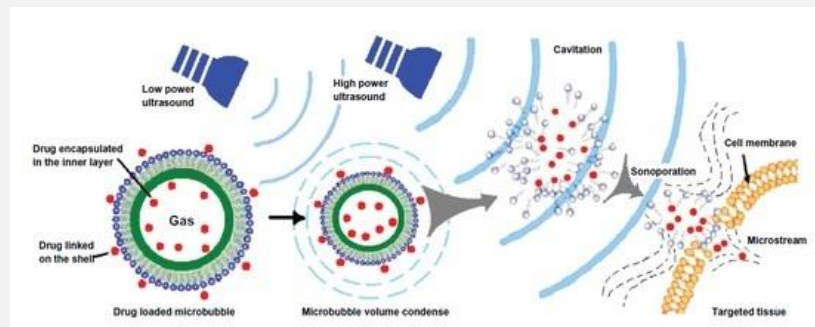
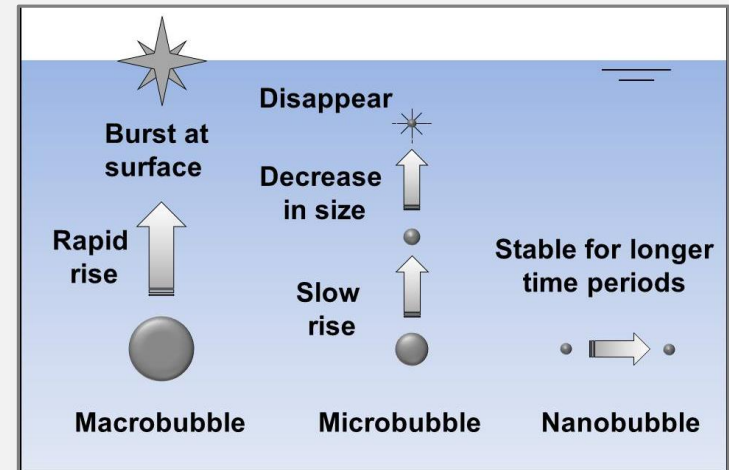


