Contents

Preface to the Second Edition	vii
Preface to the First Edition	ix
Nomenclature	XI

1. Sources of Energy

Power.

Introduction—Energy and Man—Energy Sources—Measurement of Energy—Energy Demand— Estimated Energy Reserves of the World—Direct Solar Energy—Introduction—Solar Energy Calculations—Solar Radiation at Earth's Surface—Terms related with Earth's Geometry— Solar Energy Collection System—Solar Energy Collectors—Flat Plate Solar collectors—Focussing type collector-Fossil Fuels-Hydraulic Power-Wind Power-Up-dates of Wind Power Produced in India and the World—Classification of Wind Mills—Tidal Power, Geothermal

2. Basic Concepts and Definitions of Thermodynamics

22

1

Thermodynamics—Macroscopic and Microscopic View Point—Continuum—Thermodynamic Equilibrium—System—Property—State—Path—Process—Zeroth Law of Thermodynamics— Temperature and Temperature Scale—Comparison of Temperature Scale—Devices used for the Measurement of Temperature—The Constant Volume Gas Thermometer—Heat and Work— Heat—Work—Types of Work—Some Important Points about Heat and Work—Internal Energy, Thermodynamic Equilibrium, Quasi Static Process and Reversible Process—Shaft Work— Work Done During a Non-Flow Reversible Process—Flow Work or Flow Energy—Enthalpy— Total Energy—Work Done in a Flow Process—Units and Dimensions—Force—Density— Specific Weight-Pressure-Manometer and Pressure Gauge-SOLVED PROBLEMS-EXERCISES.

3. The First Law of Thermodynamics

50

Introduction—Joule's Experiment—First Law of Thermodynamics—Internal Energy is a Property—Applications of First Law of Thermodynamics—Application on closed Systems— Definitions of Specific Heat at Constant Volume—Application of First Law to Steady Flow system—Continuity Equation—SOLVED PROBLEMS—EXERCISES

4. The Second Law of Thermodynamics

85

Limitations of the First Law and Introduction to Second Law—Statements of Second Law of Thermodynamics—Equivalence of Planck's Statement and Clausius Statement—Perpetual Motion Machine of The second kind—Efficiency and C.O.P—CARNOT cycle—Corallaries of The Second Law of Thermodynamics—Entropy—Physical Interpetation of Entropy—Temperature entropy diagram—SOLVED PROBLEMS—EXERCISES.

5. The Perfect Gases

124

The Perfect Gas—Laws of Perfect Gas—Boyle's Law—Charle's Law—Characteristic Gas Equation—Avogadro's Hypothesis and Universal gas constant—Joule's Law—Relation of Specific Heats of Gases with Gas Constant—Reversible Non-Flow Processes of a Perface Gas—Calculation of Entropy Change of Different Processes—Different Non-Flow Reversible Processes as Special case of the Polytropic Processes—Free Expansion and Throttling Processes of a Perfect Gas—Vander Waals Equation for Real Gases—Determination of Constants of Vander Waals Equation—Limitations of Vander Waals Equation—Compressibility Factor and Compressibility Chart—Beattie—Bridgeman Equation—Virial Equation of State—P-V Diagram for Real Substance—P-T Diagram for Real Substance—P-V-T Surface for Real Substance—SOLVED PROBLEMS—EXERCISES.

6. The Gas Power Cycle

157

Introduction—Terms used in Piston Cylinder Arrangement—Mean Effective Pressure—Air Standard Cycles—Carnot Cycle Air Standard Efficiency—Otto Cycle or Constant Volume Cycle—Diesel Cycle—Brayton or Joule Cycle—Some Important Points—SOLVED PROPLEMS—EXERCISES

7. Properties of Steam and Processes

205

Introduction—Phase Transformation at Constant Pressure—Effect of Pressure on Saturation Temperature—Critical Temperature—Triple Point—Generation of Steam—Quality of Steam—Thermodynamic Properties of Steam—Steam Table—Steam Property Charts—Thermodynamic Processes—Methods of Determining of Dryness Fraction of Steam—SOLVED PROPLEMS—EXERCISES.

