

Contents

Nomenclature	xix
1 Introduction	1
2 State of Knowledge	7
2.1 Fundamentals of Fluid Mechanics and Deformation of Fluid Elements .	7
2.2 Mass Transfer	11
2.3 Forces Acting on Bubbles in Bubbly Flows	19
2.4 The Viscoelastic Behaviour of Material	26
2.5 Typical Attempts to Predict Bubble Sizes	30
2.5.1 Critical Diameter	30
2.5.2 The Population Balance Equation	32
2.5.3 Highly Resolved Numerical Simulations	34
2.6 The Lattice Boltzmann Method	37
3 The Breakup Model	41
3.1 Approximation of Bubble Shape, Volume, and Surface	42
3.2 Modelling of the Bubble Deformations	43
3.2.1 Prolate Deformation	43
3.2.2 Oblate Deformation	46
3.3 Bubble Breakup	46
3.3.1 The Breakup Criterion	47
3.3.2 Daughter Bubble Sizes	49
4 Computational and Experimental Methods	51
4.1 Geometric Setup	51
4.2 Simulative Procedure	52
4.3 Experimental Methods	54

Contents

5 Results and Discussion 59

5.1 Assuring Grid Convergence 59

5.2 Results of the Flow Field 59

5.3 Results of Bubble Trajectories 60

5.4 Influence of the Initial Bubble Size 63

5.5 Bubble Size Distribution Under Pure Prolate Deformation 63

5.6 Bubble Size Distribution Under Prolate and Oblate Deformation 67

5.7 Influence of the Breakup Criterion 69

5.8 Resulting Mass Transfer 72

6 Conclusion and Outlook 81

Bibliography 85

Appendix A Mathematical Fundamentals 97

A.1 Eigenvalue Estimation with the Power Method 97

A.2 Orthogonal Projection of a Vector 98