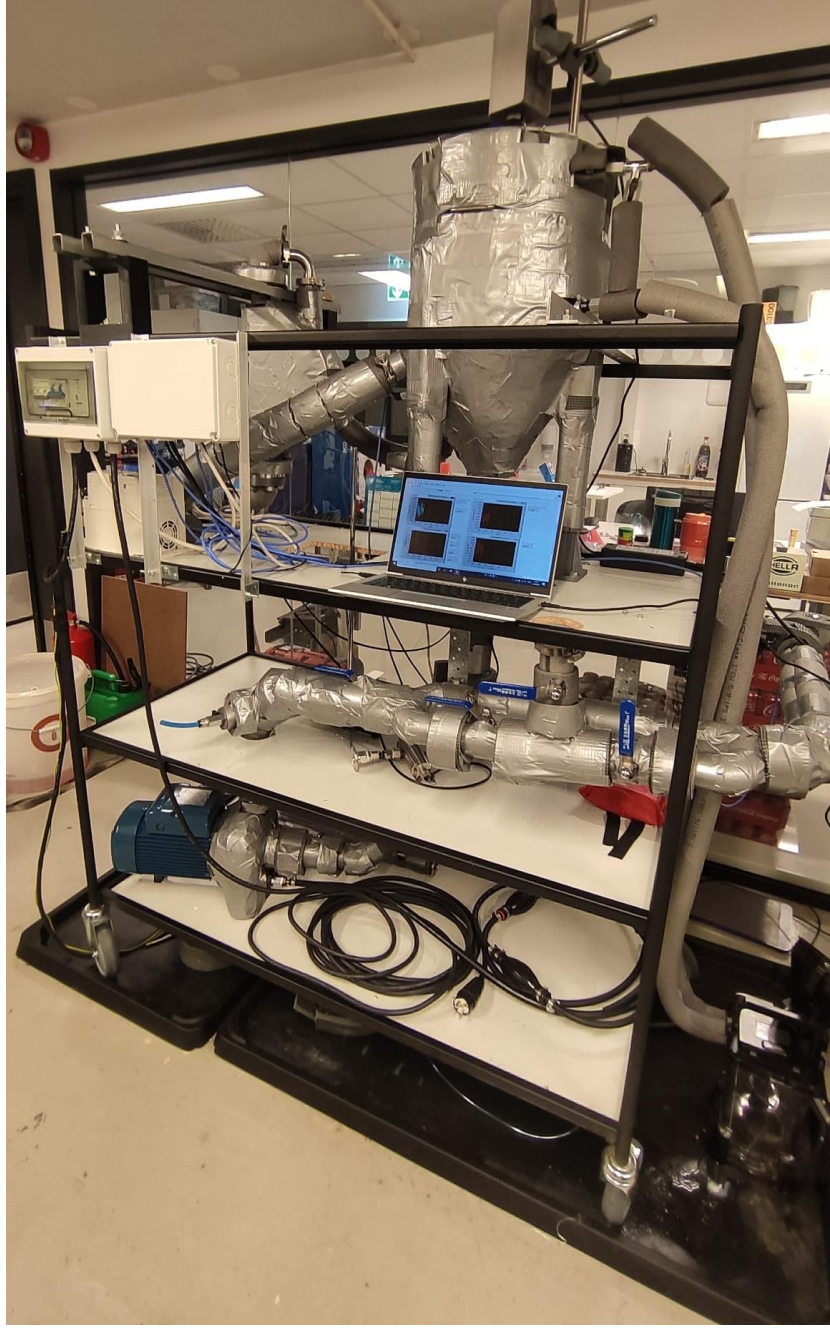
- 48 experiments
- Particle concentration 2-20 %
- Flow rate 400-2000 kg/h
- Reynolds number 5 000-25 000





