

Index

- accumulator, 189
- acoustic impedance, 174
- acoustic impulse, 90
- acoustic modes, 140
- acoustic pressure, 90
- acoustic pulse, 90
- acoustic resonance, 166–167
- actuator disc, 39, 147
- added mass
 - cross-coupled, 213
 - direct, 213
- affinity laws, 3
- air content, 71
- Alford effects, 230
- angle of attack, 7
- attached cavitation, 68
- auto-oscillation, 138, 150, 153–158
 - frequency, 154
 - hysteresis, 157
 - onset, 155
- axial resonance, 138
- backflow, 48, 105
 - cavitation, 69
 - deflector, 49
- balance piston, 138
- barotropic fluid, 173
- bearings, 139, 209
 - π -film, 218
 - hydrodynamic, 214–221
 - long, 214, 216, 218, 219
 - short, 214, 217, 219
- Bernoulli effect, 214
- Bernoulli equation, 18
- blade
 - cavitation, 68
 - drag, 23
 - flutter, 110, 137, 139, 167–169
 - leading edge, 128
 - lift, 23
- momentum thickness, 29
- passing frequency, 91, 138, 140, 166, 210
- stresses, 2
- thickness, 127
- vibration, 139
- wake, 28
- boiler feed pumps, 137
- boiling, 1, 81, 117
- boundary layer, 28
 - separation, 75
- breakdown, 123
 - cavitation number, 128
- bubble
 - break up, 113
 - cavitation, 68, 111
 - cloud, 82, 112, 167
 - collapse, 80, 82, 112
 - concentration, 112
 - dynamics, 78–83
 - growth rate, 80, 117
 - migration, 113
 - natural frequency, 88
 - rebound, 82
 - relative motion, 113
 - resonant frequency, 89
 - shape, 112
 - size, 113
- bulk flow model, 222
- camber angle, 8
- cascade
 - data, 126
 - drag coefficients, 126
 - lift coefficients, 126
 - partially cavitating, 127–134
 - supercavitating, 125–127
- cavitating jet, 94
- cavitation, 1, 55
 - blockage, 134
 - breakdown, 2, 64, 114

- cavitation (*cont.*)
 - damage, 1, 69, 83–89
 - desinent number, 70
 - effect on radial forces, 241
 - effect on rotordynamics, 241
 - effects, 246
 - erosion rates, 88
 - event rate, 92
 - head loss, 63, 132, 134
 - hysteresis, 70
 - in bearings, 218
 - inception, 58–62, 70–77
 - inception number, 56, 63
 - instabilities, 2
 - noise, 71, 83, 88–95, 138
 - noise scaling, 93
 - number, 56
 - parameters, 55–58
 - performance, 2, 63, 96, 105
 - performance correlations, 134–136
 - scaling, 62
 - thermal effect, 79
 - types of, 65–70
- characteristic impedance, 188
- choked cavitation number, 128, 131
- Clausius-Clapeyron equation, 79
- cloud
 - cavitation, 112
 - natural frequency, 113, 167
- completely active system, 193
- completely passive system, 192
- compliance, 189
- condensation shock, 113
- conservative system, 192
- Constant's rule, 28
- critical cavitation number, 119
- critical speed, 139, 168, 209
- critical temperature, 119
- critical tension, 81
- critical time, 117
- damping
 - cross-coupled, 213
 - direct, 213
- deaerator, 61
- deflection angle, 8
- depth charge, 86
- deviation angle, 7, 27–28
- diffuser, 44
 - axial, 45
 - radial, 45
- diffusion factor, 29
- discharge impedance, 195
- discharge resistance, 195
- disk friction loss, 30
- displacement flow, 32
- dissipationless systems, 189
- distributed systems, 183
- drag coefficient, 23
- dynamic activity, 193
- dynamic stall, 144
- eccentricity, 212
- efficiency
 - hydraulic, 17
 - shaft, 17
- encounter diagram, 158
- energy flux, 152, 191–195
- erosion, 83
- flat plate cascade, 9
- flexible coatings, 86
- flow coefficient, 11, 63
- fluid/structure interaction, 137
- forced vortex design, 39
- Fourier analysis, 180
- Francis turbine, 83
- free stream turbulence, 75
- free streamline methods, 122–134, 144
- free vortex design, 39
- frequency
 - blade passing, 140
 - domain methods, 179–208
 - oscillation, 140–143
 - structural, 141
 - subsynchronous, 139
- head coefficient, 11, 63
- heave oscillations, 144
- holography, 59
- homogeneous flow model, 181
- Hoover dam, 84
- hydrofoil, 122
 - Joukowski, 75
 - NACA 4412, 73
 - partially cavitating, 122
 - supercavitating, 2, 122, 144
- impedance, 188
- impellers, 19–21, 209
 - axial, 5
 - centrifugal, 5
 - mixed flow, 5
- incidence angle, 7
- incubation time, 88
- inducer, 2
 - blade angle, 131
 - blade cant, 103
 - designs, 102–104
 - helical, 21, 129
 - incidence, 104
 - leading edge, 103, 131
 - performance, 104–111
 - rotordynamics, 249–251
 - SSME, 21, 66, 129, 251
- inertance, 188

