

Sergei Sazhin

Droplets and Sprays

 Springer

Contents

1	Introduction	1
1.1	Scope of the Book	1
1.2	Topics and Assumptions	3
	References	4
2	Spray Formation and Penetration	9
2.1	Spray Formation.	9
2.1.1	Classical WAVE Model	11
2.1.2	TAB and Stochastic Models.	15
2.1.3	Modified WAVE Models.	17
2.2	Spray Penetration	24
2.2.1	The Initial Stage.	24
2.2.2	Two-Phase Flow.	25
2.2.3	Effects of Turbulence	29
2.3	Vortex Ring-like Structures in Sprays	32
2.3.1	Conventional Vortex Rings	33
2.3.2	Turbulent Vortex Rings.	37
2.3.3	Translational Velocities of the Vortex Rings-like Structures	39
	References	41
3	Heating of Non-evaporating Droplets	49
3.1	Convective Heating.	50
3.1.1	Stagnant Droplets	50
3.1.2	Moving Droplets	66
3.2	Radiative Heating.	77
3.2.1	Basic Equations and Approximations	77
3.2.2	Mie Theory	79
3.2.3	Integral Absorption of Radiation in Droplets	82
3.2.4	Geometric Optics Analysis	85
	References	89

4	Heating and Evaporation of Monocomponent Droplets	97
4.1	Empirical Correlations	98
4.2	Classical Models	101
4.2.1	Maxwell and Stefan–Fuchs Models.	101
4.2.2	Abramzon and Sirignano Model.	106
4.2.3	Yao, Abdel–Khalik, and Ghiaasiaan Model	109
4.2.4	Tonini and Cossali Model	111
4.3	Effects of Real Gases	114
4.4	Effects of the Moving Interface	117
4.4.1	Basic Equations and Approximations	118
4.4.2	Solution When $R_d(t)$ Is a Linear Function.	119
4.4.3	Solution for Arbitrary $R_d(t)$ but $T_{d0}(R) = \text{const}$	121
4.4.4	Solution for Arbitrary $R_d(t)$ and $T_{d0}(R)$	123
4.4.5	Results	126
4.5	Modelling versus Experimental Data.	130
	References	137
5	Heating and Evaporation of Multicomponent Droplets.	143
5.1	Background	144
5.2	Bicomponent Droplets.	149
5.2.1	Analytical Solutions to the Species Equation	150
5.2.2	Analysis of the Results	152
5.3	Quasidiscrete Model	162
5.3.1	Description of the Model.	162
5.3.2	Application to Diesel and Gasoline Fuel Droplets	166
	References	175
6	Kinetic Modelling of Droplet Heating and Evaporation	179
6.1	Early Results	180
6.2	Kinetic Algorithm: Effects of the Heat and Mass Fluxes.	188
6.2.1	Boltzmann Equations for the Kinetic Region	188
6.2.2	Vapour Density and Temperature at the Boundaries	193
6.3	Approximations of the Kinetic Results	197
6.3.1	Approximations for Chosen Gas Temperatures.	198
6.3.2	Approximations for Chosen Initial Droplet Radii	202
6.4	Effects of Inelastic Collisions.	205
6.4.1	Mathematical Model	206
6.4.2	Solution Algorithm	213
6.5	Kinetic Boundary Condition.	216
6.5.1	Molecular Dynamics Simulations (Background).	217
6.5.2	United Atom Model	220
6.5.3	Evaporation Coefficient.	223

6.6	Results of the Kinetic Calculations	226
6.6.1	Results for $\beta_m = 1$	226
6.6.2	Results for $\beta_m < 1$	229
6.7	Kinetic Modelling in the Presence of Three Components	230
	References	236
7	Heating, Evaporation and Autoignition of Sprays	245
7.1	Autoignition Modelling	246
7.2	Coupled Solution: A Simplified Model	250
7.2.1	Physical Model	250
7.2.2	Mathematical Formulation	251
7.2.3	Analysis	253
7.3	Coupled Solution: Dynamic Decomposition	256
7.3.1	Decomposition Techniques	256
7.3.2	Description of the Method	258
7.3.3	Application of the Method	262
	References	270
	Appendix A: Derivation of Formula (3.77)	277
	Appendix B: Derivation of Formula (3.95)	285
	Appendix C: Proof of Orthogonality of $v_n(R)$ with the Weight b	291
	Appendix D: Derivation of Formula (4.86)	293
	Appendix E: Convergence of the Series in $G_I(t, \tau, r)$	305
	Appendix F: Numerical Solution of Equation (D.36)	309
	Appendix G: Numerical Calculation of the Improper Integrals	313
	Appendix H: Derivation of Formula (5.18)	315
	Appendix I: Derivation of Formula (5.24)	323
	Appendix J: Derivation of Formula (I.29)	333
	Appendix K: Approximations for Alkane Fuel Properties	335
	Appendix L: Tikhonov's Theorem	343