Growth and Break-up of Microbubbles

Gas-Liquid

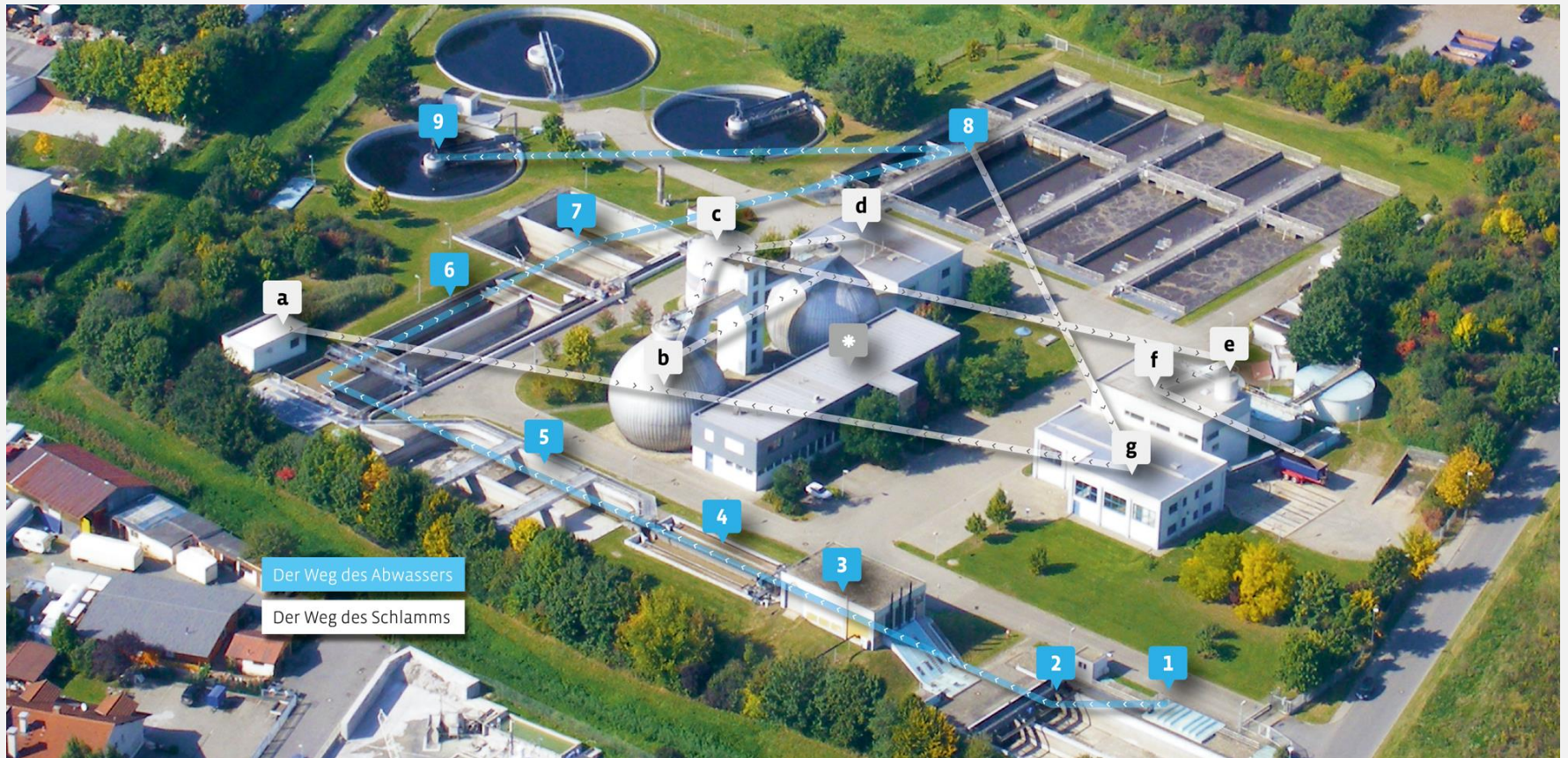


Size of Bubbles



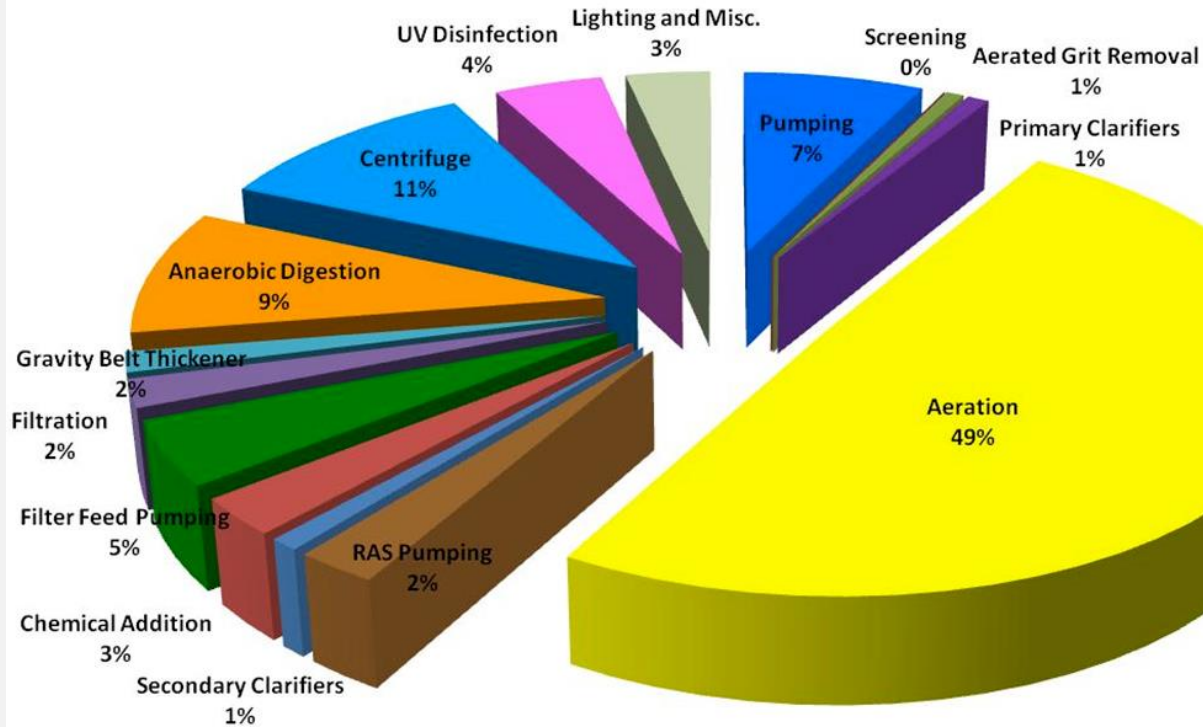
Applications

Modern wastewater treatment plant of a medium sized city
(Example Bensheim / Germany population 100.000)



