Contents

List of Figures xiil
List of Tables xvii
Nomenclature xix

1 Introduction 1
  1.1 Technological Background .............................. 1
  1.2 Droplet and Spray Combustion .......................... 2
  1.3 Oxides of Nitrogen Formation ........................... 4
  1.4 Motivation and Goals of this Thesis .................... 5
  1.5 Thesis Overview ....................................... 7

2 Combustion Theory 9
  2.1 Classification of Combustion Processes ................. 9
    2.1.1 Premixed and Nonpremixed Flames .................. 10
    2.1.2 Inhomogeneous and Partially Premixed Combustion ... 15
    2.1.3 Droplet Combustion ................................ 19
  2.2 Theory of Exhaust Gas Formation ....................... 27
    2.2.1 Carbon Monoxide .................................. 28
    2.2.2 Unburned Hydrocarbons ............................. 29
    2.2.3 Oxides of Nitrogen ................................ 30
    2.2.4 Particulate Matter ................................ 39
  2.3 Kinetic Modeling ...................................... 40
    2.3.1 Hydrocarbon Mechanism ............................. 40
    2.3.2 Nitrogen Oxide Chemistry .......................... 43
    2.3.3 Validation of the Combined Mechanism ............... 46

3 Experiments on Droplet Array Combustion 57
  3.1 Droplet Combustion Facility ........................... 58
CONTENTS

5 Results 155
5.1 Droplets in Exhaust Gas Atmosphere 156
5.2 Combustion of Partially Pre-Vaporized Droplets 161
  5.2.1 Numerical Results on Single Droplet Combustion 161
  5.2.2 Impact of Ignition Position 163
  5.2.3 Comparison with Microgravity Experiments on Droplet Arrays 174
5.3 Influence of Ambient Preheating 179
5.4 Influence of Droplet Size 185
5.5 Final Evaluation of Results 189
5.6 Recommendations and Future Tasks 192

6 Summary and Conclusions 195

APPENDIX 197

A Chemical Mechanisms 199
  A.1 Global Kinetics 199
  A.2 Concepts of Kinetics Reduction 202

B Investigated Conditions 208
  B.1 Experiment Operation Conditions for Droplet Array Combustion 208
  B.2 Supplementary Data on Numerical Simulations 212

C Design Details of Experiment Equipment 214
  C.1 Key Data of Experimental Setup 214
  C.2 Construction and Manufacturing Details 220

D Raw Data of Microgravity Experiments 223

Supervised Theses 229

References 233