
Contents

Preface	ix
Chapter 1. The Flow of Viscous Fluids. Flow in the Vicinity of a Wall: Boundary Layers and Films	1
1.1. Introduction	1
1.2. Characteristics and classification of boundary layers.	1
1.2.1. Boundary layers – various approaches	4
1.3. The outer boundary layers: an analytical approach	4
1.3.1. The laminar boundary layer developed by a flat plate in a uniform flow	4
1.3.2. The turbulent boundary layer	8
1.4. Examples of analytical approach: outer flows.	13
1.5. Examples of analytical approach: inner flows.	23
1.6. Outer boundary layers: integral methods	43
1.6.1. Principle of the integral method	43
1.6.2. Applications of integral methods	46
1.7. Channels and films	62
Chapter 2. One-dimensional Compressible Flows: Fully Reversible Flows	77
2.1. Introduction	77
2.2. One-dimensional adiabatic and reversible flows	78
2.2.1. Hypotheses adopted.	78
2.2.2. Writing the laws.	79
2.2.3. Other useful relations	79

2.2.4. Fundamental relations	85
2.2.5. Calculation of flow rate in a piping system.	88
2.2.6. De Laval nozzle	92
2.3. Applications. Reversible adiabatic flows	95
Chapter 3. One-dimensional Compressible Flows: Irreversible Flows	125
3.1. Introduction	125
3.2. Irreversible flow: straight shock wave	125
3.2.1. Establishing the fundamental relations	125
3.2.2. Applications	129
3.3. Partially irreversible flows: shock wave in a nozzle	144
3.3.1. Change of the generating state by the shock wave	144
3.3.2. Applications	146
3.4. Conclusion	156
Chapter 4. Modeling and Numerical Simulations	159
4.1. Introduction	159
4.2. Methodology description and simulation approach.	160
4.3. Modeling and simulation of coupled systems	163
4.3.1. Mathematical formulation. Behavior equations	163
4.3.2. Fluid–structure coupling conditions.	164
4.4. Variational formulation	165
4.5. Finite element approximation.	165
4.5.1. Approximation of physical unknowns	166
4.5.2. Integration of variational forms	166
4.6. The vibro-acoustic problem.	166
4.7. The hydro-elastic problem	167
4.8. Applications	168
4.9. Conclusion	196
Chapter 5. Numerical Simulation of a Vertical-axis Wind Turbine	197
5.1. Introduction	197
5.2. Construction of the rotor geometry and definition of the computational domain.	197
5.2.1. Mesh	199
5.2.2. Discretization scheme	202
5.2.3. System resolution and convergence	205

5.3. Analysis of the results	206
5.3.1. Validation of the CFD model	206
5.3.2. Influence of the characteristic parameters	210
5.4. Conclusion	216
Appendix	217
Bibliography	265
Index	269