Cost breakdown for wastewater treatment

Estimated Power Usage
20-mgd Nitrifying Activated Sludge Facility



Source: "Energy Conservation in Wastewater Treatment Facilities" – Manual of Practice – No. 32, Water Environment Federation – Copyright 2009

Why aeration is needed for wastewater treatment?

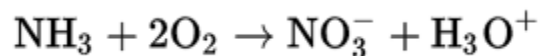
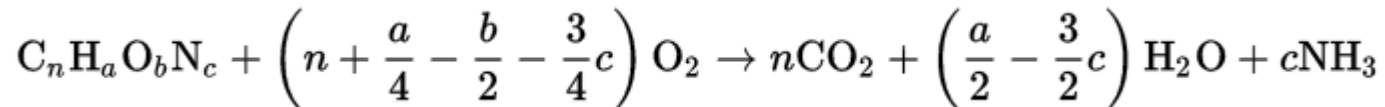


Wastewater aeration

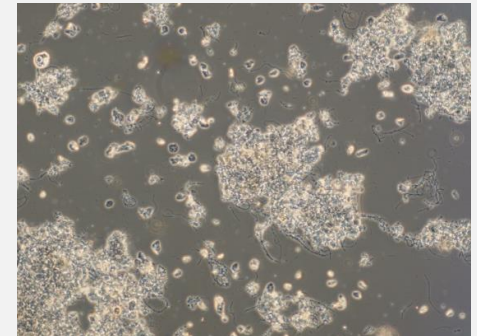
Wastewater contains carbohydrates, lignin, fats, soaps, synthetic detergents, proteins and their decomposition products.

In the activated sludge process and other biological treatment processes beneficial microorganisms degrade this organic matter.

Stoichiometric equations for oxygen demand of wastewater



'Natural' aeration is not efficient enough.

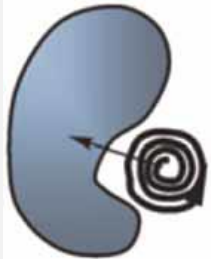


Activated sludge microbial community

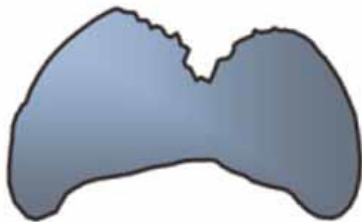
Traditional aeration equipment and fine bubble behaviour



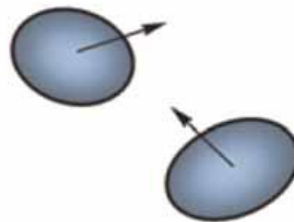
breakup due to turbulent eddy collision



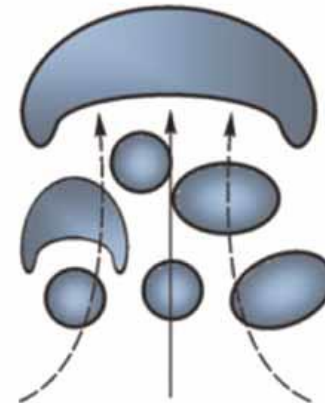
breakup due to instability of large bubbles



