FUNDAMENTALS OF THERMODYNAMICS AND HEAT TRANSFER

ENME 105

Lecture : 3 **Year : I**
Tutorial : 1 **Part : I**
Practical : 1.5

Course Objectives:
To understand the basic concepts, the laws of thermodynamics and heat transfer with their applications.

1 Introduction (6 hours)

- 1.1 Definition and scope of engineering thermodynamics
- 1.2 Microscopic versus macroscopic viewpoint
- 1.3 Concepts and definitions
  - 1.3.1 Thermodynamic systems
  - 1.3.2 Thermodynamic properties: Intensive, extensive and specific
  - 1.3.3 Thermodynamic equilibrium
  - 1.3.4 Thermodynamic state: State and path functions
  - 1.3.5 Thermodynamic process: Cyclic process, Quasi-equilibrium process, reversible and irreversible process
- 1.4 Pressure and pressure measurement
- 1.5 Temperature and the Zeroth law of thermodynamics
- 1.6 Energy and energy transfer
  - 1.6.1 Stored energy and transient energy; Total energy
  - 1.6.2 Heat and work transfer
  - 1.6.3 Expressions for displacement work transfer: Polytropic process
  - 1.6.4 Other examples of work: Electrical work and mechanical forms of work

2 Properties of Common Substances (6 hours)

- 2.1 Pure substance and state postulate
- 2.2 Phase-change processes of pure substances
- 2.3 Property diagrams for phase-change processes
  - 2.3.1 The T-V and the P-V diagram: Two-Phase (Liquid and vapour) systems; Phase change; Subcooled liquid, saturated liquid, Wet mixture, critical point, quality, moisture content, saturated vapour and superheated vapour
  - 2.3.2 Properties of two-phase mixtures
  - 2.3.3 The P-T diagram
  - 2.3.4 The P-V-T surface

2.4 Tables of thermodynamic properties
2.5 Ideal gas, ideal-gas state and ideal-gas relations
2.6 The compressibility factor

3 First Law of Thermodynamics (9 hours)

3.1 Joule's experiments, internal energy
3.2 First law of thermodynamics for control mass; First law of thermodynamics for control mass undergoing cyclic process
3.3 Enthalpy, heat capacity
3.4 First law of thermodynamics for control volume
3.5 Control volume analysis: Steady state analysis and unsteady state analysis
3.6 Control volume applications: Steady and unsteady work applications and steady and unsteady flow applications
3.7 Other statements of the first law

4 Second Law of Thermodynamics (9 hours)

4.1 Necessity of formulation of second law
4.2 Heat engine, heat pump and refrigerator
4.3 Kelvin-Planck and Clausius statements of the second law of thermodynamics and their equivalence
4.4 Reversible and irreversible processes
4.5 Carnot cycle, reverse Carnot cycle
4.6 Thermodynamic temperature scale and ideal-gas temperature scale
4.7 Clausius inequality and entropy - A property of a system
4.8 Entropy generation and the increase of entropy principle
4.9 Entropy change of pure substances
4.10 Entropy change relations for an ideal gas and incompressible substances
4.11 Isentropic process for an ideal gas and incompressible substances
4.12 Entropy balance for control mass
4.13 Entropy balance for control volume
4.14 Isentropic efficiency

5 Power Cycle, Refrigeration and Liquefaction (9 hours)

5.1 Classification of cycles
5.2 Rankine cycle and steam power plant
5.3 Internal combustion cycles: Otto cycle and Diesel cycle
5.4 Vapor compression refrigeration cycle
5.5 The choice of refrigerants
5.6 Absorption refrigeration
5.7 Liquefaction processes: Ways of liquefaction; Linde and Claude process

6 Introduction to Heat Transfer (6 hours)

6.1 Basic concepts and modes of heat transfer
6.2 One-dimensional steady state heat conduction through a plane wall
6.3 Radial steady state heat conduction through a hollow cylinder and a hollow sphere
6.4 Heat flow through composite structures
  6.4.1 Composite plane wall
  6.4.2 Multilayer tubes
6.5 Electrical analogy for thermal resistance
6.6 Combined heat transfer and overall heat transfer coefficient for plane wall and tube, composite wall and tube
6.7 Convection: Nature of convection, convection boundary layers
6.8 Radiation: Nature of heat radiation, radiation properties, blackbody radiation, emission from real surfaces
6.9 The Planck distribution, Wien's displacement law and The Stefan-Boltzmann law

Tutorials (15 hours)

1. Sample problems related to the thermodynamic properties and displacement work transfer
2. Sample problems related to properties of liquid-vapor mixture system
3. Sample problems related to mass and energy conservation of control mass, cyclic process, control volume
4. Sample problems related to entropy change, entropy generation for ideal gas, isolated system, control mass and control volume, isentropic efficiency
5. Sample problems related to performance of heat engine, heat pump and refrigeration
6. Sample problems related to power cycle and refrigeration system
7. Sample problems related to composite plane wall, cylinders and sphere, combined heat transfer and overall heat transfer coefficient

Assignments

1. Systems, properties and energy transfer
2. Property diagrams for phase-change processes and ideal gas relations
3. First law of thermodynamics
4. Second law of thermodynamics
5. Power cycle, refrigeration and liquefaction processes
6. Heat transfer

Practical (22.5 hours)

1. Temperature measurements
2. Experiment related to first law
3. The coefficient of performance of heat pump
4. Vapor compression refrigeration system
5. Steam power plant

6. Heat conduction
7. Heat radiation

Reference

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2. Smith, J. M., Van Ness, H. C., Abbott, M. M., Swihart, M. T. (2022). Introduction to chemical engineering thermodynamics. McGraw-Hill Education.
3. Luintel, M. C. (2016). Fundamentals of thermodynamics and heat transfer. Heritage Publishers & Distributors.
4. Van Wylen, G. J., Sonntag, R. E., Borgnakke, C. (2025). Fundamentals of thermodynamics. John Wiley & Sons, Inc.
5. Moran, M. J., Shapiro, H. N. (2018). Fundamentals of engineering thermodynamics. Wiley.
6. Bergman, T. L., Lavine, A. S., Incropera, F. P., DeWitt, D. P. (2018). Fundamentals of heat and mass transfer. John Wiley & Sons, Inc.
7. Holman, J. P. (2010). Heat transfer. McGraw-Hill Education.