

Cutting of rising bubbles by a wire without contact

M. Börnhorst¹, T.A.M. Homan³, P. Rohlf¹, N.G. Deen³, O. Deutschmann^{1,2}, M. Wörner²

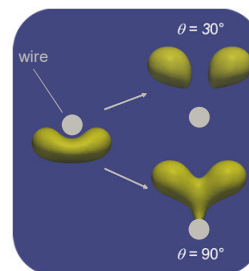
¹Karlsruhe Institute of Technology (KIT), Institute for Chemical Technology and Polymer (ITCP)

²Karlsruhe Institute of Technology (KIT), Institute of Catalysis Research and Technology (IKFT)

³Eindhoven University of Technology, Power & Flow Group

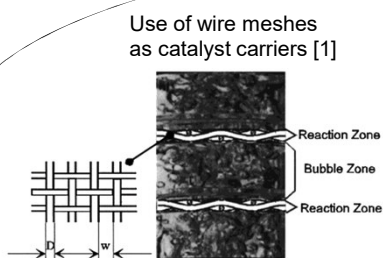
Motivation

- Widespread use of bubble columns in industry with high optimization potential
- Installation of internals in the reactor to break up the bubbles
 - Increase of the interfacial area
 - Increase of heat and mass transfer



Numerical simulations predict strong effect of contact angle θ on bubble breakup behavior [2]

What is the influence of wire material on bubble breakup in reality?



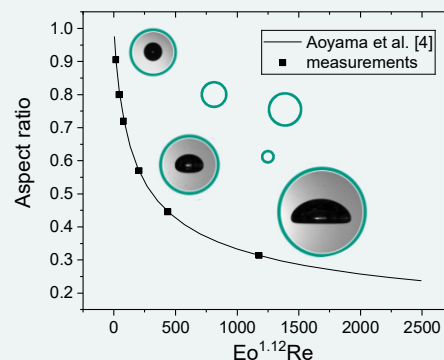
Experiments

- Experiments with 90 wt.-% viscous glycerol-water solution
- Recording of bubble cutting process by high-speed camera

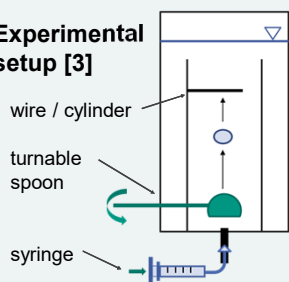
- Variation of cylinder diameter d_c and material (contact angle θ)

- $d_c = 3\text{mm}, 4\text{mm}, 5\text{mm}$
- Glass $\theta \approx 40^\circ$, Teflon $\theta \approx 90^\circ$, hydrophobic coating $\theta \approx 150^\circ$

- Image analysis with Matlab and ImageJ



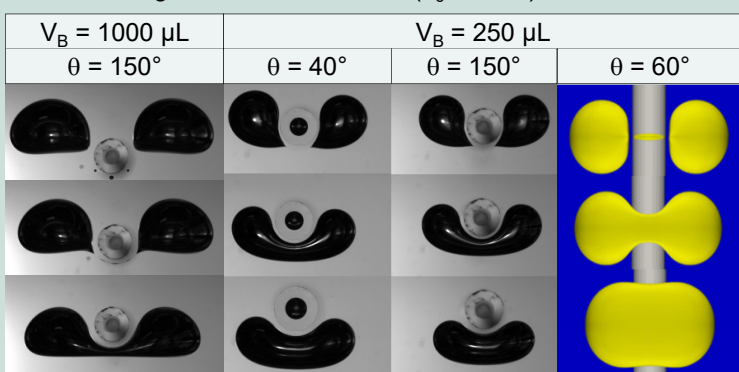
Experimental setup [3]



Bubble Volumes $V_B / \mu\text{L}$	50, 250, 500, 1000
Equivalent diameter / mm	4.6 - 12.4
Eötvös number $E_o / -$	3.8 - 27.3
Morton number $Mo / -$	0.0164

Results

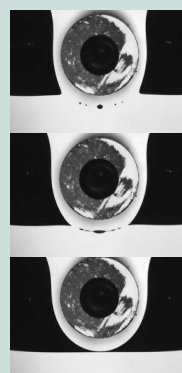
Bubble cutting at various conditions ($d_c = 4\text{mm}$)



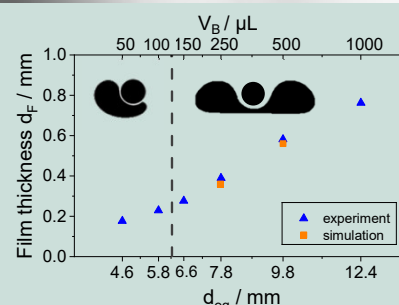
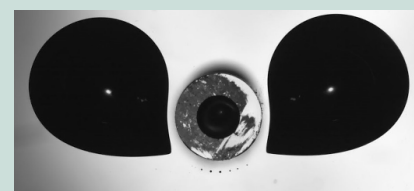
Experimental recordings (side view)

Numerical simulation, bottom view [6]

- Bubble size and velocity affect film thickness during cutting
- Formation of satellite bubbles during breakup of large bubbles



Formation of small satellite bubbles by fragmentation of a gas thread during bubble breakup



Increasing film thickness with V_B [5]

Conclusions

- Separation of bubbles and cylinder by a uniform liquid film
- No influence of cylinder wettability on bubble cutting process

[1] Höller et al., *Ind. Eng. Chem. Res.* **40** (2001) 1575–1579
[2] Cai et al., *Catalysis Today* **273** (2016) 151–160
[3] Q. Segers, PhD thesis, TU Eindhoven, 2015

[4] Aoyama et al., *Int. J. Multiphase Flow* **79** (2016), 23–30
[5] P. Rohlf, Bachelor thesis, KIT, 2018
[6] S. Wang, Master thesis, KIT, 2019