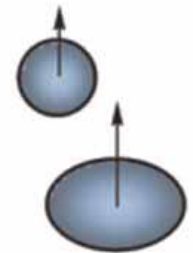
coalescence due to turbulent eddy



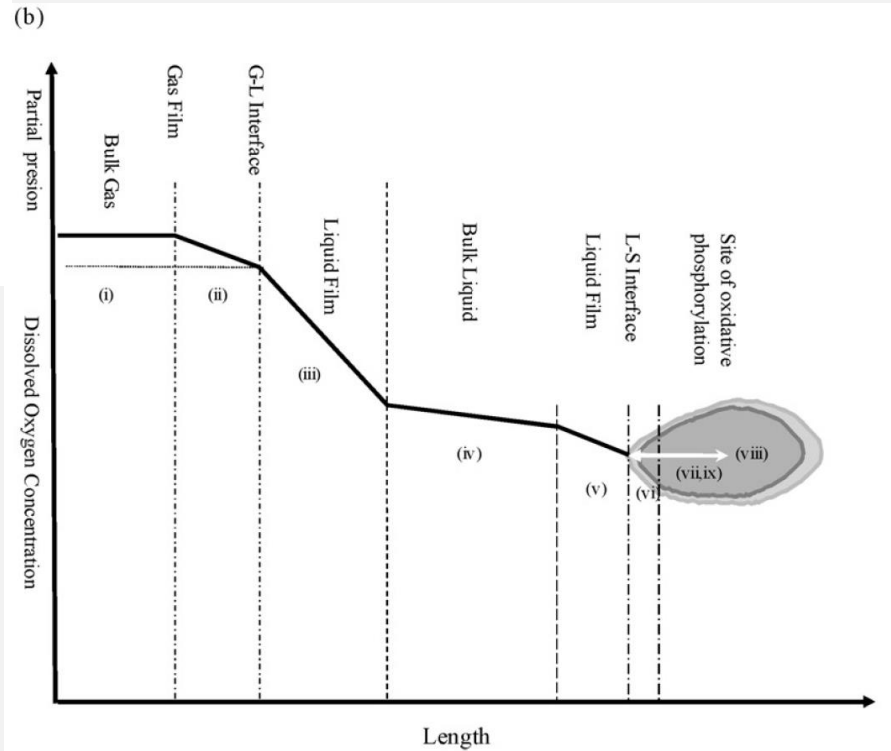
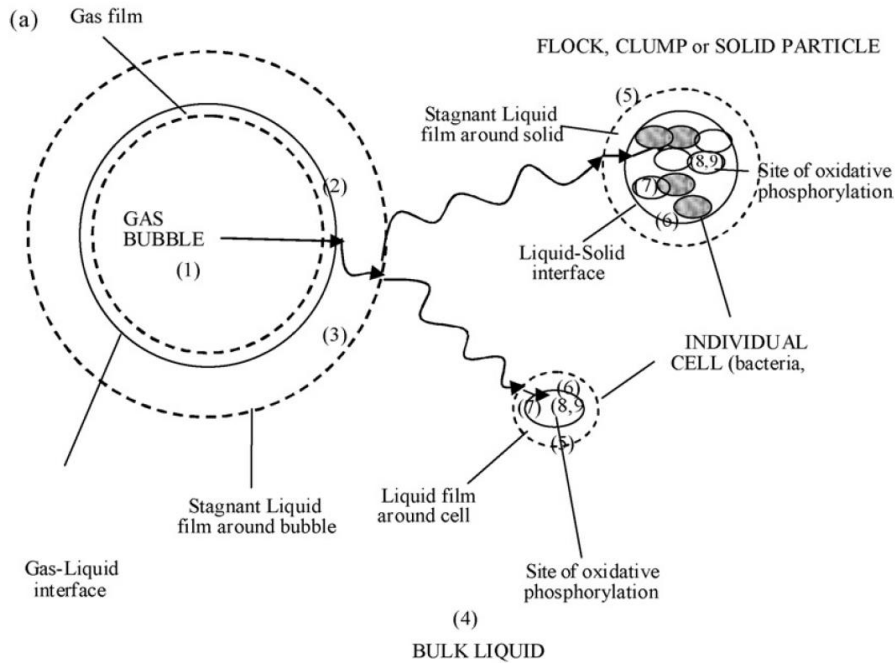
coalescence due to bubble wake



