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Coalescence Modelling for Settler Design

David Leleu, Andreas Pfennig
dleleu@uliege.be
Products, Environment, and Processes (PEPs)
Department of Chemical Engineering
Université de Liège
www.chemeng.uliege.be/Pfennig

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agenda

- introduction
- coalescence probability
- contact time
- coalescence time
- summary
- settling simulation

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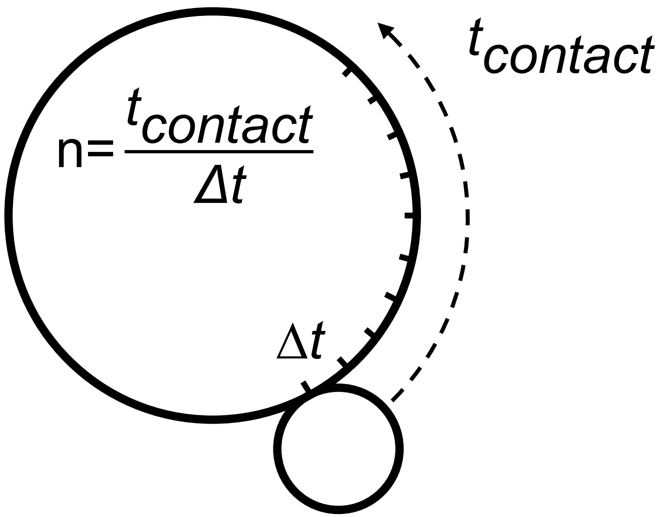
technical equipment’s

coalescence probability: fundamental investigation

$$p_{coal,C\&T} = \exp\left(-\frac{t_{coal}}{t_{contact}}\right)$$



$$p_{non-coal,n\Delta t} = p_{non-coal,\Delta t}{}^{n}$$

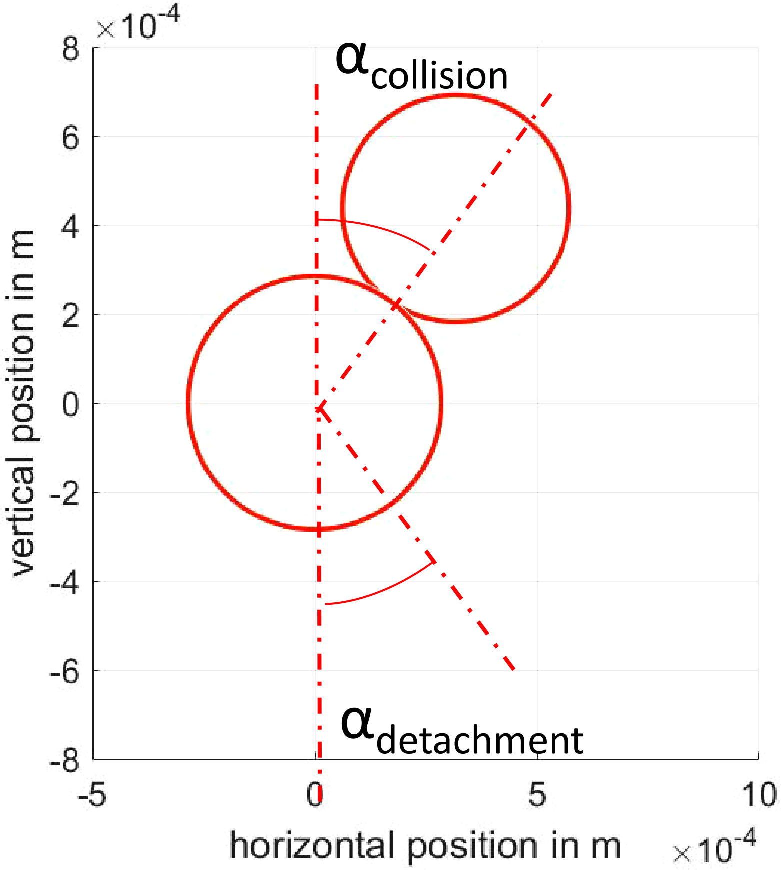
$$p_{non-coal,\Delta t} = \exp\left(-\frac{\Delta t}{t_{coal}}\right)$$