Index**269**

- inertia effect, 214
- input impedance, 194
- input resistance, 194
- interblade spacing, 160
- ITTC
 - headform, 90
 - tests, 59, 70
- jet-wake structure, 34
- leading edge, 109
 - flutter, 169
- leakage flow, 30, 52, 139, 222
- lift coefficient, 23, 144
 - fluctuating, 161
- line of action, 142, 246–249
- line resonance, 138
- linear cascade, 8, 22–30
- liquid quality, 58
- liquid temperature, 114
- Lomakin effect, 215
- loss coefficient, 24
- LRC systems, 189
- lumped parameter models, 189
- magnetostrictive device, 84
- meridional
 - Reynolds number, 224
 - surface, 5
 - velocity, 5
- method of characteristics, 177–179
- microbubbles, 58
- microjet, 86
- mixed flow pump, 5, 10, 97
- nomenclature, xi–xv
- normal force, 212
- NPSH, 57, 63, 134
- NPSP, 56
- nucleation, 58
 - homogeneous, 58
 - sites, 58
- nuclei, 58, 68
 - critical size, 82
 - number distribution, 59
 - ocean, 59
 - population, 70
 - residence time, 61
- number of blades, 32
- oil whip, 217
- organ-pipe modes, 190
- partial cavitation, 69, 138
 - oscillation, 164, 169
- Pogo instability, 139, 169–171, 207
- potentially active system, 193
- power density, 137
- prerotation, 47, 105
- pressure coefficient, 55
 - fluctuating, 161
 - mimum, 56
- pressure surface, 28
- propagation operator, 188
- propellers, 125
- pseudo-cavitation, 61
- pump
 - characteristic, 63, 151
 - supercavitating, 69
 - vibration, 137–171
- radial bending moments, 142
- radial cascade, 9, 30–34
- radial equilibrium, 38
- radial forces, 139, 142, 209–212, 232–241
- Rayleigh-Plesset equation, 78, 91, 111
- reentrant jet, 85
- relative eddies, 32
- remnant cloud, 86
- residence time, 62
- resistance, 188
- resorber, 61
- Reynolds number, 14, 55, 62, 75, 214
- rotating cavitation, 138, 149–151
 - propagation speed, 150
- rotating stall, 138, 140, 146–149
 - cavitation, 138
 - cell, 138
 - in vaned diffuser, 149
 - in volute, 149
 - propagation speed, 146, 149
- rotor-stator interaction, 139
 - flow patterns, 158–159
 - forces, 159–164
- rotordynamic forces, 139, 142, 209–251
- rotordynamic instability, 137
- rotordynamic moments, 142, 246–249
- Schiebe headform, 90
- screening effects, 112
- seals, 139, 209, 214–215
 - annular, 222–228
 - damper, 228
 - labyrinth, 229–230
 - long, 214
 - short, 214
- secondary flows, 30, 47, 51–54
- shock wave, 86
- simple cascade, 9
- slip factor, 8, 32
- slip velocity, 8, 33
- solidity, 7, 10, 108
- sonic speed, 173
- sound pressure level, 92
- specific speed, 12–14

speed of sound, 173
spiral collector, 45
squeeze film dampers, 214, 221–222
stall flutter, 168
stator vanes, 44
stiffness
 cross-coupled, 213
 direct, 213
Strouhal number, 168
structural damping, 158
subscripts, xiv
suction specific speed, 57, 64, 134
suction surface, 28
supercavitation, 69, 138
superscripts, xv
surface roughness, 62, 75
surge, 138, 150–153
surge tank, 189
susceptibility meter, 59
system instability, 151, 193
system order, 180

tangential force, 212
tension, 58
 critical, 58
thermal effects, 114–121
thermal suppression, 80
thermodynamic equilibrium, 112
Thoma cavitation factor, 57, 64
thrust, 142, 210
time domain methods, 172–179
tip clearance, 76
tip clearance effect, 109
tip clearance flow, 51, 69
tip leakage flow, 51
tip vortex cavitation, 66
torque, 19, 142, 210

total head, 11
total pressure, 11
transfer matrices, 181–208
 combinations, 184
 determinant, 186
 properties, 184–188
 pumps, 195–206
 quasi-reciprocal, 186
 reciprocal, 186
 symmetric, 187
transmission matrix, 183

uniform system, 183
unsteady flows, 2–3, 143–146, 172–208

ventilated cavity, 166
 pulsation, 166
volute, 45
 circular, 96, 233
 matching, 20, 46
 spiral, 20, 233
 throat, 47
vortex
 cavitation, 66
 pressures, 61
 shedding, 84, 139

water column separation, 178
water-hammer methods, 172
wear, 137
whirl
 frequency, 211
 frequency ratio, 212
 motion, 212
 orbit, 212
 ratio, 213