coalescence due to different rise velocities



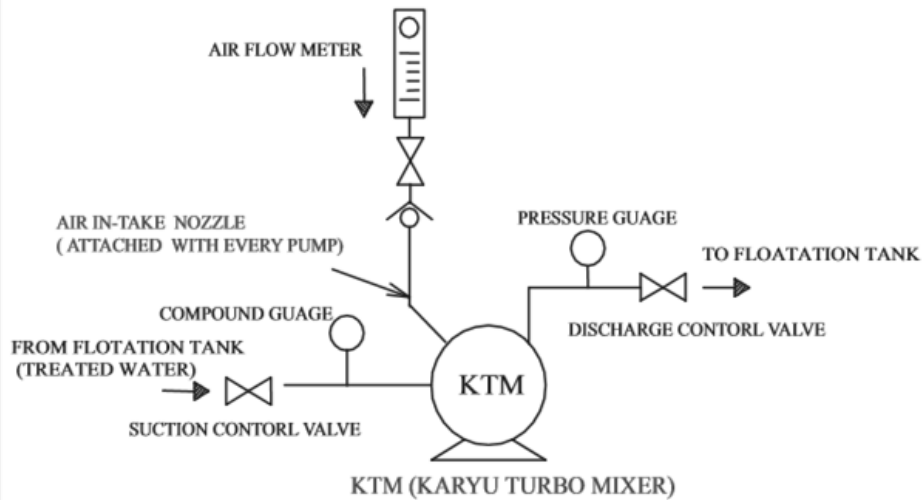
Transport Mechanisms



Hypothesis

- Small scale bubbles will significantly improve the mass transfer of oxygen from gas to liquid phase
- The technology can be retrofitted to existing wastewater treatment plants
- The potential energy savings from using small scale bubbles in large scale waste water treatment is significant
- Smoother process control can be achieved due to improved mixing conditions

Microbubble Generation



NOTES : KTM & AIR IN-TAKE NOZZLE WILL BE SUPPLIED BY NIKUNI
OTHERS ACCESSORIES CAN SUPPLY AS OPTIONAL CASE.



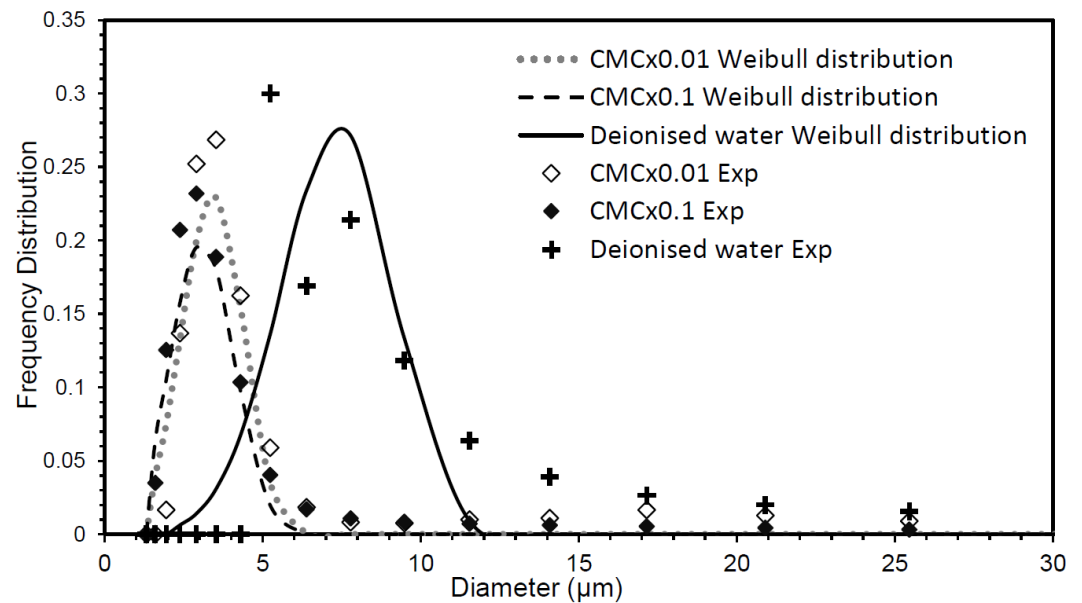
NIKUNI KARYU Turbo Mixer

A cross-sectional diagram of the Karyu Turbo Mixer. It shows a central impeller with a gear-like design. On the left, a blue arrow labeled 'Water' points into the mixer. Above the impeller, a blue arrow labeled 'Carbon dioxide' points into the mixer. On the right, a blue arrow labeled 'Mixed water' points out of the mixer. The diagram illustrates the mixing process where water and carbon dioxide are combined.