$$p_{non-coal,n\Delta t} = \exp\left(-\frac{n\Delta t}{t_{coal}}\right)$$

$$p_{non-coal} = \exp\left(-\frac{t_{contact}}{t_{coal}}\right)$$

$$p_{coal} = 1-\exp\left(-\frac{t_{contact}}{t_{coal}}\right)$$

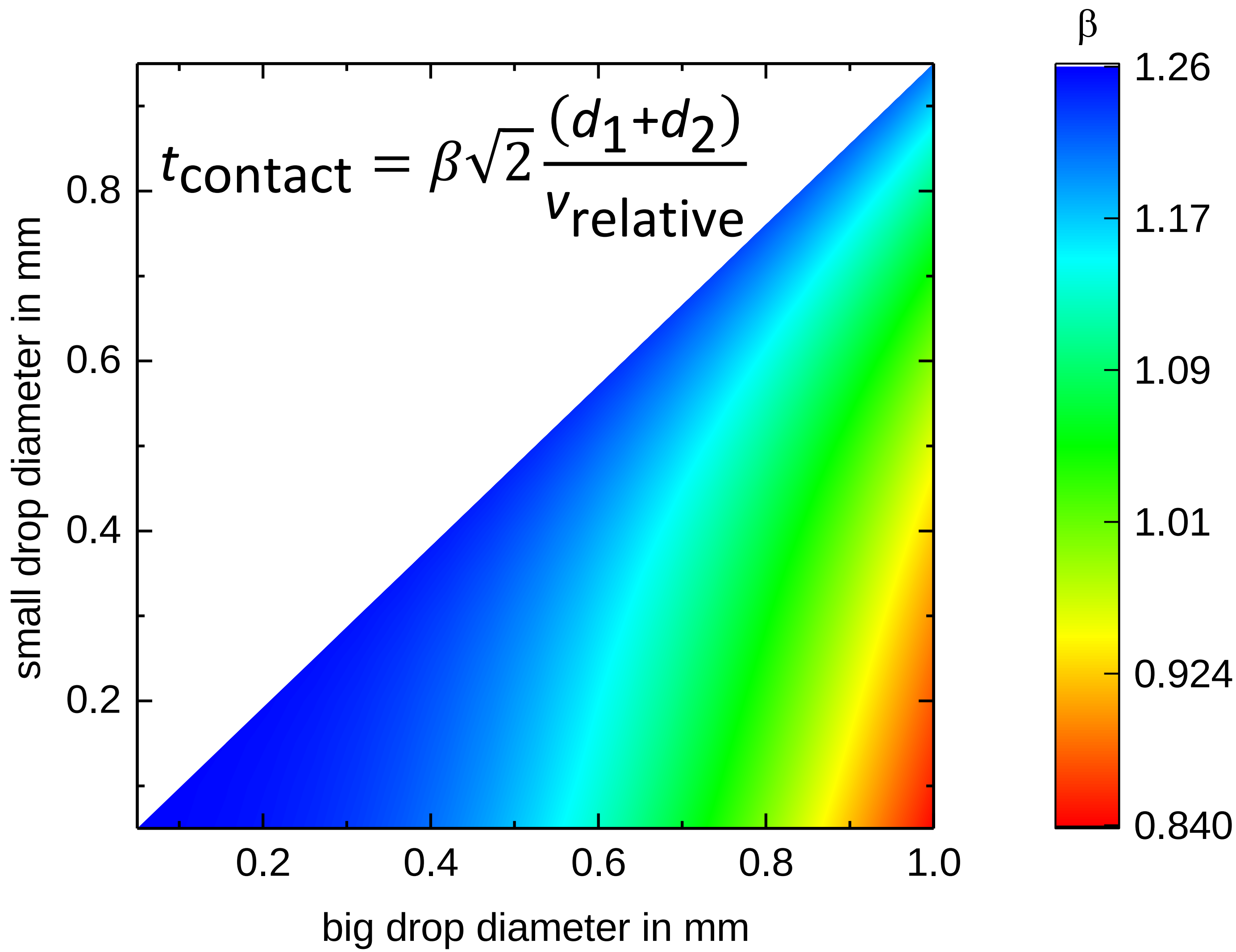
contact time: motion simulation



$$t_{\mathrm{contact}} \approx \sqrt{2}\,\frac{(d_1+d_2)}{v_{\mathrm{relative}}}$$

