

Contents

1	Introduction	1
1.1	State of the Art	2
1.1.1	Eulerian and Lagrangian Approaches for Free Surface Flow Analysis	3
1.1.2	Stabilization Techniques	5
1.1.3	Algorithms for FSI Problems	7
1.2	Numerical Model	8
1.2.1	Reasons	8
1.2.2	Essential Features	9
1.2.3	Outline	12
	References	12
2	Velocity-Based Formulations for Compressible Materials	17
2.1	Velocity Formulation	18
2.1.1	From the Local Form to the Spatial Semi-discretization	18
2.1.2	Time Integration	20
2.1.3	Linearization	21
2.1.4	Incremental Solution Scheme	26
2.2	Mixed Velocity–Pressure Formulation	27
2.2.1	Quasi-incompressible Form of the Continuity Equation	28
2.2.2	Solution Method	30
2.3	Hypoelasticity	32
2.3.1	Velocity Formulation for Hypoelastic Solids	36
2.3.2	Mixed Velocity–Pressure Formulation for Hypoelastic Solids	38
2.3.3	Theory of Plasticity	40
2.3.4	Validation Examples	47
2.4	Summary and Conclusions	61
	References	62

3 Unified Stabilized Formulation for Quasi-incompressible	
Materials	63
3.1 Stabilized FIC Form of the Mass Balance Equation	66
3.1.1 Governing Equations.	66
3.1.2 FIC Mass Balance Equation in Space and in Time.	67
3.1.3 FIC Stabilized Local Form of the Mass Balance Equation	68
3.1.4 Variational Form.	70
3.1.5 FEM Discretization and Matrix Form	73
3.2 Solution Scheme for Quasi-incompressible Newtonian Fluids	74
3.2.1 Governing Equations.	75
3.2.2 Solution Scheme	78
3.3 Solution Scheme for Quasi-incompressible Hypoelastic Solids. . . .	79
3.4 Free Surface Flow Analysis	82
3.4.1 The Particle Finite Element Method	83
3.4.2 Mass Conservation Analysis	93
3.4.3 Analysis of the Conditioning of the Solution Scheme. . . .	103
3.5 Validation Examples.	119
3.5.1 Validation of the Unified Formulation for Newtonian Fluids	120
3.5.2 Validation of the Unified Formulation for Quasi-incompressible Hypoelastic Solids.	135
3.6 Summary and Conclusions	141
References.	142
4 Unified Formulation for FSI Problems	147
4.1 Introduction	147
4.2 FSI Algorithm	148
4.3 Coupling with the Velocity Formulation for the Solid	150
4.4 Coupling with the Mixed Velocity–Pressure Formulation for the Solid	152
4.5 Numerical Examples.	154
4.6 Summary and Conclusions	169
References.	169
5 Coupled Thermal–Mechanical Formulation	171
5.1 Introduction	171
5.2 Heat Problem	173
5.2.1 FEM Discretization and Solution for a Time Step.	174
5.3 Thermal Coupling.	175
5.3.1 Numerical Examples	176
5.4 Phase Change	180
5.4.1 Numerical Example: Melting of an Ice Block.	182
5.5 Summary and Conclusions	184
References.	184

6 Industrial Application: PFEM Analysis Model of NPP Severe Accident	187
6.1 Introduction	187
6.1.1 Assumptions Allowed by the Specification	190
6.2 Numerical Method	190
6.3 Basic Model	191
6.3.1 Problem Data	191
6.3.2 Preliminary Study	193
6.3.3 Numerical Results	194
6.4 Detailed Model	200
6.4.1 Problem Data	200
6.4.2 Preliminary Study	201
6.4.3 Numerical Results	201
6.5 Summary and Conclusions	205
References	206
7 Conclusions and Future Lines of Research	207
7.1 Contributions	207
7.2 Lines for Future Work	209
Reference	210
About the Author	211

<http://www.springer.com/978-3-319-45661-4>

Unified Lagrangian Formulation for Fluid and Solid
Mechanics, Fluid-Structure Interaction and Coupled
Thermal Problems Using the PFEM

Franci, A.

2017, XIX, 211 p. 168 illus., 147 illus. in color.,

Hardcover

ISBN: 978-3-319-45661-4