

Content

Nomenclature	3
1. Introduction	5
2. Fundamentals	6
3. Thermal Equilibrium and Temperature	10
3.1 Temperature	10
3.2 Thermal equation of state	14
4. The First Law of Thermodynamics	19
4.1 Work, kinetic and potential energy.....	19
4.2 Internal Energy	25
4.3 Heat	26
4.4 The first law of thermodynamics for closed systems	27
4.5 The first law of thermodynamics for open systems.....	29
4.6. Application of the first law of thermodynamics.....	35
5. Equations of state and changes of state	38
5.1 Caloric equation of state	38
5.2 Changes of state.....	43
5.3 Cyclic process – Carnot cycle.....	52
6. The Second Law of Thermodynamics	57
6.1 Generalisation of Carnot cycles	58
6.2 Entropy	59
6.3 Applications of the second law	68
6.4 Exergy and Anergy	70
7. Thermodynamic properties of pure fluids	84
7.1 States of pure substances - vapours	86
7.2 Thermal equations of state for real gases	91
7.3 Main equations of thermodynamics and thermodynamic potentials	93
7.4 The relationship between thermal and calorific state variables and entropy for any substance.....	96
7.5 Diagrammatic representations of h , u and T as a function of entropy s	102
7.6 Third Law of Thermodynamics	104

8. Cyclic processes	105
8.1 Carnot cycle	105
8.2 Joule process	107
8.3 Otto process	114
8.4 Diesel process	118
8.5 Stirling process	121
8.6 Changes of state in two-phase processes	122
8.7 Cyclic processes with steam - Clausius-Rankine processes	127
8.8 Combined processes	131
8.9 Cold vapor / heat pump processes	131
9. Gas-vapor mixtures	137
9.1 Characteristic variables of a gas mixture	137
9.2 Properties of ideal gas mixtures	138
9.3 Gas-vapor mixtures: humid air	141
9.4 State variables for humid air	142
9.5 The h, x diagram for humid air	145
9.6 Changes of state in an h,x diagram for humid air	147
9.7 Air conditioning and indoor climate control	151
10. Static flow processes	154
10.1 Incompressible flow processes	154
10.2 Isentropic nozzle flows:	158
10.3 Working processes	165
11. Combustion processes	168
11.1 Exhaust gas composition:	168
11.2 Calorific value and heating value	176
11.3 Adiabatic flame temperature	178
11.4 Exergetic efficiency of steam cycle processes	179
Index	185