Water **Carbon dioxide** **Mixed water**

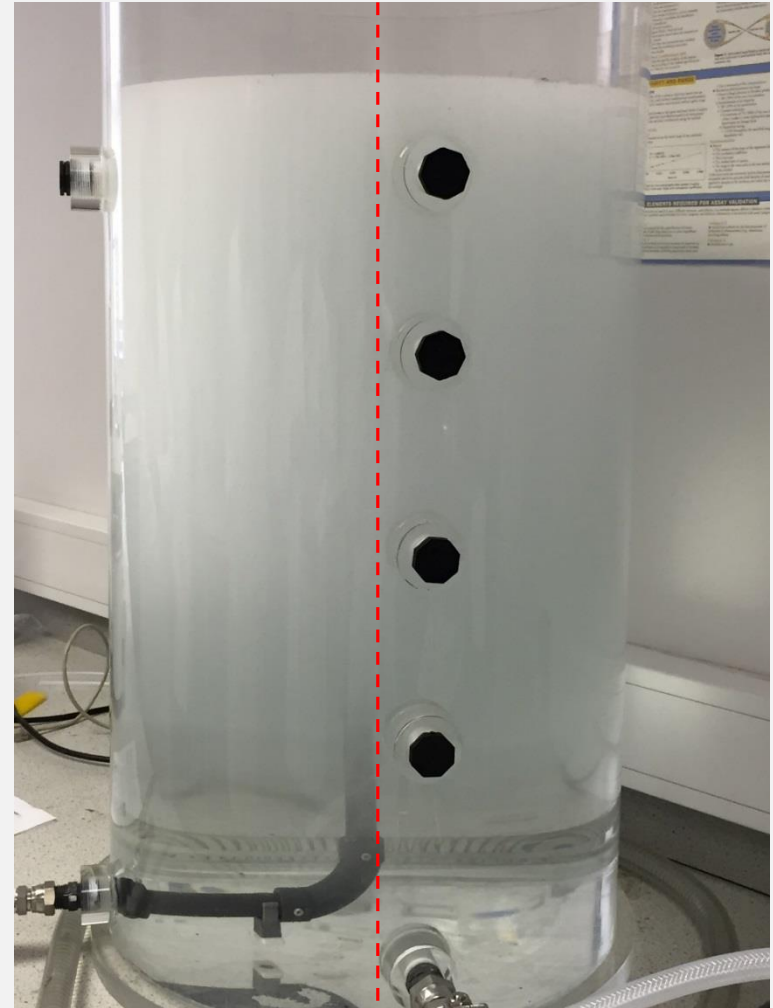
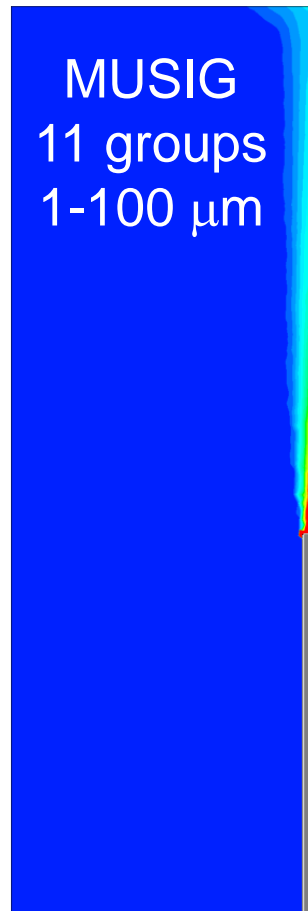
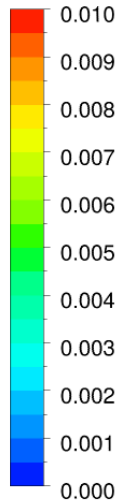
KTM can perform mixing of a variety of other gases and liquids.

