

Contents

1. Introduction	1
1.1. Load control in horizontal axis wind turbines	1
1.2. Adaptive camber airfoil	3
1.3. Preceding and related Work	4
1.4. Motivation and outline	5
2. Equations of motion	7
3. Panel method	21
3.1. Assumptions	21
3.2. Method description	23
3.2.1. Induced velocity	26
3.2.2. Pressure calculation and the Kutta condition	31
3.2.3. Unsteady wake formulation	34
3.2.4. Solution procedure	37
3.3. Coupling scheme	39
3.3.1. Integral aerodynamic forces and moments	39
3.3.2. Surface velocity	40
3.3.3. Fluid structure interaction	41
4. Thin-airfoil theory	43
4.1. Aerodynamic forces on chordwise sections of a harmonically deforming airfoil	46
4.2. Aerodynamic forces due to a sinusoidal gust	52
4.3. Steady thin-airfoil theory	56

5. Linear analysis of the adaptive camber airfoil	59
5.1. Equilibrium state in steady inflow	60
5.1.1. Influence of airfoil precambering	72
5.1.2. Influence of the airfoil thickness	77
5.2. Frequency domain analysis	79
5.2.1. Transfer functions	80
5.2.2. Load reduction	97
5.2.3. Flutter	103
6. Simulation	109
6.1. Comparison to experiments	109
6.2. Sinusoidal gust	116
6.3. Deterministic gusts	117
6.4. Rotationally sampled turbulence	125
7. Summary and Outlook	129
Bibliography	133
A. Thin-airfoil theory for chordwise sections	137
A.1. Aerodynamic forces for harmonic downwash	137
A.2. Expressions for the general flexible airfoil	140
A.3. Steady aerodynamic forces	145
A.4. Influence numbers for the harmonically deforming adaptive camber airfoil	147
B. Coordinate transformation	153
B.1. Coordinate transformation for the thin-airfoil theory	153
B.2. Rotation matrices	154
C. Equations of motion	155
C.1. Non-linear equations of motion	155
C.2. Non-dimensional system matrices	157
C.3. Non-linear spring mechanism	158
C.4. Non-linear coupling mechanism	159