

Contents

Mathematical Modelling of Glass Forming Processes	1
J.A.W.M. Groot, Robert M.M. Mattheij, and K.Y. Laevsky	
1 Introduction	2
1.1 Glass Forming	2
1.2 Process Simulation	6
1.3 Outline	7
2 Mathematical Model	8
2.1 Geometry, Problem Domains and Boundaries	8
2.2 Balance Laws	9
3 Parison Press Model	16
3.1 Mathematical Model	16
3.2 Slender-Geometry Approximation	18
3.3 Motion of the Plunger	23
3.4 Simulation Model	26
3.5 Results	30
4 Blow Model	31
4.1 Mathematical Model	32
4.2 Glass-Air Interfaces	36
4.3 Variational Formulation	39
4.4 Simulation Model	42
4.5 Results	45
5 Direct Press Model	46
5.1 Mathematical Model	47
5.2 Simulation Model	49
5.3 Results	51
References	53
 Radiative Heat Transfer and Applications for Glass Production Processes	57
Martin Frank and Axel Klar	
1 Introduction	57
2 Radiative Heat Transfer Equations for Glass	58
2.1 Fundamental Quantities	59

2.2	Blackbody Radiation	61
2.3	The Transfer Equation.....	62
2.4	Overall Energy Conservation	65
2.5	Boundary Conditions.....	66
2.6	Summary	68
3	Direct Numerical Methods	70
3.1	Ordinates and Space Discretizations	71
3.2	Linear System Formulation	73
3.3	Preconditioning Techniques.....	77
3.4	A Fast Multilevel Preconditioner	82
3.5	Numerical Results	85
4	Higher-Order Diffusion Approximations.....	92
4.1	Asymptotic Analysis and Derivation of the SP_N Approximations	94
4.2	Boundary Conditions for SP_N Approximations.....	100
5	Moment Models	104
5.1	Spherical Harmonics	105
5.2	Minimum Entropy Closure.....	107
5.3	Flux-Limited Diffusion and Entropy Minimization	108
5.4	Partial Moments	110
5.5	Partial Moment P_N Closure	112
5.6	Partial Moment Entropy Closure	113
6	Frequency-Averaged Moment Equations.....	115
6.1	Entropy Minimization	116
6.2	Inversion of the System	117
6.3	Properties	118
7	Numerical Comparisons.....	119
7.1	Numerical Results	119
7.2	Grey Transport.....	119
7.3	Grey Cooling	120
7.4	Multigroup Transport.....	123
7.5	Multigroup Cooling	125
7.6	Adaptive methods for the Simulation of 2-d and 3-d Cooling Processes.....	125
	References	131

Radiative Heat Transfer and Applications for Glass Production

Processes II 135

Norbert Siedow

1	Introduction	135
2	Models for Fast Radiative Heat Transfer Simulation	137
2.1	Introduction	137
3	Indirect Temperature Measurement of Hot Glasses.....	148
3.1	Introduction	148

3.2	The Basic Equation of Spectral Remote Temperature Sensing	149
3.3	Some Basics of Inverse Problems	150
3.4	Spectral Remote Sensing	159
3.5	Reconstruction of Initial Temperature	161
3.6	Conclusions	170
References		170

Non-Isothermal Flow of Molten Glass: Mathematical

Challenges and Industrial Questions

Angiolo Farina, Antonio Fasano, and Andro Mikelić

1	Introduction	173
2	Mathematical Modelling	176
2.1	Definitions and Basic Equations	176
2.2	Fluids Physical Properties and Constitutive Equations	177
2.3	The General Model	181
2.4	Scaling and Dimensionless Formulation	183
3	Study of the Stationary Non-Isothermal Molten Glass Flow in a Die	187
3.1	Existence and Uniqueness Result for the Stationary Problem...	189
3.2	Oberbeck–Boussinesq Model	194
4	Modelling the Viscous Jet at the Exit of the Die	198
4.1	Definition of L and Jet's Profile at the End of Stage (c)	201
5	Terminal Phase of the Fiber Drawing	207
5.1	Derivation of the Model of Matovich–Pearson for the Thermal Case	209
5.2	Solvability of the Boundary Value Problems for the Stationary Effective Equations	216
References		223

List of Participants

225

Mathematical Models in the Manufacturing of Glass

C.I.M.E. Summer School, Montecatini Terme, Italy 2008

Farina, A.; Klar, A.; Mattheij, R.M.M.; Mikelić, A.; Siedow,

N. - Fasano, A. (Ed.)

2011, XI, 227 p., Softcover

ISBN: 978-3-642-15966-4