- assumptions:
  - drops follow contour during the sedimentation
  - detachment angle = random between π/2 and π

contact time: simulations vs model



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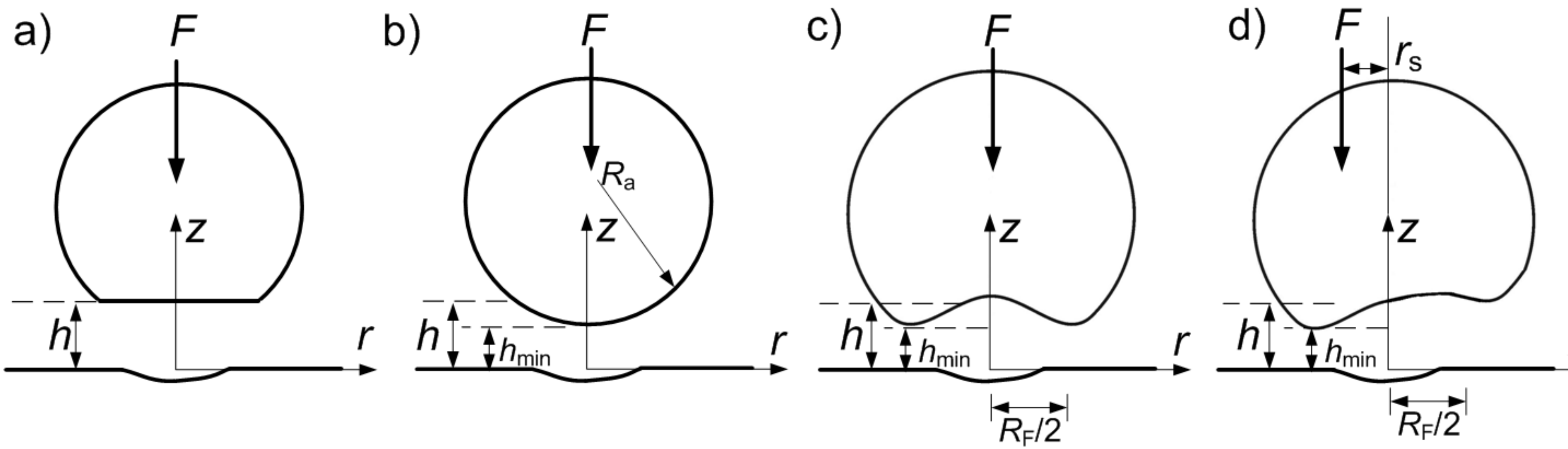
coalescence time: asymmetric dimple



