ELECTRICAL ENGINEERING MATERIALS

Unit V : Special Purpose Materials

Topic: Thermocouples

Important Questions with Answers (3rd Semester, Electrical Engg.)

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Short Answer Questions

Q.1 Discuss the working of a thermocouple and mention its important applications.

Ans. A thermocouple is a temperature-measuring device made of two wires of different metals joined at two junctions. When the two junctions are at different temperatures, a small EMF is produced (Seebeck effect).

Working:

1. One junction (hot junction) is placed where the temperature is to be measured, for example in a furnace.
2. The other junction (cold junction) is kept at a steady temperature and is connected to a millivoltmeter.
3. Because of the temperature difference, a thermo-EMF is produced and a small current flows through the millivoltmeter.
4. The greater the temperature of the hot junction, the greater the EMF. The meter scale is marked in degrees Celsius.

Applications:

1. Measuring temperature of furnaces, kilns and ovens.
2. Boilers, steam lines and turbines in power plants.
3. Engines, exhaust gases and chemical plants.
4. Flame-failure safety in gas geysers and stoves.
5. Temperature monitoring of electrical machines and transformers.
6. Thermocouple instruments for measuring high-frequency current.

Q.2 What is the Seebeck effect? How does it differ from the Peltier and Thomson effects?

Ans. Seebeck effect: when two different metals are joined to form a closed circuit and the two junctions are kept at different temperatures, an EMF (thermo-EMF) is produced and a current flows. A thermocouple works on this principle.

Effect	What happens
Seebeck effect	Temperature difference between two junctions gives an EMF
Peltier effect	Current through a junction of two different metals makes it hot or cold
Thomson effect	Heat is given out or absorbed along a single conductor when current flows and its ends are at different temperatures

Joule effect	Heat produced by current in a resistance (I squared R)

Q.3 Name the common thermocouple materials and their temperature ranges.

Ans. The common thermocouples are given below.

Thermocouple	Metals	Approximate range
Copper-constantan	Copper and constantan	about -200 to 350 °C
Iron-constantan	Iron and constantan	about 0 to 750 °C
Chromel-alumel	Nickel-chromium and nickel-aluminium	about -200 to 1250 °C
Platinum-rhodium	Platinum with platinum-rhodium alloy	up to about 1500 °C or more

Note: These are textbook values and are not given in the syllabus.

Q.4 Write the desirable properties of thermocouple materials, and the advantages and limitations of a thermocouple.

Desirable properties:

1. High thermo-EMF for a given temperature difference.
2. EMF rising steadily (almost in a straight line) with temperature.
3. High melting point.
4. Good resistance to oxidation and corrosion.
5. Stable calibration.
6. Good strength and ductility.
7. Low cost.

Advantages	Limitations
Wide temperature range	Very small output (millivolts)
Simple, strong and cheap	Needs a steady cold junction or compensation
Quick response at a point	Moderate accuracy
No external supply needed	EMF is not exactly linear with temperature

Long Answer Question

Q.5 Describe the thermocouple with a diagram and mention its important applications.

Ans. A thermocouple is a device for measuring temperature. It is made of two wires of different metals (A and B) joined together at two points called junctions. Its principle is the Seebeck effect: if the two junctions are at different temperatures, a thermo-EMF is produced in the circuit. The EMF depends on the pair of metals and on the temperature difference between the junctions.

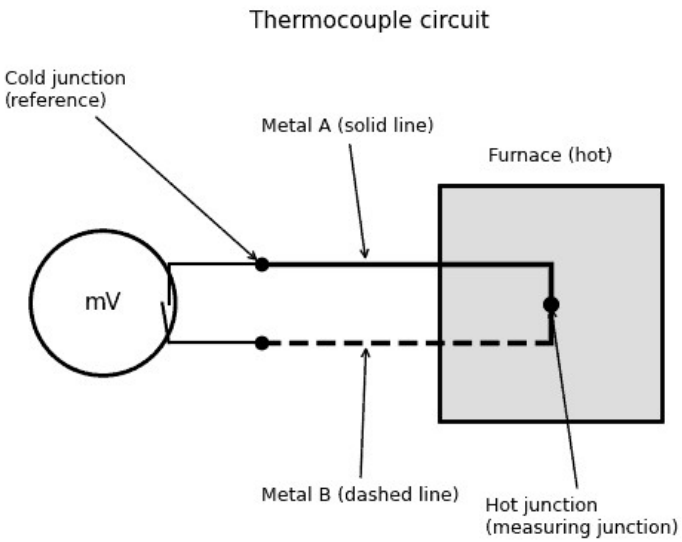


Fig. 1 Thermocouple circuit

Construction:

1. The wires A and B are welded together at the hot junction (measuring junction), placed in the furnace or other place to be measured.
2. The free ends form the cold junction (reference junction) at a known steady temperature, and are connected to a millivoltmeter.
3. The millivoltmeter scale is marked directly in degrees Celsius.

Working:

1. The hot junction is heated, while the cold junction stays at a steady temperature.
2. A thermo-EMF is produced (Seebeck effect) and a small current flows through the millivoltmeter.
3. Higher temperature gives higher EMF and a higher meter reading.

Materials:

Copper-constantan, iron-constantan, chromel-alumel and platinum-rhodium pairs, chosen by the temperature range.

Applications:

1. Furnaces, kilns and ovens.
2. Boilers, steam lines and turbines of power plants.
3. Engines and exhaust gases.
4. Flame-failure safety devices in gas geysers and stoves.
5. Temperature monitoring of electrical machines.
6. Thermocouple instruments for high-frequency current.

Note: The temperature ranges are approximate textbook values and are not given in the syllabus.

Points to Remember (for MCQ and True/False)

1. A thermocouple works on the Seebeck effect.
2. A thermocouple is made of two different types of metal (True).

3. Seebeck effect: temperature difference between junctions gives EMF. Peltier effect: current gives heating or cooling at a junction.
4. The EMF depends on the metals and on the temperature difference of the two junctions.
5. Hot junction is at the place to be measured; cold junction is at a steady temperature.
6. Common pairs: copper-constantan, iron-constantan, chromel-alumel, platinum-rhodium.