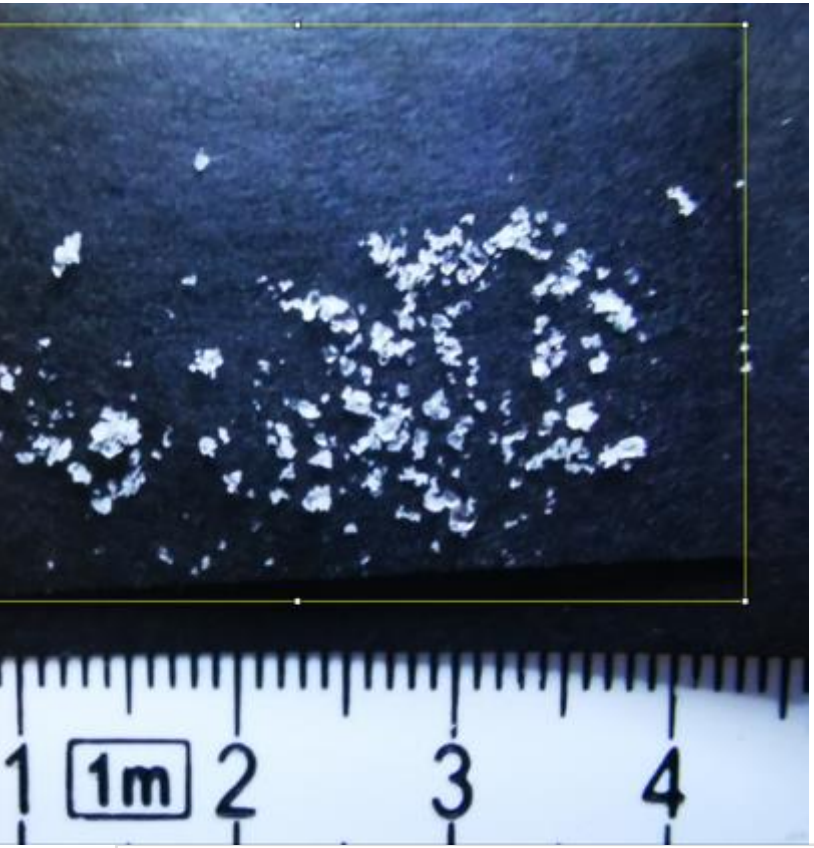


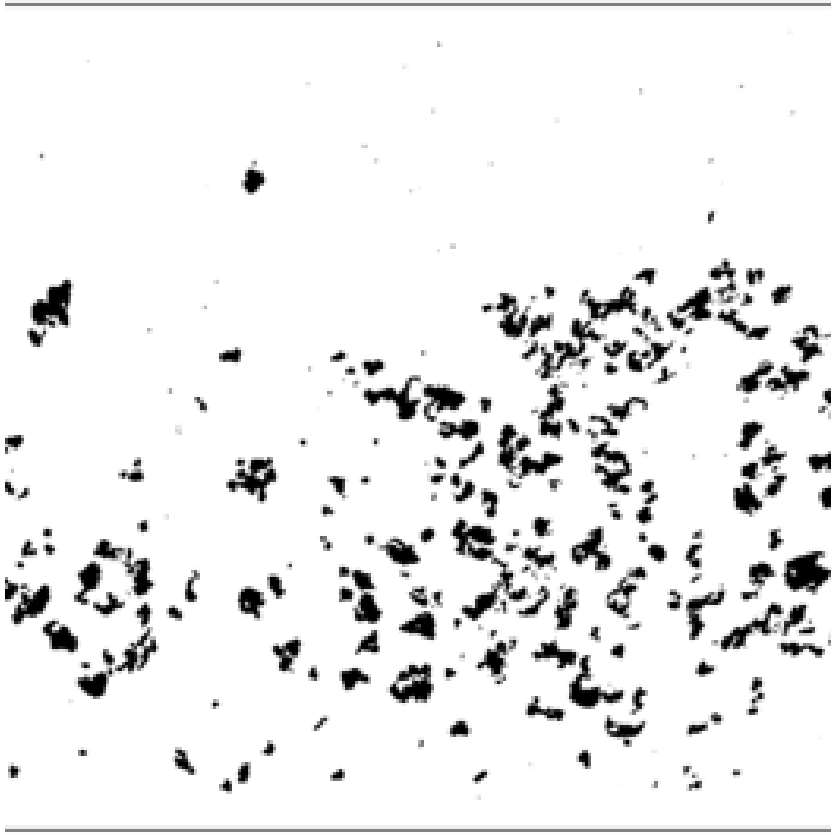




Flow loop

- Ice in decane
- Movable rig