8. Steam Power Cycles

230

Introduction—Carnot Cycle—Limitation of Carnot Cycle using Vapour as Working substance—Rankine Cycle—Specific Steam Consumption—Relative Efficiency—Rankine Engine—Thermodynamic Variables Affecting Efficiency and Out put of Rankine Cycle—Modified Rankine Cycle—Desirable properties of on Ideal Fluid used in a Vapour Power Cycle—Reheat Cycle—Regenerative Cycle—Binary Vapour Cycle—Combined Reheat Regenerative Cycle—EXERCISES.

9. Boiler

278

Introduction—Essentials of a Good Boiler—Classification of Boilers—Boilers Parts—Distinction between Fire Tube and Water Tube Boilers—Boiler Mountings—Boiler Accessories—Basic Types of Steam Generators—Description of some Important Boilers—Boiler Draught (Draft)—Boiler Performance.

10. Air Compressor

338

Introduction and General Classification—Reciprocating Compressor—Positive Displacement Rotary Compressors—Turbine Vs. Compressor Blades—Nonpositive Displacement of steady—

Flow Rotary Compressors—Centrifugal Compressor—Axial Flow Compressor—Surging and Choking of Compressors—Difference between Centrifugal and axial Flow Compressor—Static and Total Head (or Satagnation) Quantities in Rotary Compressors—Isentropic Efficiency in Rotary Compressor.

11. Refrigeration and Air Conditioning

402

Fundamentals—Standard Rating of a Refrigeration Machine—Heat Engine, Refrigeration and Heat Pump—Selection of Operating Temperatures—Ideal Refrigerating Cycle (Reversed Carnot Cycle)—Air Refrigeration System—Vapour Compression Refrigeration System—Household Refrigerator—Water Cooler—Multistage of Compound Compression System—Vapour Absorption System—Refrigerants—Air Conditioning—Psychometric Terms—Psychometric Chart—Psychometric Process—Room (or Conditioned Space) Sensible Heat Factor (RSHF)—Grand Sensible Heat Factor (GSHF)—Effective Surface Temperature—Cooling and Humidification—Humidifying Efficiency—Other Processes: Air Washer—Water Injection—Steam Injection—Evaporative Cooling—By Pass Factor—Summer Air-conditioning Systems—Winter Air Conditioning—Year-Round Air-conditioning—Purpose of Ventilation During Airconditioning.

12. Steam Engine

558

Introduction—Classification of Steam Engine—Steam Engine Parts and their Functions—Terms used in Steam Engine—Operation of Steam Engine—Actual Indicator Diagram—Theoretical Work Done and Mean Effective pressure—Cylinder Dimensions and Indicated Power—Efficiencies of Steam Engine. Steam Consumption from Indicator Diagram and Missing Quantity—SOLVED PROPLEMS—EXERCISES.

13. Steam Condensers and Cooling Water Supply

575

Introduction—Advantages of a Condenser in a Steam Power Plant—Elements of a Condensing Plant—Types of Condensers—Jet Condensers—Surface Condensers—Advantages and Disadvantages of Jet Condensers—Advantages and Disadvantages of Surface Condensers—Sources of air in the Condenser and its Effects—Condenser Vacuum and its Measurement—Dalton's Law of Partial Pressure—Condenser Efficiency—Thermodynamic Analysis of Condenser—Air Pumps—Cooling Water Supply—Cooling Pond—Cooling Towers—Hyperbolic Cooling Towers—SOLVED PROBLEMS—EXERCISES.

14. Steam Nozzles

614

Introduction—Flow of Steam Through Nozzle—General Relationship between Area, Velocity and Pressure in the, Nozzle Flow—Mass of Discharge Through Nozzle—Throat Pressure for Maximum Discharge—Physical Explanation of Critical Pressure—Nozzle Operating in the off-Design Condition—Effect of Friction on Nozzle Performance—Length of Nozzle—Supersaturated Flow Through Nozzle—Steam Injector—SOLVED PROBLEMS—EXERCISES.