MB Particle Size Distribution

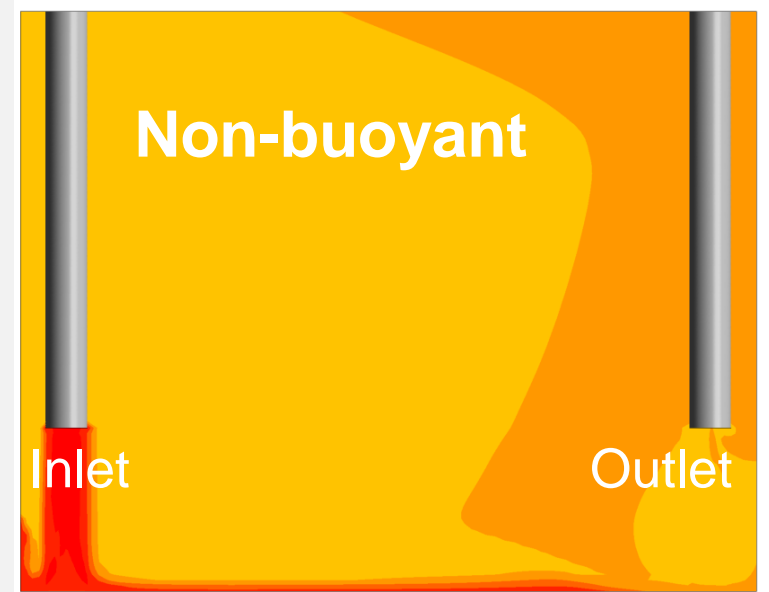
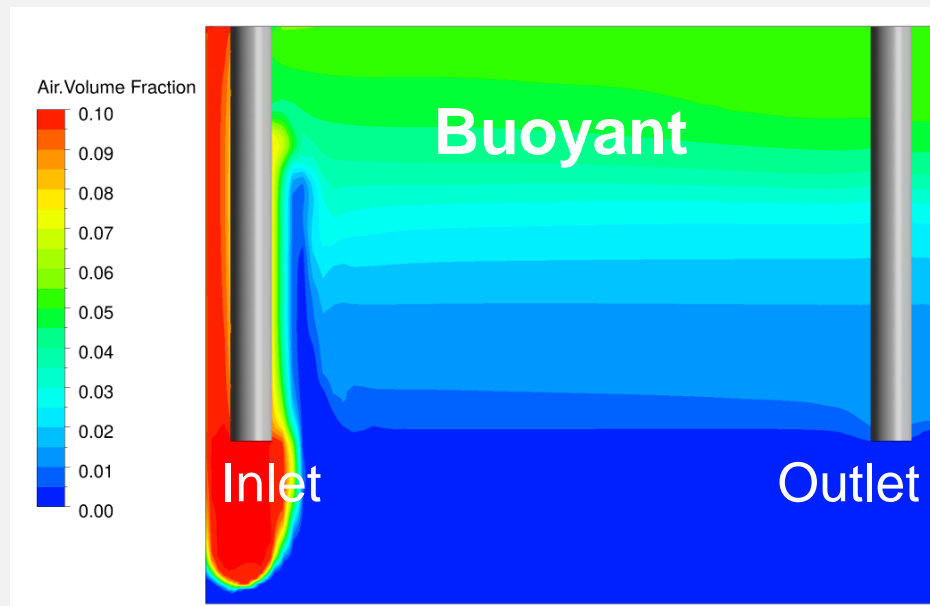
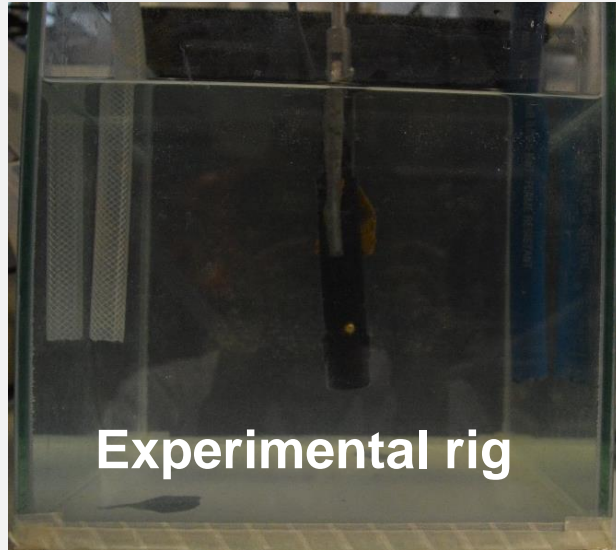