- Thermally insulated
- Removable test section





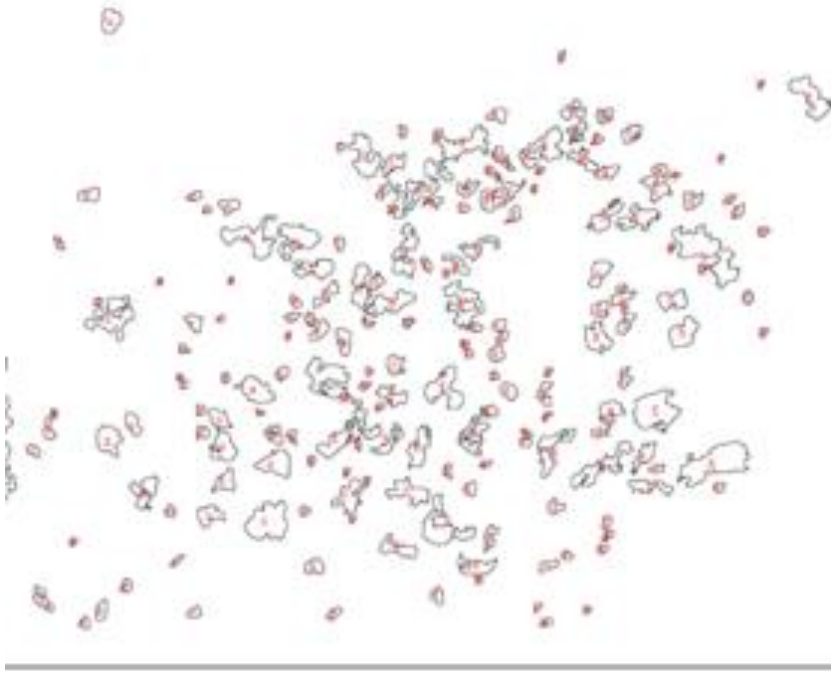
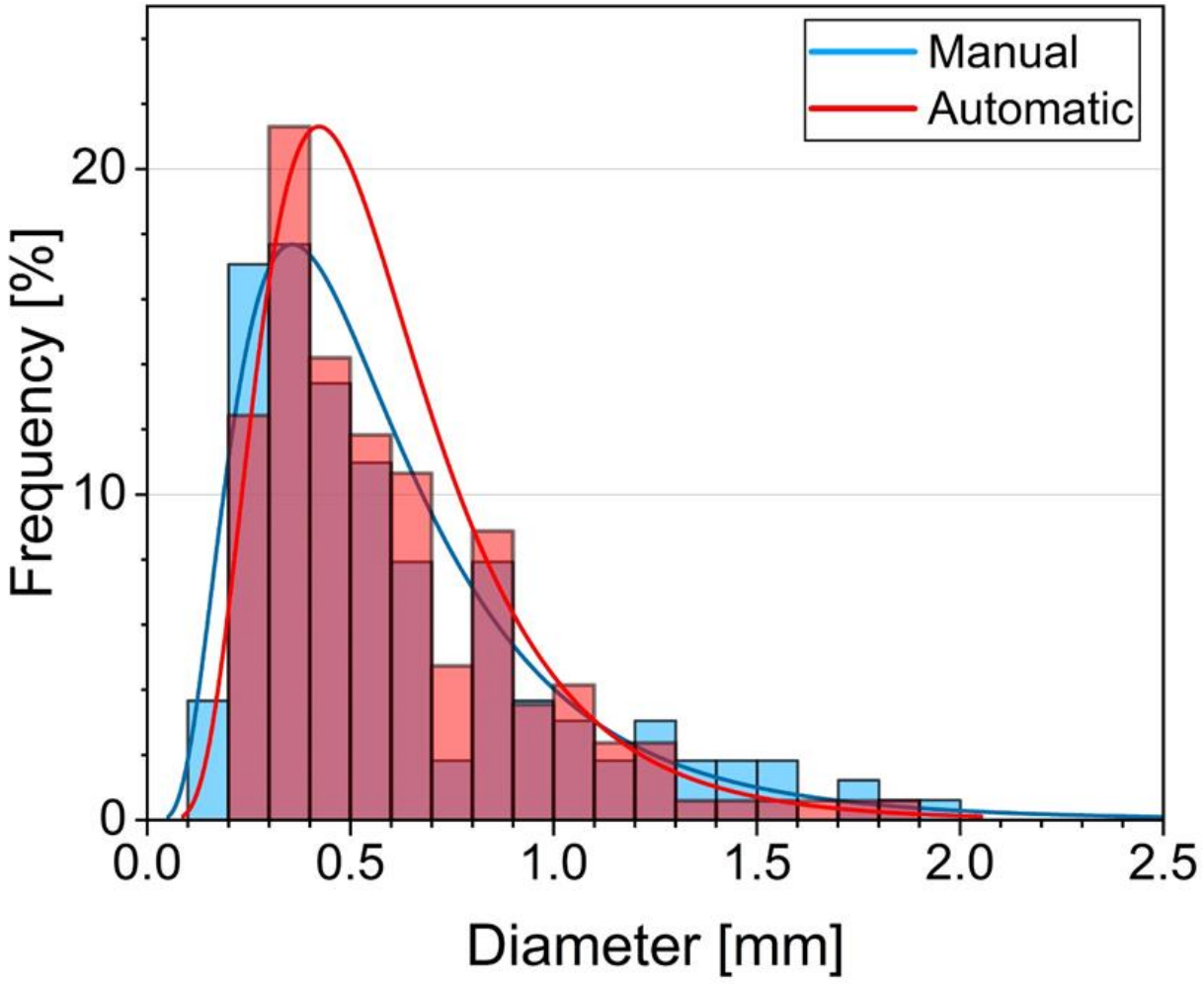


