Modelling bubble-particle interaction
NUMAP-FOAM 2009

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Outline

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2. Solver
3. Preliminary results
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Mineral froth flotation

Source: Gijsbert Wierink NUMAP-FOAM 2009

Modelling bubble-particle interaction
Scope

**Aim**: development of a turbulent bubble-particle interaction solver

Bubble-particle interaction models are used to improve design and optimization of froth flotation equipment

Bubbles: 0.7-1.5 mm, particles: ~ 100 µm, $Re_b$: 200-400

(Courtesy of B. Omelka, HUT, August 2009)
Bubble-particle interaction (bpiFoam):

- Bubble-water interface tracking (bubbleInterTrackFoam\(^1\))
- Lagrangian particle tracking (dropletFoam\(^2\))
- LES turbulence model
- Additional drag and lift forces
- Bubble-particle interaction models

\(^1\)Z. Tukovic and H. Jasak
\(^2\)H. Jasak
Modelling steps

- Bubble and particle have own velocity
- Upon collision
  - Interface patch hit is identified
  - Particle velocity is forced along interface:
    \[ U_{particle} \rightarrow \nabla S \cdot U_{patch} \] (1)
- Particle slides along interface as long as
  \[ P_{detach} = \exp \left[ A_S \left( 1 - \frac{1}{B_0^*} \right) \right] < 0.5 \] (2)
  \[ B_0^* = f(\Delta \rho, \varepsilon, g, d_p, d_b, \sigma, \theta)^3 \] (3)
- After detachment particle regains own velocity

\[^3\text{Schulze, 1993}\]

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Preliminary results (2D)

- Bubble: 1.5 mm, particle: 100 \mu m (quartz)

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Future development

- Test the solver for stability and parallelization
- Implement more accurate bubble-particle interaction models
- Improve accuracy of surface force calculation
- Implement particle-particle interaction
- Include Van der Waals force, $\zeta$-potential, and Eh-Ph-conditions
- Experimental validation of statistics and extrapolation to larger scale

Re $\sim 5000$
Conclusions

- The turbulent bubble-particle interaction model bpiFoam has been implemented in OpenFOAM
  - bubbleInterTrackFoam and dropletFoam have been merged
  - Addition of lift force, “dirty water” drag force, an interaction model, and LES turbulence model
- The first 2D test case shows the solver is stable and runs in parallel
- Future development:
  - Test bpiFoam for longer run times and in 3D
  - Make detachment criterion time step independent
  - Statistical validation using bubble-particle collision experiments