Basic Mechanical Engineering Unit–4 Notes
Thermodynamics and Steam Engineering

UNIT–4 TOPICS

Thermodynamics:
• Thermodynamic System
• Properties, State and Process
• Zeroth Law of Thermodynamics
• First Law of Thermodynamics
• Second Law of Thermodynamics
• Constant Pressure Process
• Constant Volume Process
• Enthalpy and Entropy

Steam Engineering:
• Classification of Boilers
• Working of Boilers
• Boiler Mountings and Accessories
• Efficiency and Performance Analysis
• Natural and Artificial Draught
• Steam Properties
• Steam Tables

1. INTRODUCTION TO THERMODYNAMICS

Thermodynamics is branch of science dealing with heat, work and energy interactions.

Applications:
• Power plants
• Refrigeration systems
• Automobiles
• Steam turbines

2. THERMODYNAMIC SYSTEM

A thermodynamic system is quantity of matter or region under study.

Types of Thermodynamic Systems:

(a) Open System
Both mass and energy cross system boundary.

Examples:
• Steam turbine
• Compressor

(b) Closed System
Only energy crosses boundary but mass remains constant.

Examples:
• Gas in piston-cylinder arrangement

(c) Isolated System
Neither mass nor energy crosses boundary.

Examples:
• Thermos flask

3. THERMODYNAMIC PROPERTIES

Properties define condition of system.

Examples:
• Pressure
• Temperature
• Volume
• Density

Types of Properties:

Intensive Properties:
Independent of mass.

Examples:
• Pressure
• Temperature

Extensive Properties:
Depend on mass.

Examples:
• Volume
• Internal energy

4. STATE AND PROCESS

State:
Condition of system at particular instant.

Process:
Change of system from one state to another.

Types of Thermodynamic Processes:
• Isothermal process
• Adiabatic process
• Isochoric process
• Isobaric process

5. ZEROTH LAW OF THERMODYNAMICS

If two bodies are separately in thermal equilibrium with third body, then they are in thermal equilibrium with each other.

Importance:
Basis of temperature measurement.

6. FIRST LAW OF THERMODYNAMICS

First law states that energy can neither be created nor destroyed, only transformed from one form to another.

Expression:

$Q = \Delta U + W$

Where:
Q = heat supplied
ΔU = change in internal energy
W = work done

Applications:

• Heat engines
• Refrigerators
• Turbines

7. SECOND LAW OF THERMODYNAMICS

Second law defines direction of heat transfer.

Kelvin-Planck Statement:
No heat engine can convert all heat into work.

Clausius Statement:
Heat cannot flow from colder body to hotter body without external work.

8. CONSTANT PRESSURE PROCESS (ISOBARIC)

In this process, pressure remains constant.

Work Done:

$W = P(V_2 - V_1)$

Applications:
• Heating of gases in open vessels

9. CONSTANT VOLUME PROCESS (ISOCHORIC)

In this process, volume remains constant.

Work Done:

$W = 0$

Applications:
• Gas storage tanks

10. ENTHALPY

Enthalpy is total heat content of system.

Expression:

$H = U + PV$

Where:
H = enthalpy
U = internal energy

Units:
kJ/kg

11. ENTROPY

Entropy is measure of randomness or disorder of system.

Expression:

$dS = dQ/T$

Where:
S = entropy
Q = heat transfer

T = temperature

12. STEAM ENGINEERING

Steam engineering deals with generation and use of steam for power production.

13. BOILERS

Boiler is closed vessel used to generate steam by heating water.

Classification of Boilers:

(a) Fire Tube Boiler
Hot gases flow inside tubes.

Example:
• Lancashire boiler

(b) Water Tube Boiler
Water flows inside tubes.

Example:
• Babcock and Wilcox boiler

14. BOILER MOUNTINGS

Boiler mountings are safety devices fitted on boiler.

Examples:
• Safety valve
• Pressure gauge
• Water level indicator
• Fusible plug

15. BOILER ACCESSORIES

Accessories improve efficiency of boiler.

Examples:
• Economizer
• Superheater
• Air preheater

16. EFFICIENCY OF BOILERS

Boiler efficiency is ratio of heat utilized to heat supplied.

Expression:

Efficiency = (Heat utilized / Heat supplied) × 100

17. DRAUGHT

Draught is flow of air and flue gases in boiler furnace.

Types:
• Natural draught
• Artificial draught

18. STEAM PROPERTIES

Important steam properties:

• Dryness fraction
• Specific volume
• Enthalpy
• Entropy

19. STEAM TABLES

Steam tables provide thermodynamic properties of steam at different pressures and temperatures.

Applications:
• Boiler calculations
• Steam turbine analysis

MOST IMPORTANT 14 MARK QUESTIONS

1. Explain thermodynamic system and its types.

2. Explain thermodynamic properties, state and process.

3. State and explain Zeroth law of thermodynamics.

4. State and explain First law of thermodynamics.

5. State and explain Second law of thermodynamics.

6. Explain constant pressure and constant volume processes.

7. Explain enthalpy and entropy with significance.

8. Explain classification and working of boilers.

9. Explain boiler mountings and accessories.

10. Explain boiler efficiency and performance analysis.

11. Explain natural and artificial draught.

12. Explain steam properties and use of steam tables.

IMPORTANT 7 MARK QUESTIONS

1. Define thermodynamic system.

2. Explain intensive and extensive properties.

3. Explain isobaric process.

4. Explain isochoric process.

5. Define entropy and enthalpy.

6. Explain boiler mountings.

7. Explain steam tables.

IMPORTANT NUMERICALS

1. First law numerical problems.

2. Work done in constant pressure process.

3. Enthalpy calculation problems.

4. Boiler efficiency numerical.

EXAM TIPS

• Draw neat boiler diagrams.
• Learn thermodynamic laws carefully.
• Practice boiler efficiency numericals.
• Revise steam table properties regularly.
• Write formulas with units properly.