Computational Modelling

Air Volume Fraction

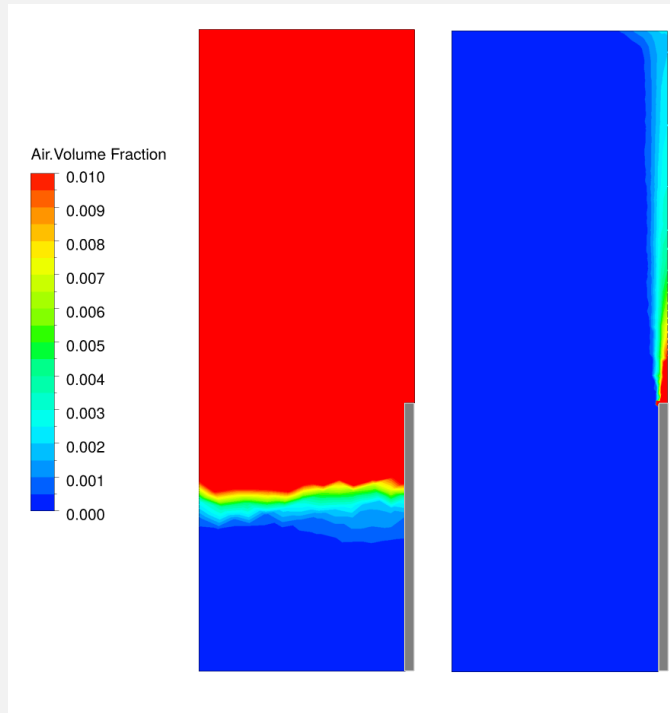


Computational vs. Experimental

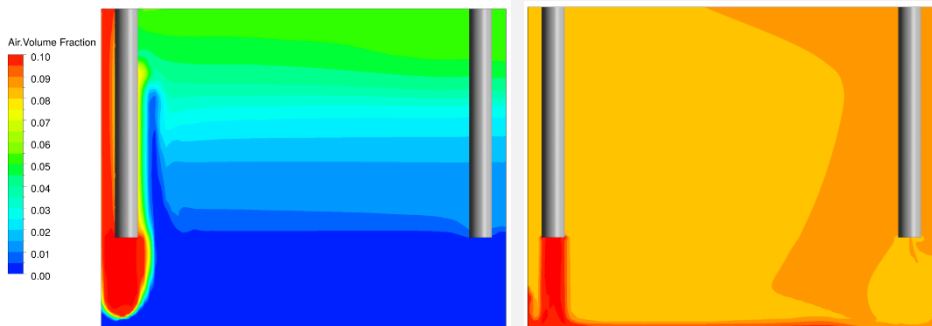


Limitations

Key Questions to Answer



- Inaccuracy of drag model – affects the rise velocity and bubble coalescence
- Buoyancy effect is less significant for MBs



Population Balance Method

Mass conservation:

$$\frac{\partial(\rho_i \alpha_i)}{\partial t} + \nabla(\rho_i \alpha_i \vec{u}_i) = 0$$

Momentum conservation:

$$\frac{\partial(\rho_i \alpha_i \vec{u}_i)}{\partial t} + \nabla(\rho_i \alpha_i \vec{u}_i \vec{u}_i) = -\alpha_i \nabla p + \nabla[\alpha_i \mu_i (\nabla \vec{u}_i + (\vec{u}_i)^T)] + F_{lg} + \alpha_i \rho_i \vec{g}$$

Multiple discrete bubble size groups:

$$\frac{\partial n_i}{\partial t} + \nabla(\vec{u}_g n_i) = \left(\sum_j R_j \right)_i$$
$$\left(\sum_j R_j \right)_i = (P_C + P_B - D_C - D_B)$$

Break-up rate:

$$P_B = \sum_{j=1}^N \Omega(v_j: v_i) v_j \quad D_B = \Omega_i n_i \text{ with } D_B = \sum_{k=1}^N \Omega_{ik}$$

Coalescence rate:

$$P_C = \frac{1}{2} \sum_{k=1}^1 \sum_{l=1}^1 \eta_{jki} \chi_{ij} n_i n_j \quad D_C = \sum_{j=1}^N \chi_{ij} n_i n_j$$