Kopriwa, PhD thesis, 2013

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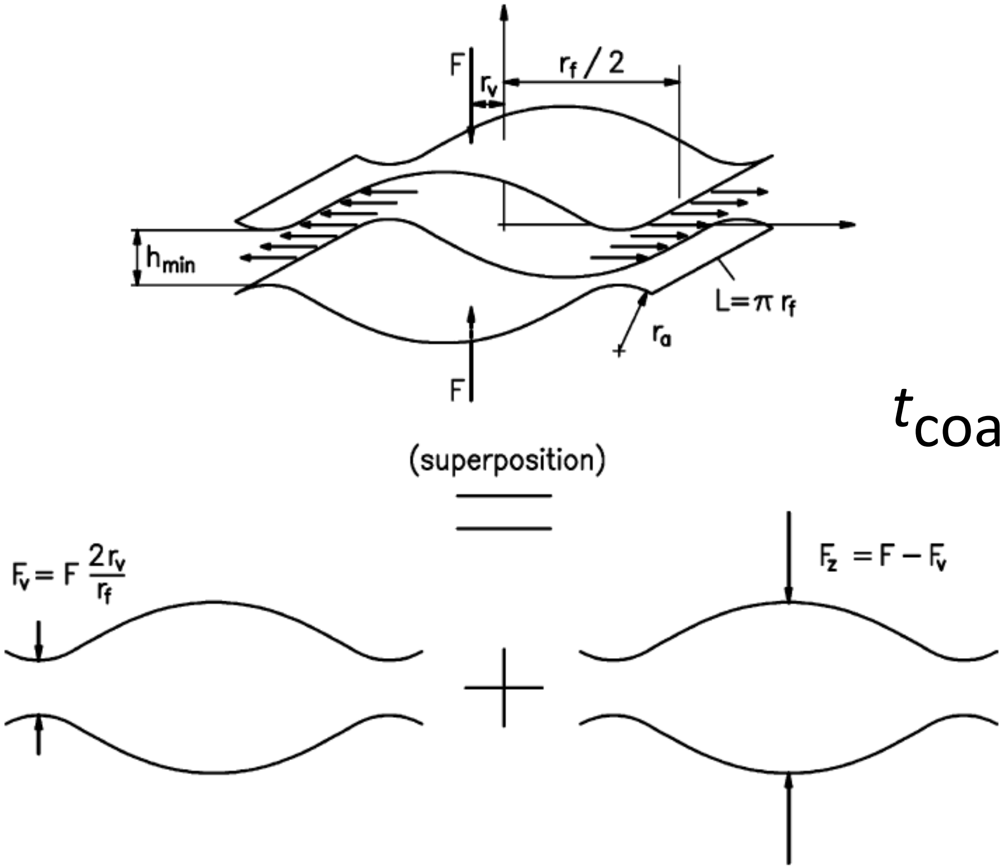
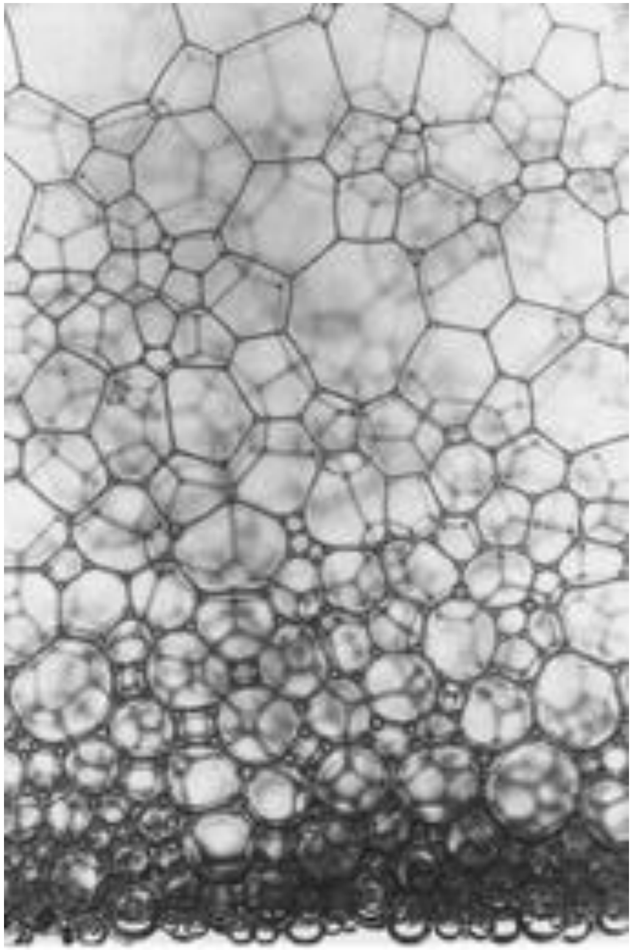
coalescence time: film drainage process



$$t_{coalescence} = \frac{3\pi^{1.5} \mu R_f R_a^{1.5}}{4 r_s^* F_{driving} \sqrt{h_{min}}}$$

