Enhanced and suppressed breakup of drops in confined geometries

Citation for published version (APA):
Janssen, P. J. A., Anderson, P. D., & Meijer, H. E. H. (2008). *Enhanced and suppressed breakup of drops in confined geometries*. Poster session presented at Mate Poster Award 2008 : 13th Annual Poster Contest.

Document status and date:
Published: 01/01/2008

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: 16. Nov. 2023

Polymer Technology

Technische Universiteit
Eindhoven
University of Technology

Enhanced and suppressed breakup of drops in confined geometries

P.J.A. Janssen, P.D. Anderson, and H.E.H. Meijer
Den Dolech 2, PO Box 513, Eindhoven, The Netherlands

DUTCH POLYMER INSTITUTE

Introduction

The Grace curve is a set of experimental data that describes the relationship between the viscosity ratio λ (of drop to matrix viscosity) and the capillary number Ca (ratio of viscous forces and interfacial forces) at breakup [1]. Recent experiments suggest that the behavior is different in confined geometries (Fig 1.), depending on the viscosity ratio [2]:

- $\mathrm{Ca}_{\mathrm{crit}}$ goes up for low-viscosity drops with increasing confinement ratio R/W.
- Equi-viscous drops are hardly affected.
- $\mathrm{Ca}_{\mathrm{crit}}$ goes down for high-viscosity drops.

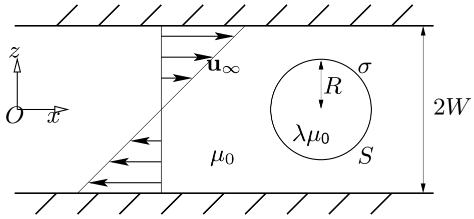

Fig. 1 *Schematic picture of the problem.*

Objective

Investigate and explain the breakup behavior of confined drops.

Methods

A boundary-integral method is used for the numerical simulations [3]. The experimental and numerical method are complementary to each other, as the simulations have difficulty with low-viscosity drops, while high-viscosity drops give complications in the experiments.

Results

The critical capillary number for a large number of viscosity and confinement ratios is found in both experiments, as well as using our numerical method (Fig. 2).

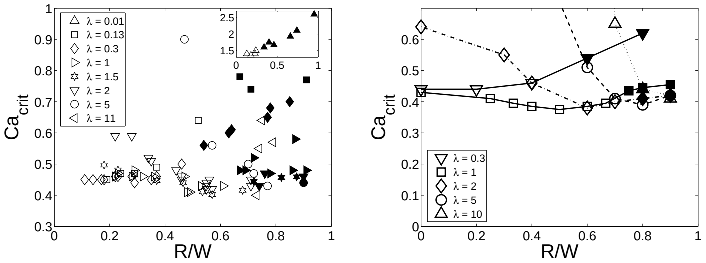

Fig. 2 *Ca_{crit} as function of the confinement ratio R/W for a large number of viscosity ratios λ. Experimental data left, and numerical results right.*

Both methods show enhanced and suppressed breakup, depending on the viscosity and confinement ratio, and ternary breakup at high confinement ratios (Fig. 3, right).

Breakup mechanism

To explain the behavior, we look at the influence of the walls on the rotation of the drop, and define several regions:

I Unconfined behavior
II The walls hinder rotation: $\mathrm{Ca}_{\mathrm{crit}}$ goes down
III Balance between II and IV
IV Drops become long and align more in flow direction: $\mathrm{Ca}_{\mathrm{crit}}$ goes up; onset of ternary breakup.
V Asymptotic regime reached [4]

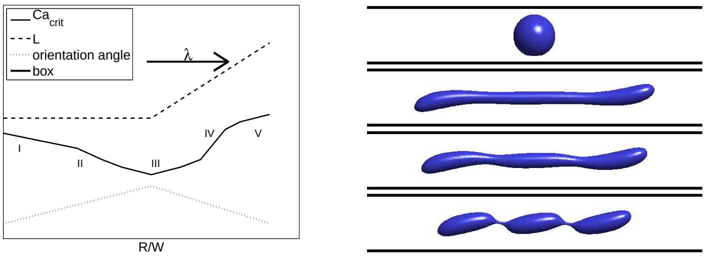

Fig. 3 *Left: effect of the confinement on breakup. Right: ternary breakup.*

Data to support this assumption is given in the next figure, where drop length and orientation angle in stable situations just below $\mathrm{Ca}_{\mathrm{crit}}$ are given. The shift over the confinement axis is obvious.

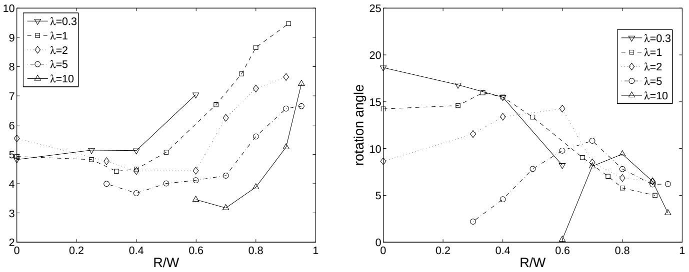

Fig. 4 *Drop length and orientation angle for sub-critical Ca.*

Conclusions

The effect of confinement on drop breakup is investigated. Enhanced and suppressed breakup are explained by different alignment in flow direction. All viscosity ratios show the same behavior, but are shifted over the confinement axis, yielding *seemingly* different behavior for high and low viscosity ratios.

References:

[1] H.P. Grace, Chem. Eng. Commun., 14:225, 1982

[2] A. Vananroye, P. van Puyvelde, and P. Moldenaers, Langmuir, 22:3972, 2006.

[3] P.J.A. Janssen and P.D. Anderson, J. Comput. Phys., 227:8807, 2008

[4] P.J.A. Janssen, Ph.D. thesis, Eindhoven University of Technology, 2009