

Contents

| | | |
|----------|---|-----------|
| 1 | Introduction | 1 |
| 2 | State of the art and research goals | 7 |
| 2.1 | Steady-state interfaces under isothermal conditions | 8 |
| 2.1.1 | Steady-state interfaces | 9 |
| 2.1.2 | Static contact lines and angles | 10 |
| 2.2 | Contact line boundary conditions under isothermal conditions | 10 |
| 2.2.1 | Moving contact lines and dynamic contact angles | 11 |
| 2.2.2 | Relations for the dynamic contact angle and the contact line motion | 13 |
| 2.3 | Phase change at the interface and the contact line | 15 |
| 2.4 | Contact line boundary conditions with interfacial phase change | 17 |
| 2.4.1 | Relations for the dynamic contact angle | 17 |
| 2.5 | Capillary-driven flow with interfacial phase change | 21 |
| 2.5.1 | Capillary rise with phase change | 22 |
| 2.5.2 | Droplet spreading with phase change | 24 |
| 2.6 | Reorientation and damped interface oscillations | 28 |
| 2.6.1 | Isothermal reorientation and interface oscillations | 28 |
| 2.6.2 | Non-isothermal reorientation | 40 |
| 2.7 | Synopsis and goals of the present work | 40 |
| 3 | Theory | 45 |
| 3.1 | Model assumptions and implications | 45 |
| 3.2 | Interface configurations during the non-isothermal reorientation | 46 |
| 3.2.1 | Steady-state interface under terrestrial gravity | 48 |
| 3.2.2 | Steady-state interface under microgravity | 49 |
| 3.3 | Field equations, boundary conditions and scaling | 50 |
| 3.3.1 | Dimensional form of the field equations and boundary conditions | 50 |
| 3.3.2 | Non-dimensional form of the field equations and boundary conditions | 53 |
| 3.3.3 | Scaling concept and ranges | 59 |
| 3.4 | Step response of linear systems of second order | 62 |
| 3.4.1 | General characteristics of the step response | 63 |
| 3.4.2 | Transient characteristics of the step response | 66 |



XII Contents

| | |
|---|-----|
| 4 Materials and methods. | 69 |
| 4.1 Cryostat setups. Operation and experiment preparation. | 69 |
| 4.1.1 Cryostat setups | 70 |
| 4.1.2 Operation and experiment preparation. | 72 |
| 4.2 Experimental cylinders and liquids | 73 |
| 4.3 Temperature measurement | 77 |
| 4.4 Pressure measurement. | 77 |
| 4.5 Heating equipment | 77 |
| 4.6 Illumination unit and reflector | 77 |
| 4.7 Visual detection and data evaluation | 78 |
| 4.7.1 Refraction | 78 |
| 4.7.2 Fisheye effect | 81 |
| 4.7.3 Acquisition of the interface position | 82 |
| 4.8 Experimental procedure | 82 |
| 5 Experimental results and discussion | 85 |
| 5.1 Experiment features | 85 |
| 5.1.1 Experiment M17 with LCH ₄ and 1.9 K/mm | 86 |
| 5.2 Interface dynamics | 90 |
| 5.2.1 Center point. | 90 |
| 5.2.2 Contact line | 95 |
| 6 Conclusions and outlook | 103 |
| References | 105 |
| A Appendix | 109 |
| A.1 Experimental parameters | 109 |
| A.1.1 Initial conditions | 109 |
| A.1.2 Scales | 114 |
| A.1.3 Dimensionless numbers | 116 |
| A.2 Experimental results | 118 |
| A.2.1 Tables with the values of the interface characteristics | 118 |
| A.2.2 Tables with the values of the pressure and temperature characteristics | 122 |
| A.2.3 Plots of the temperature evolutions | 127 |
| A.3 Material properties | 146 |