

Contents

Introduction	4
List of markings used	7
1. Normal shock waves	9
1.1 Formation of shock waves	9
1.2 Basic equations for the normal shock waves	10
1.3 Graphic – numerical solution for normal shock waves	11
1.4 Numerical solutions for normal shock waves	11
1.5 Moving normal shock waves	13
1.6 Dynamic function for normal shock waves in an ideal gas	16
1.7 Normal shock waves - examples	16
1.7.1 Graphical – numerical solution to normal shock waves	16
1.7.2 Calculation of the shock waves from known static pressures	18
1.7.3 Calculation of the shock waves from known velocity of the wave	20
1.7.4 Measurement of supersonic speeds using the Pitot tube	22
1.7.5 Moving normal shock wave - after a nuclear explosion	24
1.7.6 Moving shock wave in front of a projectile	25
1.7.7 Sudden stop of moving gas	28
2. Flow in nozzles and diffusers	31
2.1 Normal shock waves in the diverging channel	32
2.2 Other regimes of combined-shape nozzle	33
2.3 Shock waves in a converging channel	36
2.4 Supersonic converging inlet	37
2.5 Supersonic wind tunnel	39
2.6 Other configurations of two converging cross-sections	40
2.7 Flow in nozzles and diffusers - examples	41
2.7.1 Characteristic back pressures combined-shape nozzle	41
2.7.2 Determining back pressure at a known position of shock waves in in a combined-shape nozzle	43
2.7.3 Determining regimes of flow with known back pressure	45
2.7.4 Design of a supersonic wind tunnel diffuser	48
2.7.5 Supersonic wind tunnel inlet with known ratio of cross-sections	49
2.7.6 Design of supersonic wind tunnel inlet for known Mach number	52
2.7.7 Design of cross-sections in a supersonic wind tunnel	53
2.7.8 Design of cross-sections and calculation of back pressure in a supersonic wind tunnel	55
2.7.9 Calculation of the characteristic back pressure for a channel with two throats	58
2.7.10 Calculation of the characteristic back pressure for a channel with three throats	61

Appendix	65
1. T-s diagram for ideal air	66
2. Dynamic function diagram for isentropic flow of ideal gas for $\kappa = 1.4$.	67
3. Dynamic function for isentropic flow of ideal gas for $\kappa = 1.4$, part 1/6.	68
4. Dynamic function for isentropic flow of ideal gas for $\kappa = 1.4$, part 2/6.	69
5. Dynamic function for isentropic flow of ideal gas for $\kappa = 1.4$, part 3/6.	70
6. Dynamic function for isentropic flow of ideal gas for $\kappa = 1.4$, part 4/6.	71
7. Dynamic function for isentropic flow of ideal gas for $\kappa = 1.4$, part 5/6.	72
8. Dynamic function for isentropic flow of ideal gas for $\kappa = 1.4$, part 6/6.	73
9. Dynamic function diagram for normal shock waves in an ideal gas for $\kappa = 1.4$.	74
10. Dynamic function for normal shock waves in an ideal gas for $\kappa = 1.4$, part 1/4.	75
11. Dynamic function for normal shock waves in an ideal gas for $\kappa = 1.4$, part 2/4.	76
12. Dynamic function for normal shock waves in an ideal gas for $\kappa = 1.4$, part 3/4.	77
13. Dynamic function for normal shock waves in an ideal gas for $\kappa = 1.4$, part 4/4.	78
14. Regimes of a combined-shape nozzle.	79
15. Cross-section ratio A_D/A_I for absorption of shock waves in supersonic inlet, part 1/2, for $\kappa = 1.4$.	80
16. Cross-section ratio A_D/A_I for absorption of shock waves in supersonic inlet, part 2/2, for $\kappa = 1.4$.	81
17. Dependency ratio A_D/A_I of absorption and ejection of shock wave on Mach number for $\kappa = 1.4$.	81
List of recommended literature	82