Henschke, Chemical Engineering Journal 85 (2002) 369–378

close-packed zone



Arnaud Saint-Jalmes, 2006

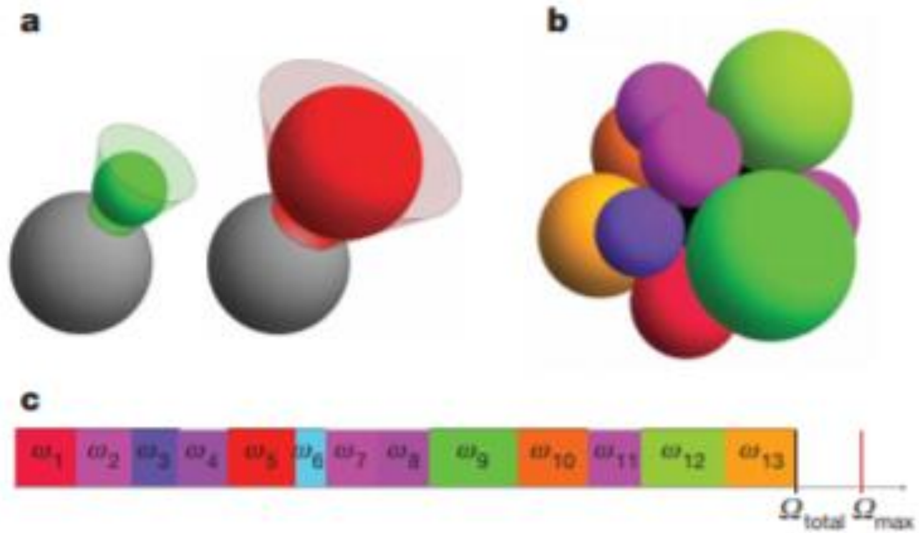
- drops deformation

  $R_{dimple} \propto A_{contact}$

- film drainage

  $F_{driving} \propto \Delta P_{hydro} - \Delta P_{flow}$

polydispersed packing



