Basic Mechanical Engineering Unit–1 Notes Materials

UNIT–1 TOPICS

• Classification of Engineering Materials
• Cast Iron and Carbon Steel Composition
• Iron Carbon Diagram
• Alloy Steels and Applications
• Mechanical Properties of Materials
• Tensile Test
• Stress-Strain Diagram
• Hooke’s Law and Modulus of Elasticity
• Hardness Testing
• Impact Testing
• Brinell Hardness Number (BHN)

1. ENGINEERING MATERIALS

Engineering materials are materials used for manufacturing machines, tools, structures and engineering components.

Classification of Engineering Materials

1. Metals and Alloys
2. Ceramics
3. Polymers
4. Composites

(a) Metals and Alloys

Metals are good conductors of heat and electricity.

Examples:
• Iron
• Copper
• Aluminium

Advantages:
• High strength
• Ductility
• Toughness

(b) Ceramics

Ceramics are hard and brittle materials resistant to heat.

Examples:
• Glass
• Cement
• Porcelain

(c) Polymers

Polymers are lightweight materials having low density.

Examples:
• Plastic
• Rubber

(d) Composites

Composites are combination of two or more materials.

Examples:
• Fiberglass
• Reinforced concrete

2. CAST IRON

Cast iron is an alloy of iron containing carbon more than 2%.

Composition of Cast Iron:

• Carbon = 2% to 4%
• Silicon = 1% to 3%
• Manganese = 0.5% to 1%
• Sulphur and phosphorus in small amount

Properties:
• High compressive strength
• Good machinability
• Brittle in nature

Applications:
• Machine beds
• Pipes
• Engine blocks

3. CARBON STEEL

Carbon steel is steel containing carbon up to 2%.

Types of Carbon Steel:

1. Low Carbon Steel
2. Medium Carbon Steel
3. High Carbon Steel

Properties:
• Good strength
• High toughness
• Good weldability

Applications:
• Automobile parts
• Structural works
• Machine tools

4. IRON-CARBON DIAGRAM

Iron-carbon diagram shows relationship between temperature, carbon percentage and phases present in steel and cast iron.

Important Phases:
• Ferrite
• Austenite
• Cementite
• Pearlite

Importance:
• Heat treatment processes
• Selection of materials

• Understanding steel properties

5. ALLOY STEELS

Alloy steels are steels containing alloying elements like chromium, nickel, molybdenum etc.

Common Alloying Elements:
• Chromium
• Nickel
• Vanadium
• Molybdenum

Advantages:
• Increased hardness
• Corrosion resistance
• High strength

Applications:
• Automobile industry
• Aircraft industry
• Cutting tools

6. MECHANICAL PROPERTIES OF MATERIALS

(a) Strength
Ability to resist external force without failure.

(b) Hardness
Resistance to wear and scratching.

(c) Toughness
Ability to absorb energy before fracture.

(d) Ductility
Ability to be drawn into wires.

(e) Brittleness
Property of breaking without deformation.

(f) Malleability
Ability to be hammered into sheets.

7. TENSILE TEST

Tensile test is performed to determine strength and deformation behavior of material.

Procedure:
Material specimen is subjected to tensile load until fracture occurs.

Important Terms:
• Yield strength
• Ultimate tensile strength
• Breaking strength

Applications:
• Material selection
• Quality control

8. STRESS-STRAIN DIAGRAM

Stress-strain diagram shows relationship between stress and strain during tensile test.

For Ductile Material:
• Elastic region
• Yield point
• Plastic region
• Ultimate point
• Fracture point

For Brittle Material:
• Very small plastic region
• Sudden fracture

9. HOOKE'S LAW

Within elastic limit, stress is directly proportional to strain.

Expression:

Stress $\propto$ Strain

or

$\sigma = E\varepsilon$

Where:
σ = stress
ε = strain
E = modulus of elasticity

10. MODULUS OF ELASTICITY

Modulus of elasticity is ratio of stress to strain within elastic limit.

Expression:

E = Stress / Strain

Units:
N/m^2 or Pascal

11. HARDNESS TESTING

Hardness test measures resistance of material to indentation.

Types of Hardness Tests:
• Brinell hardness test
• Rockwell hardness test
• Vickers hardness test

12. BRINELL HARDNESS TEST (BHN)

In Brinell test, hardened steel ball is pressed into specimen surface.

Brinell Hardness Number Formula:

BHN = Load / Surface area of indentation

Applications:
• Determination of hardness of metals
• Quality control

13. IMPACT TESTING

Impact test determines toughness of material under sudden load.

Types:
• Izod test
• Charpy test

Applications:
• Material selection for shock loading conditions

MOST IMPORTANT 14 MARK QUESTIONS

1. Explain classification of engineering materials.

2. Explain composition and properties of cast iron.

3. Explain carbon steels and their types.

4. Explain Iron-Carbon diagram with phases.

5. Explain alloy steels and their applications.

6. Explain mechanical properties of materials.

7. Explain tensile test and stress-strain diagram for ductile material.

8. Explain Hooke’s law and modulus of elasticity.

9. Explain hardness testing and Brinell hardness test.

10. Explain impact testing of materials.

IMPORTANT 7 MARK QUESTIONS

1. Define ductility and malleability.

2. Explain brittleness and toughness.

3. Explain BHN.

4. Explain stress-strain curve.

5. Explain elastic limit.

6. Explain impact strength.

7. Explain ferrite and cementite.

IMPORTANT NUMERICALS

1. Stress and strain calculation.

2. Modulus of elasticity numerical.

3. BHN numerical problems.

4. Tensile strength numerical.

EXAM TIPS

• Draw stress-strain diagram neatly.
• Learn Iron-Carbon diagram properly.
• Practice BHN numericals regularly.

• Revise mechanical properties carefully.
• Write definitions with examples in exams.