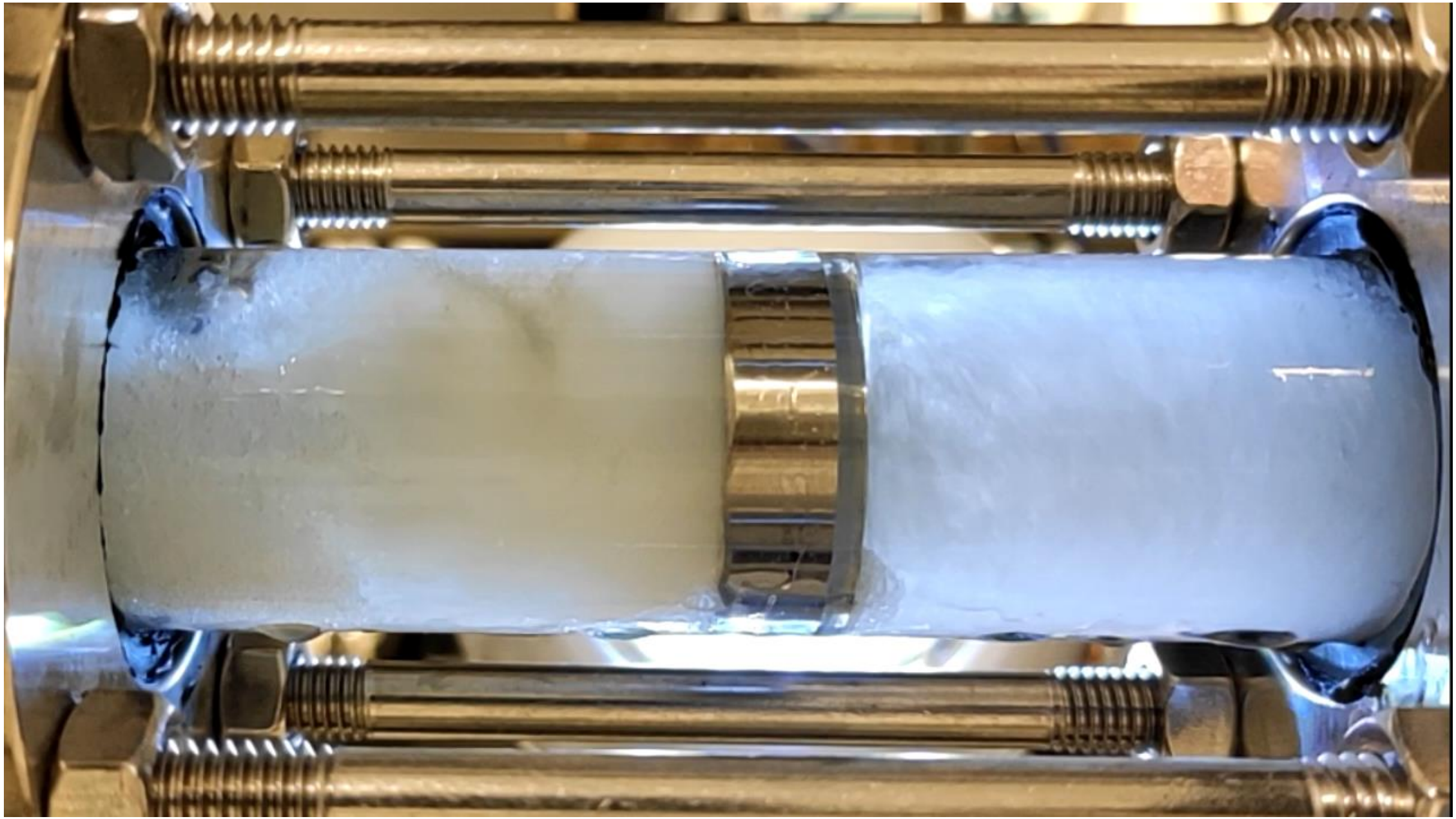
Image-J

- Image-J measurement
- Data treatment in Excel

Particle size distribution

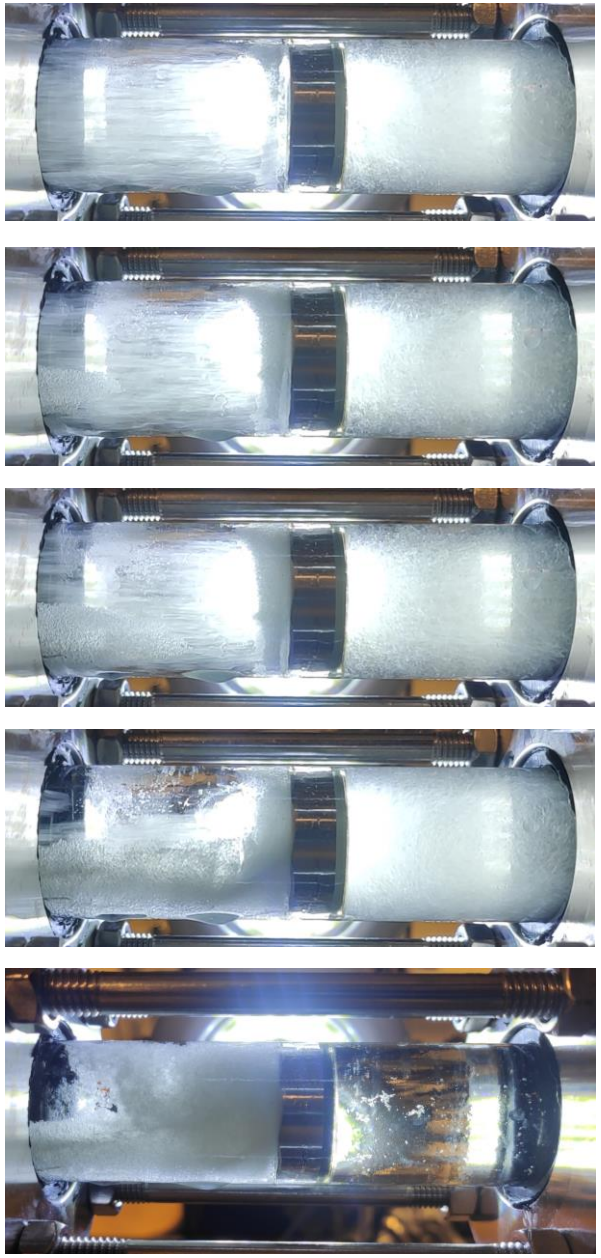
- ~170 particles analyzed
- Log-normal distribution
- Average 0.41 mm
- Deviation 0.39 mm