$$\mu \in [0;1mm] \text{ and } \sigma \in [0;50\%]$$

$$\rightarrow \varepsilon \in [70\%;80\%]$$

Corwin et al. Nature 460 (2009) 611-615

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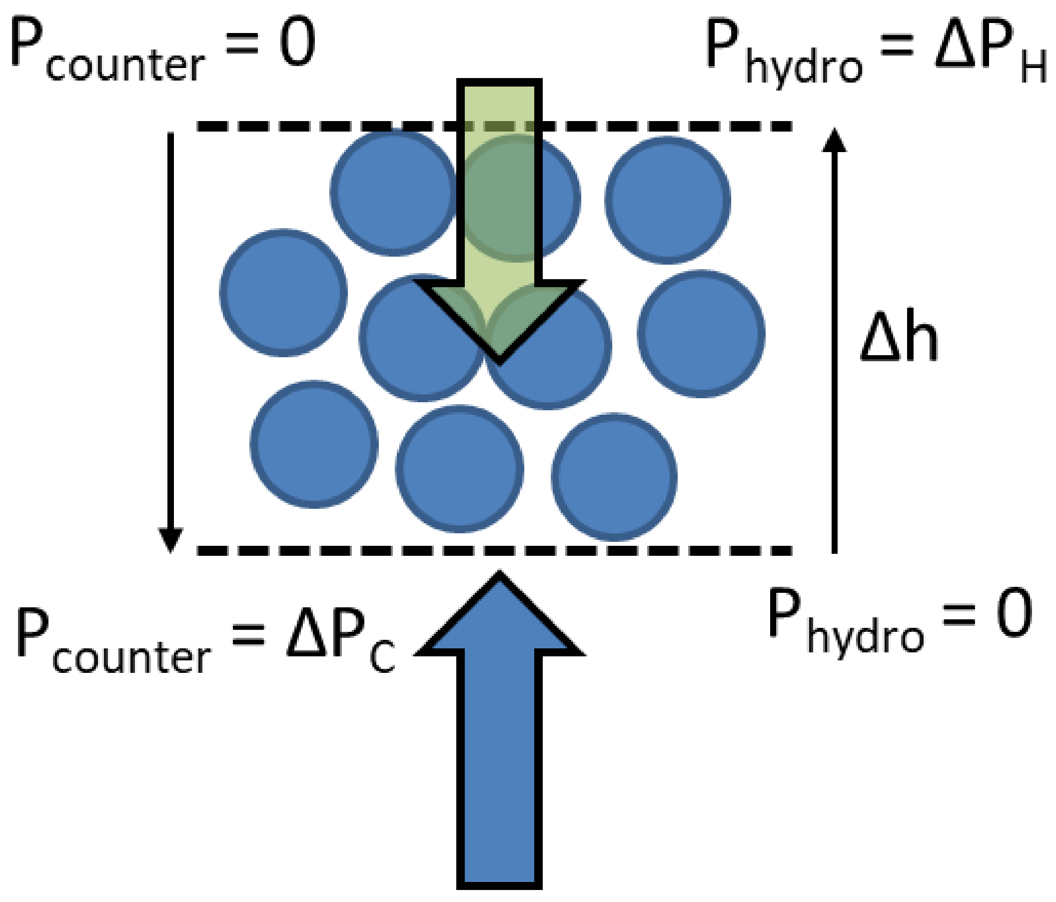
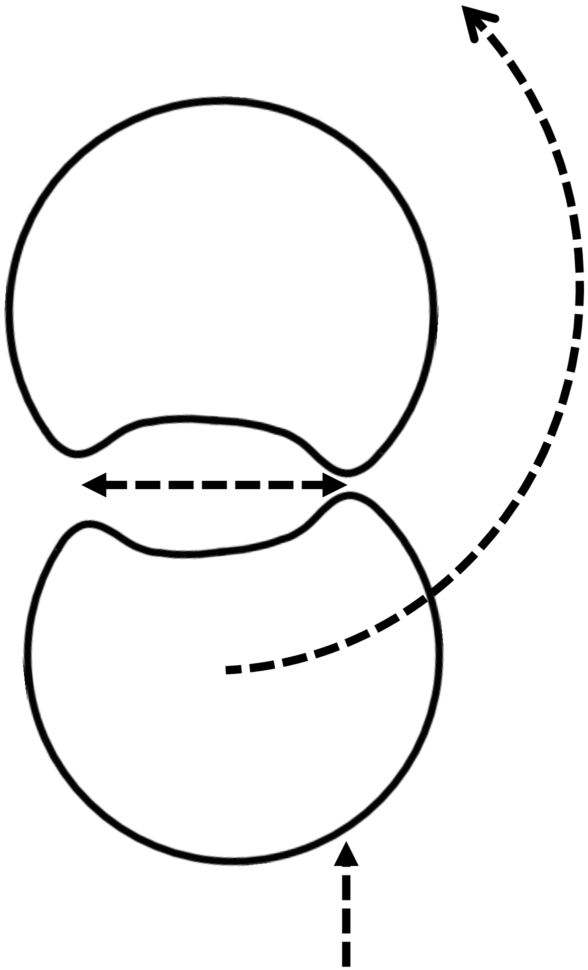
counterflow



