

Contents

1	Introduction	1
1.1	Introduction	2
1.1.1	CFD codes	3
1.1.2	Turbomachinery modeling	4
1.2	Objectives	6
1.3	Methodology	7
	Chapter 1 bibliography	11
2	Set-up analysis and optimization of numerical simulations for radial turbines	13
2.1	Introduction	14
2.1.1	CFD in turbomachinery	14
2.2	Computational methodology. Definition of a reference case. . .	16
2.2.1	Experimental methodology	17
2.2.2	Computational domain	21
2.2.3	Boundary conditions	23
2.2.4	Wheel rotation strategies	24
2.2.5	Viscous model	25
2.3	Mesh independence	27
2.3.1	Volute	29
2.3.2	Stator	30
2.3.3	Rotor	33
2.3.4	Outlet section	36
2.3.5	Final considerations and selected mesh	37
2.4	Set-up Comparison	40
2.4.1	Type of solver	40
2.4.2	Mesh motion strategy	43
2.4.3	Temporal discretization	46
2.5	Summary of the results: Turbine map	49

2.6	Summary and conclusions	51
	Chapter 2 bibliography	59
3	Implementation of a 1D-3D coupling computational fluid dynamic boundary condition	61
3.1	Introduction	62
3.2	Coupling methodology	64
3.2.1	The method of characteristics	64
3.2.2	Homentropic flow	67
3.2.3	Non-Homentropic flow	67
3.3	Implementation	68
3.3.1	OpenWAM	69
3.3.2	ANSYS-FLUENT	70
3.4	Validation	71
3.4.1	Sod's problem	71
3.4.2	Impulse test rig	72
3.5	Conclusions	76
	Chapter 3 bibliography	78
4	Development of an anechoic boundary condition for computational fluid dynamic codes	79
4.1	Introduction	80
4.2	Non-reflecting boundary conditions	82
4.2.1	Assessment of NRBCs available in ANSYS-FLUENT	83
4.2.2	Implementing a boundary condition in a CFD commercial code	86
4.3	Proposal of a new non-reflecting boundary condition for non-homentropic flow	89
4.3.1	Modifications for non-homentropic flow	89
4.3.2	Implementation of an anechoic condition	90
4.3.3	Incident pressure condition	94
4.4	Application to the analysis of the acoustic response of a muffler	95
4.4.1	Experimental facility	95
4.4.2	Full three-dimensional simulation	96
4.4.3	Proposed Methodology	97
4.5	Summary and conclusions	99
	Chapter 4 bibliography	105

5	Analysis of the influence of real flow effects in computational fluid dynamics boundary conditions based on the method of characteristics	107
5.1	Introduction	108
5.2	Non-perfect gas	109
5.3	Viscous flow	110
5.4	Swirling flow	114
5.5	Possible applications of the developed boundary conditions . .	118
5.5.1	Anechoic BC	118
5.5.2	Coupled 1D-3D simulation	118
5.6	Conclusions	120
	Chapter 5 bibliography	123
6	Computational analysis of pulsating flow in radial turbomachinery and its application to engine modelling	125
6.1	Introduction	126
6.2	Computational methodology and steady flow results	127
6.3	Pulsating flow results	129
6.3.1	Overall behavior	130
6.3.2	Local behavior of the different components	131
6.4	Discussion of results	133
6.5	Application to engine modeling	139
6.5.1	Proposed model	141
6.5.2	Model calibration	146
6.5.3	Pulsating results	147
6.6	Conclusions	151
	Chapter 6 bibliography	155
7	Conclusions and future works	157
7.1	Conclusions	158
7.1.1	Computational methodology: Case configuration	158
7.1.2	Developed boundary conditions	161
7.1.3	Pulsating flow	163
7.2	Original contributions	165
7.3	Future works	167
	Chapter 7 Bibliography	170
	Global bibliography	171

Appendix 1: UDF code	185
Appendix 2: OpenWAM CFD connection	213