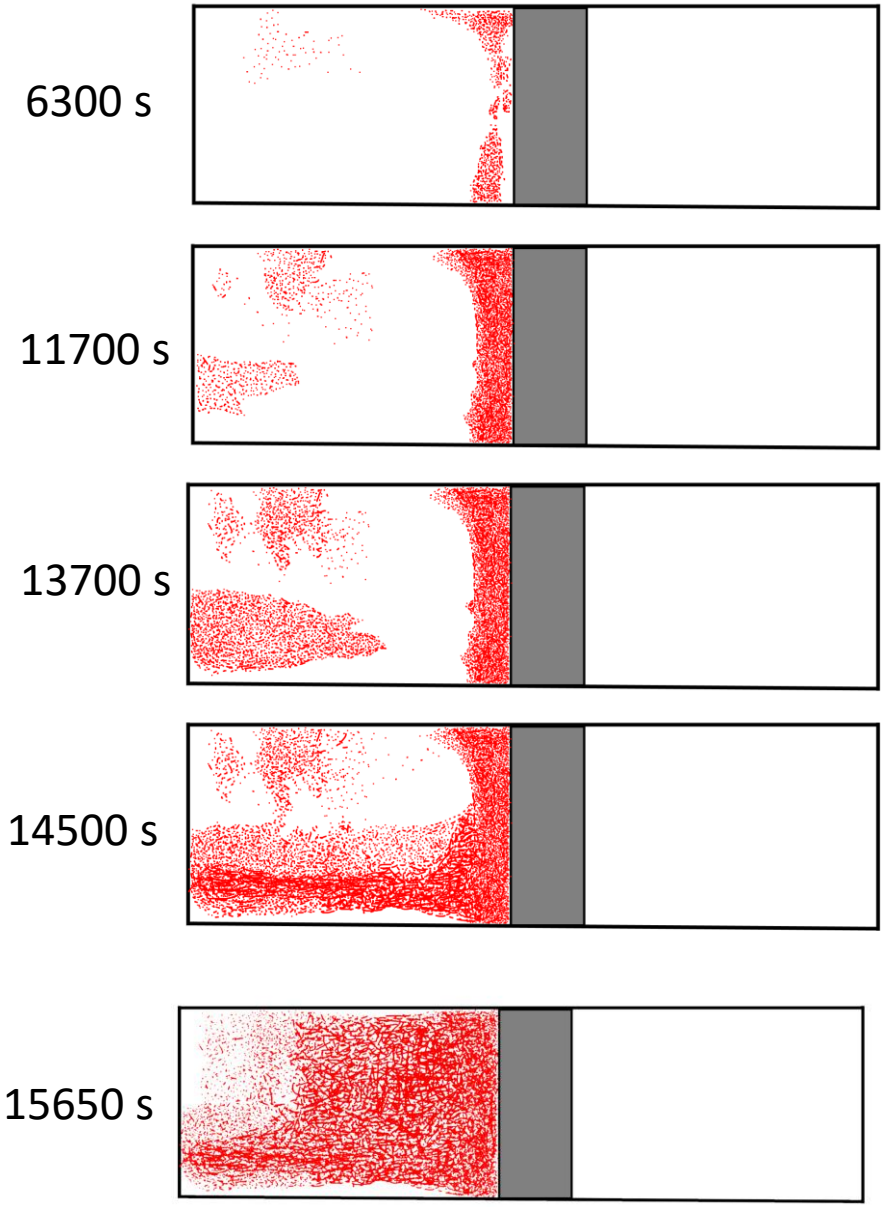




Plug Formation

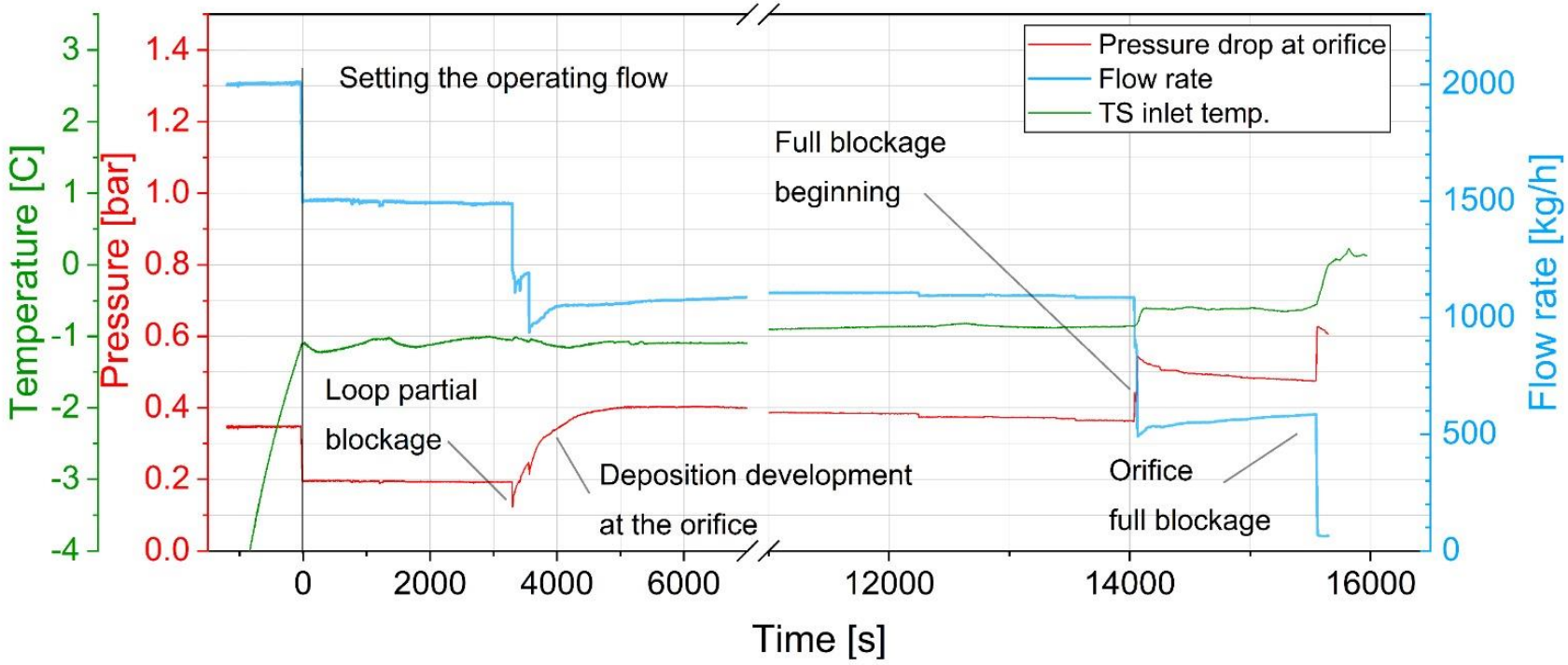
- Initial deposition at the orifice
- Bed formation
- Rapid growth