15. Steam Turbine

663

Introduction—Comparison of Steam engine and Turbine—Working Principle of Turbine—Classification of Steam Turbine—Difference Between Impulse and Reaction Turbine—Compounding of Impulse Turbine—Velocity Diagram—Work Developed on Turbine Blades and Efficiencies—Condition for Maximum Efficiency of Impulse Turbine—Velocity Diagram for Velocity Compounds Impulse Turbine—Most Economical Ratio of Blade Speed to Steam

Speed for a Two Row Velocity Compounded Impulse Wheel—Blade Height—Velocity Triangle for Reaction Turbine—Degree of Reaction—Efficiency of a Reaction Turbine—Blade Height in Reaction Turbine—Losses in Steam Turbine—Steam Turbine—Performance—Maximum Gross Stage Efficiency of a 50% Parson Reaction Turbine—SOLVED PROBLEMS—EXERCISES.

16. Fuels and Combustion

718

Introduction—Classification of Fuels—Combustion—Composition of Air—Theoretical Air Fuel Ratio—Minimum Air Required in kg of Solid or Liquid Fuel—Theoretical Air Fuel Ratio for Hydrocarbon—Mass Balance—Combustion Control Throgh Flue gas Analysis—Conversion From Volumetric Analysis into Mass Analysis—Conversion From Mass Analysis into Volumetric Analysis—Calorific value of Fuel—Energy Release in Combustion—Enthalpy of Formation—Adiabatic Flame Temperature—SOLVED PROBLEMS—EXERCISES.

17. Heat and Mass Transfer

750

Introduction—Modes of heat Transfer—Fourier's Law of Heat conduction—Effect of Temperature on Thermal Conductivity—one Dimensional Heat Conductions Through a Plane Wall—Radial Heat Conduction Through a Hollow Cylinder—Radial Heat Flow Through a Spherical Wall—Newton's Law of Cooling—Heat Conduction Through Composite Structure—Overall Heat Transfer Co-efficient—Critical Thickness of Insulation for Pipes—Effect of non-uniform Thermal Conductivity—Convection—Introduction—Energy Transfer Mechanism and fluid Flow—Boundary Layer Theory—Boundary Layer and Nusselt Number—Evaluation of Convective Heat Transfer Co-efficients—Dimensional Analysis—Correlations For Convective Heat Transfer—Boundary Layer Equations on a Flat Plate—Colburn Analogy—Convection—Radiation—Definitions—Heat Transfer with Change in Phase—Correlation For Pool Boiling—Dropwise and Filmwise Condensation—Mass Transfer—Introduction—Analogy between Heat and Mass Transfer—Modes of Mass Transfer—Mass Transfer by Molecular Diffusion—Convective Mass Transfer—Analogy Between Momentum, Heat and Mass Transfer—SOLVED PROBLEMS EXERCISES.

18. Direct Energy Conversion

838

Introduction—Thermoelectric Convertors—Thermionic Convertors—Fuel Cells—Magneto Hydroelectric Generator—Photo Voltaic Systems (Solar Cells)—Losses in the Solar Cell—Advantages and Disadvantages of Solar Cells—Solar Cell Materials—Efficiency of Solar Cell and Rating—EXERCISES.

19. Conversion of Nuclear Energy

856

Introduction—Nuclear Physics—Nuclear Fission—Nuclear Fusion—Chain Reaction—Thermal Neutrons—Nuclear Reactor—Layout of Nuclear Power Plant—Neutron Multiplication Factor—Nuclear Reactors—Nuclear Power Station in India—Power of a Nuclear Reactor—Advantages of Nuclear Power Plants—Summary of Materials for Nuclear Power Reactors—SOLVED PROBLEMS—EXERCISES

Appendix
Bibliography
Index

880
939