

Contents

Contents	xi
List of Tables	xiii
List of Figures	xv
Nomenclature	xix
1 Introduction	1
1.1 Motivation	1
1.2 Challenges in radial turbine design	5
1.3 Design methods for radial turbines	12
1.4 Objective of this work	14
1.5 Thesis structure	16
2 Modelling and simulation	19
2.1 Geometry and Parametrization	19
2.2 Numerical fluid mechanics	22
2.3 Numerical solid mechanics	27
3 Optimization methods	31
3.1 Derivatives	31
3.2 CAD-free optimization	37
3.2.1 Calculation of mesh sensitivities	37
3.2.2 Accuracy of mesh sensitivities	54
3.2.3 Surface sensitivities	58
3.2.4 Shape update	62
3.3 CAD-based optimization	65
3.3.1 Design velocities and data interpolation	67
3.3.2 Quality of parameter gradients	71
3.3.3 The gradient projection algorithm	75

4	Radial turbine optimization	79
4.1	Surface sensitivities of a radial turbine wheel	79
4.2	Examples of single discipline CAD-free optimization	91
4.2.1	Reducing centrifugal force induced stress	92
4.2.2	Reducing the dynamic compliance	95
4.2.3	Increasing efficiency	100
4.3	Examples of multidisciplinary CAD-based optimization	107
4.3.1	Extension of operational range	107
4.3.2	Inertia vs. efficiency	112
4.3.3	Increasing Efficiency	118
4.3.4	Reducing the dynamic compliance	121
5	Conclusion	129
	Bibliography	I
	Appendix	XI