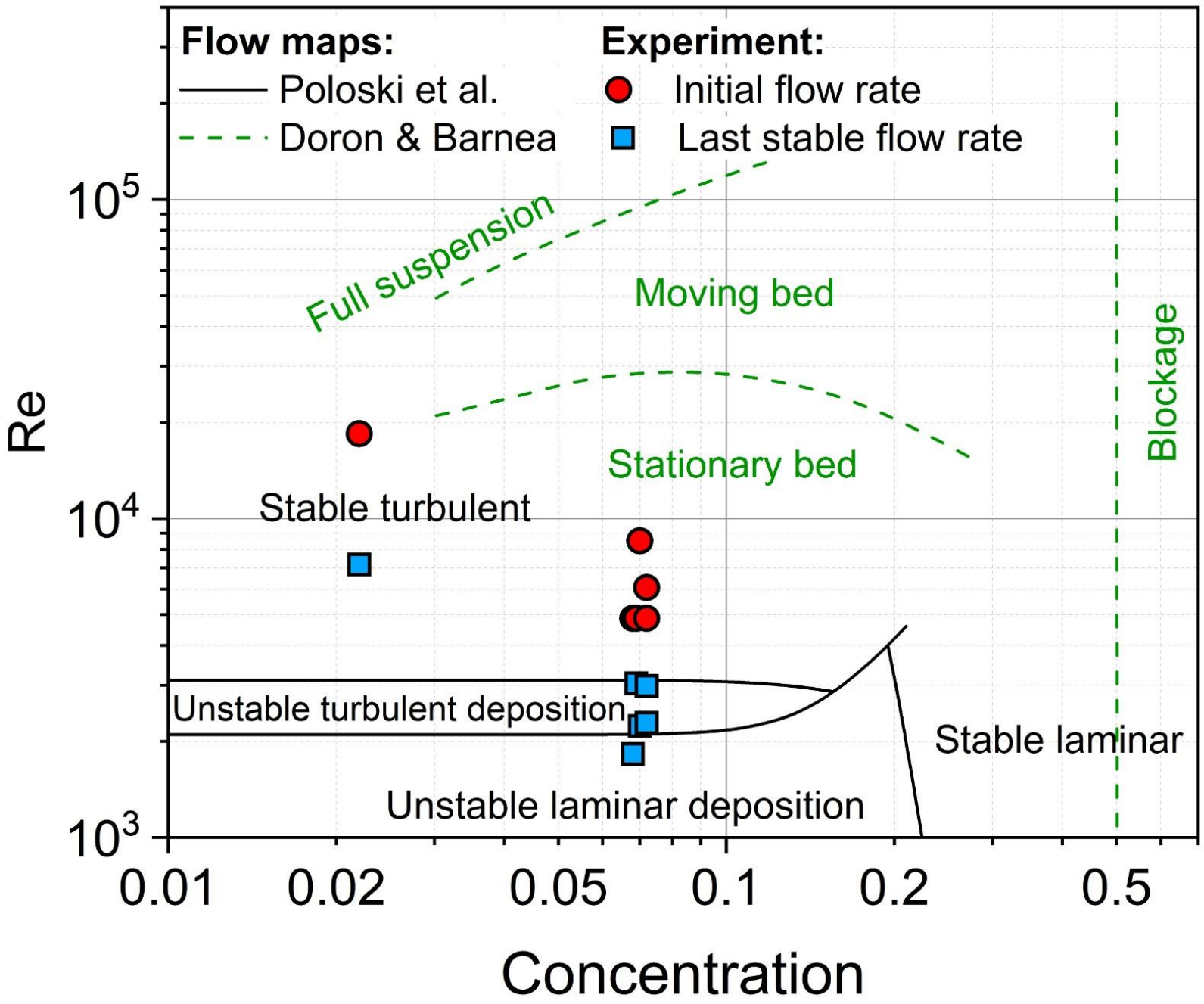


Experimental log

- Flow rate and temperature vs time
- Slurry concentration vs time

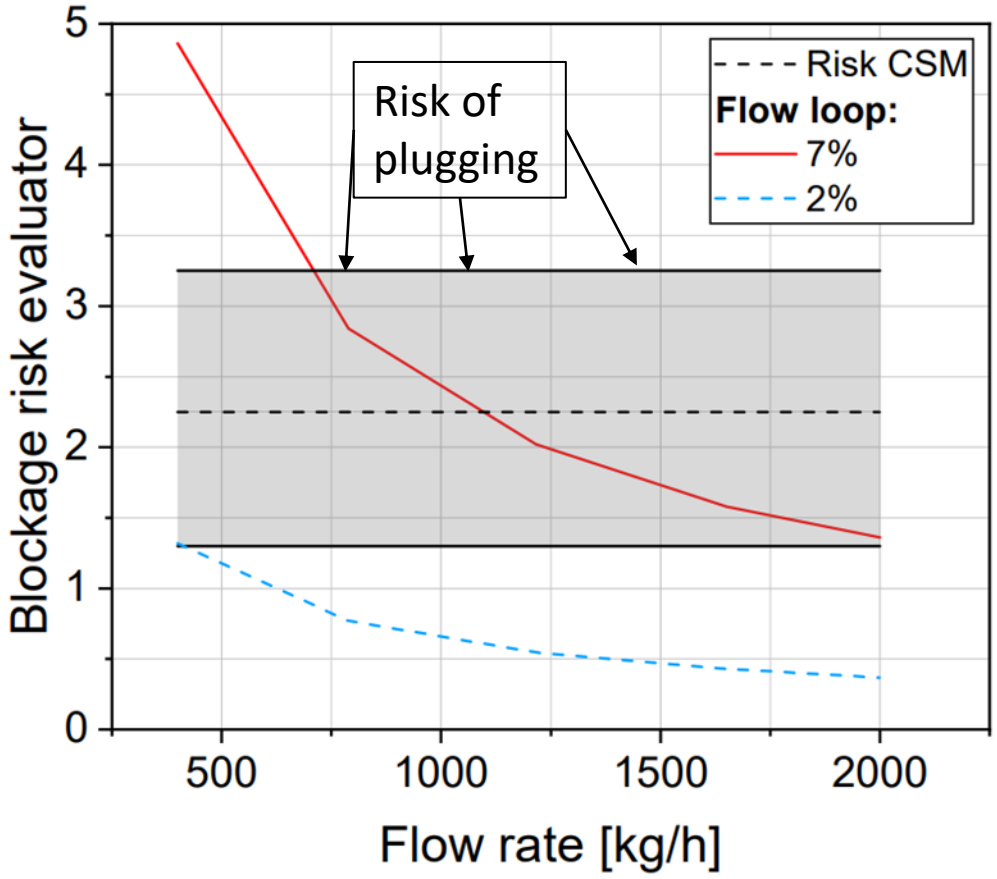


Flow map


Flow maps:
Poloski et al.
Doron & Barnea
Experiment:
Initial flow rate
Last stable flow rate
Full suspension
Moving bed
Stationary bed
Blockage
Stable turbulent
Unstable turbulent deposition
Stable laminar
Unstable laminar deposition
Re
10^5
10^4
10^3
0.01
0.02
0.05
0.1
0.2
0.5
Concentration