$$\Delta P_{total} = \Delta P_H - \Delta P_C$$

summary



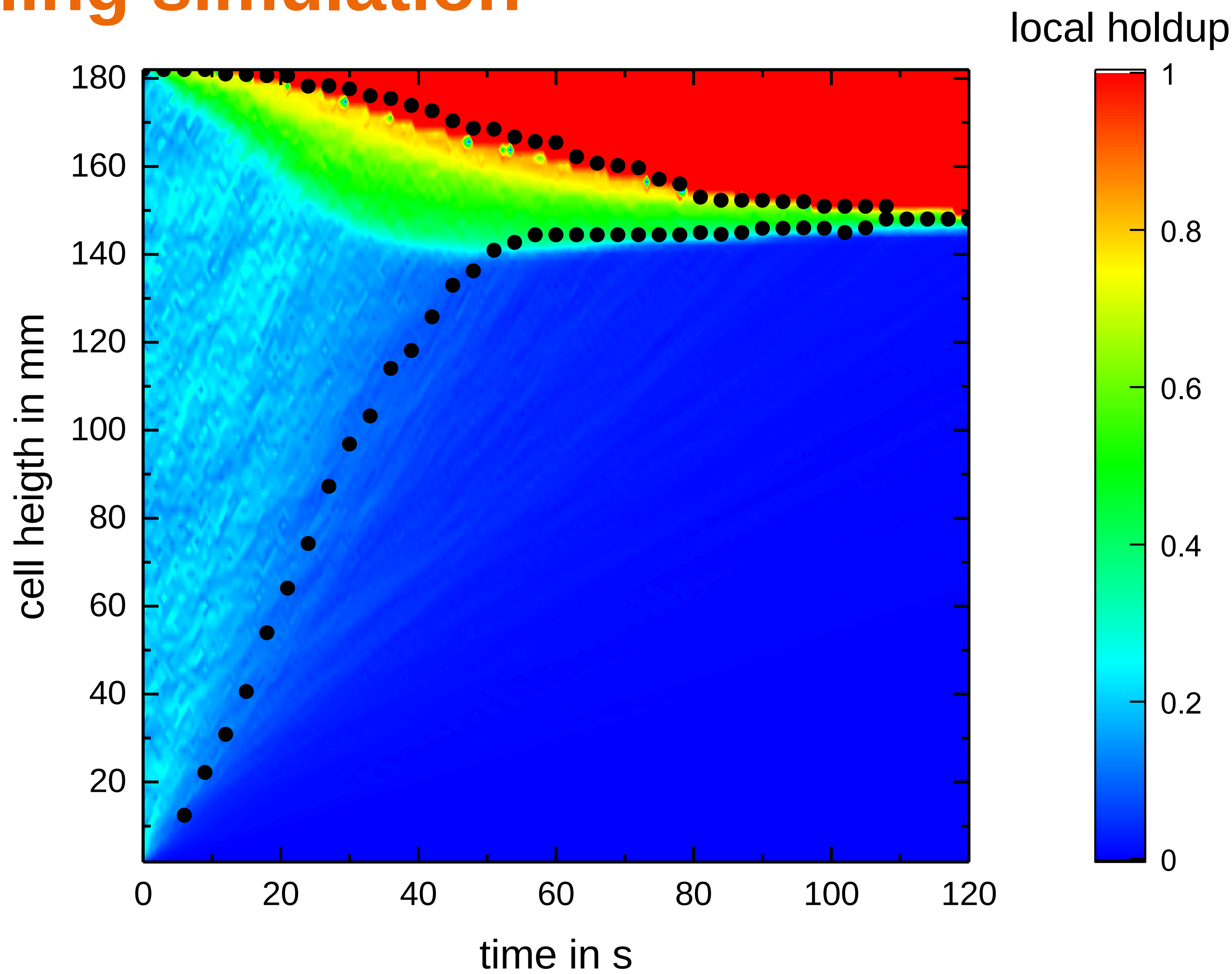
$$p_{coal} = 1 - \exp\left(-\frac{t_{contact}}{t_{coal}}\right)$$

$$t_{contact} \propto \frac{(d_1 + d_2)}{v_{relative}}$$

$$\text{dimple} \propto \begin{cases} \text{drops diameter} \\ \text{deformed drops dimension} \end{cases}$$

$$F_{driving} = \begin{cases} F_{buoyancy} \\ F_{turbulences} \\ F_{hydrostatic\_pressure} \end{cases}$$

settling simulation



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