Breaking up is easy, coalescence is hard

Citation for published version (APA):
Janssen, P. J. A., Anderson, P. D., Peters, G. W. M., & Meijer, H. E. H. (2005). *Breaking up is easy, coalescence is hard*. Poster session presented at Mate Poster Award 2005 : 10th Annual Poster Contest.

Document status and date:
Published: 01/01/2005

Document Version:
Publisher’s PDF, also known as Version of Record (includes final page, issue and volume numbers)

Please check the document version of this publication:

• A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
• The final author version and the galley proof are versions of the publication after peer review.
• The final published version features the final layout of the paper including the volume, issue and page numbers.

Link to publication

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal.

If the publication is distributed under the terms of Article 25fa of the Dutch Copyright Act, indicated by the “Taverne” license above, please follow below link for the End User Agreement:

www.tue.nl/taverne

Take down policy
If you believe that this document breaches copyright please contact us at:

openaccess@tue.nl

providing details and we will investigate your claim.

Download date: 17. Nov. 2023

TU/e technische universiteit eindhoven

Breaking up is easy, coalescence is hard

P.J.A. Janssen, P.D. Anderson, G.W.M. Peters and H.E.H. Meijer

Introduction

Drop break-up and coalescence are the two competing mechanisms that determine the microstructure of a blend. Break-up is unavoidable at a relatively large neck radius d (see figure 1), while for coalescence the dimensions of the film between two drops can be many orders smaller than R (figure 2), and still it is not sure if they merge. The extreme length scales involved ($h \ll a \ll R$) complicate studies on coalescence and therefore asymptotic theories are used that only model the film.

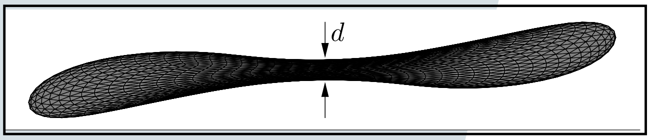

Figure 1 *A drop breaking up in shear flow.*

Objective

To determine the parameter space where asymptotic theories, that use lubrication theory for the film drainage, can be applied.

Method

- ☐ Boundary integral method [1], that gives the velocity:

$$\mathbf{u}(\mathbf{x}_0) = \mathbf{u}_\infty(\mathbf{x}_0) - \frac{1}{8\pi}\int_S \mathbf{G}(\mathbf{x}_0, \mathbf{x}) \cdot \mathbf{f}(\mathbf{x}) dS(\mathbf{x}).$$

- ☐ Only capillary and disjoining pressure included:

$$\mathbf{f}(\mathbf{x}) = \frac{1}{\mathrm{Ca}}\left(2\kappa(\mathbf{x}) - \frac{A}{h^3(\mathbf{x})}\right)\mathbf{n}(\mathbf{x}).$$

Results

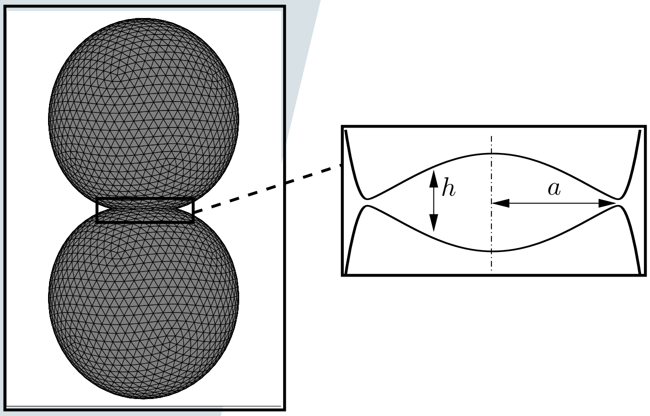

Figure 2 *Two coalescing drops and the thin film that forms between them.*

Film drainage

Coalescence occurs if van der Waals forces become dominant over capillary forces ($h_{min} < h_{crit}$) and rupture the film, thus the evolution of h_{min} is one of the most important parameters to investigate (figure 3). Due to the external flow, a stationary profile can form (figures 3 and 4). The film drainage for low capillary numbers is only in partial agreement with asymptotic theories [3].

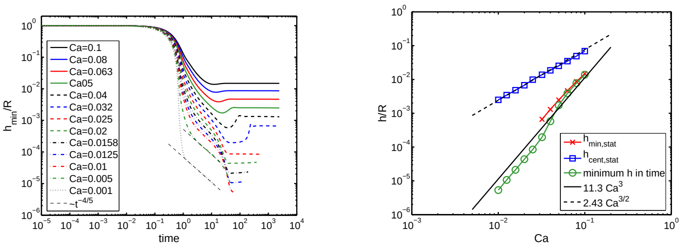

Figure 3 *Film drainage for multiple Ca (left) and the stationary film thickness obtained, alongside two predictions from [2] (right).*

Van der Waals forces

While the film drainage itself does not fully correspond, we find an excellent match for the critical film thickness (figure 4 left) with an asymptotic theory [4].

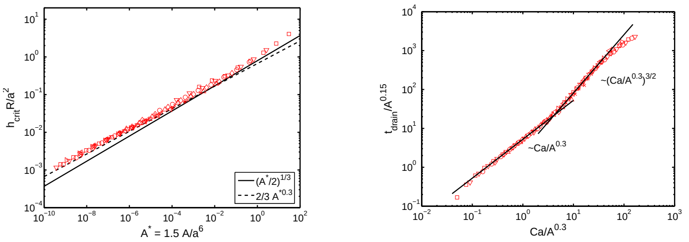

Figure 4 Critical film thickness as function of Hamaker parameter A (left), and drainage time as function of Ca and A (right).

Drainage time

A new scaling is found for the drainage time (figure 4 right) [3], but, using a relatively simple model, we can find the drainage time as:

$$t_{drain}A^{-0.15} \sim \mathrm{Ca}A^{-0.3}$$

for touching spherical drops, and

$$t_{drain}A^{-0.15} \sim \left(\mathrm{Ca}A^{-0.3}\right)^{3/2}$$

for a collision with a fully developed film.

Conclusions

- ☐ Numerical method available to simulate coalescence with realistic length scales for full parameter range.
- ☐ Parameter space determined where asymptotic theories are valid.

Future work

- ☐ Effects of surfactants.
- ☐ Effects of confined geometries on break-up.

References:

[1] Bazhlekov *et al.*, Phys.Fluids 16, pp 1064, 2004
[2] Nemer *et al.*, Phys. Review Letters, 92, 114501, 2004
[3] Janssen *et al.*, J. Fluid Mech., submitted
[4] Chesters *et al.*, J. Colloid Interface Sci., 230, pp 229, 2000

/**department of mechanical engineering**

PO Box 513, 5600 MB Eindhoven, the Netherlands