CSM Risk Evaluator

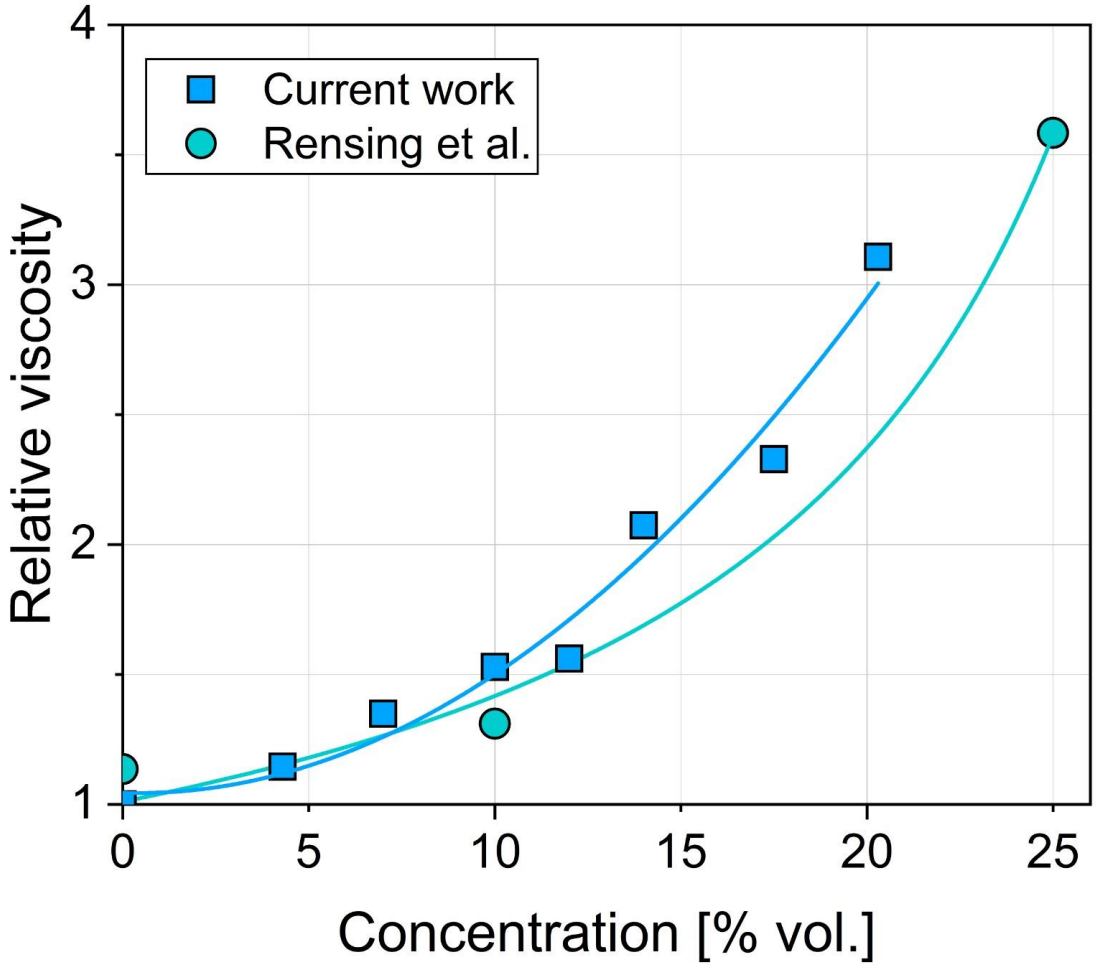
- Risk evaluator
- Dependent on particle concentration, Re, and dimensionless cohesion
- Risk zone in grey



A correlation to quantify hydrate plugging risk in oil and gas production pipelines based on hydrate transportability parameters – Chaudhari et al.

Relative viscosity

- Pressure drop based estimate
- Relative viscosity (μ_{mix}/μ_l)
- 20.3% = 3.0
- Rensing et al. studied similar oil-based slurry
- Average discrepancy (ø>12%) is 22%



Viscosity and yield stresses of ice slurries formed in water-in-oil emulsions – Rensing et al.

Summary

- Multiphase flow loop study
- Particle concentration 2-20 %
- Temperature -2 °C to -1 °C
- Reynolds number 5000 – 25 000
- 40% less of **cohesive** particles to make a plug
- CSM risk evaluator works!

Acknowledgements

- Norwegian Research Council (project 300286)
- Subsea Operations Conference
- Supervisors
  - Boris V. Balakin
  - Pavel G. Struchalin
  - Pawel Kosinski

The Research Council of Norway

Western Norway University of Applied Sciences

Thank you!

Questions?