ELECTRICAL ENGINEERING MATERIALS

Unit IV : Magnetic Materials

Topic: Soft Magnetic Materials

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

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Short Answer Questions

Q.1 Write a short note on soft ferrites and its uses.

Ans. Ferrites are ceramic materials made from iron oxide mixed with oxides of metals such as manganese, zinc or nickel. The powder is pressed and sintered into shape. Soft ferrites are of the manganese-zinc and nickel-zinc types.

Properties:

1. Very high electrical resistivity, so eddy current loss is almost nil, even at high frequency.
2. Low coercivity and low hysteresis loss.
3. Moderate permeability and lower saturation flux density than steel.
4. Hard and brittle; cannot take shocks; made only by moulding.
5. Cheap in large numbers and light.

Uses:

1. Cores of high-frequency transformers (SMPS, chargers).
2. Inductors, chokes and filters in radio and TV.
3. Antenna rods of radios.
4. Recording heads and microwave devices.

Q.2 Write the properties of Mu metal and its applications.

Ans. Mu metal is a nickel-iron alloy with a very high nickel content (about 75 to 80%) and small amounts of copper and molybdenum.

Properties:

1. Extremely high permeability (tens of thousands up to about a lakh).
2. Very low coercivity and very low hysteresis loss.
3. Low saturation flux density, so it saturates easily in strong fields.
4. Soft and costly; it must be annealed after shaping and is spoilt by shocks and bending.

Applications:

1. Magnetic shielding of sensitive instruments, cathode ray tubes and cables.
2. Cores of audio and low-level signal transformers.
3. Magnetic recording heads and sensitive instruments.

Q.3 What is grain orientation? Write the properties and applications of C.R.G.O.

Ans. Steel is made of tiny crystals called grains. In each grain, magnetism is easiest along one direction. In ordinary steel the grains point in all directions. In grain-oriented steel the

grains are lined up in one direction (the rolling direction) by cold rolling and special heat treatment. Such steel has very high permeability and very low loss when the flux flows along the rolling direction.

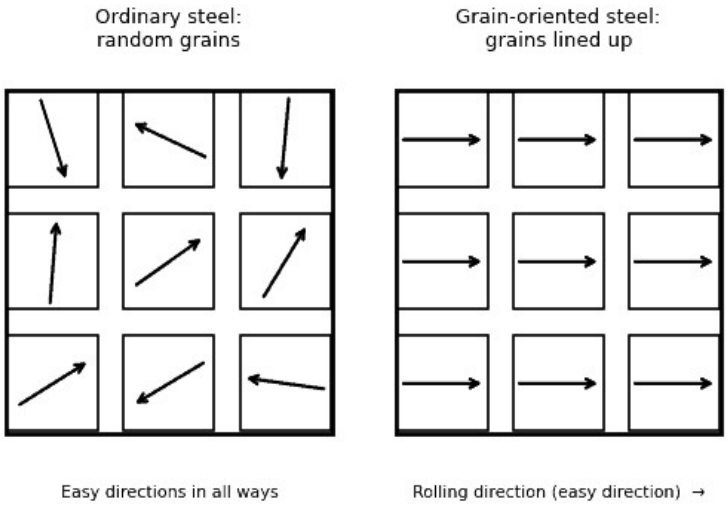


Fig. 1 Grain orientation in ordinary steel and in grain-oriented steel

Properties of C.R.G.O. (Cold Rolled Grain Oriented silicon steel):

1. Very high permeability and very low hysteresis loss along the rolling direction.
2. Thin laminations with an insulating coating, so eddy current loss is low.
3. Smaller and lighter cores and lower no-load loss.
4. More costly than ordinary silicon steel.
5. Poor properties across the rolling direction; spoilt by bending and cutting stress.

Applications:

Cores of power and distribution transformers.

Remember: C.R.G.O. is used where the flux flows in one fixed direction (transformers). It is not used for cores of rotating machines, where non-oriented silicon steel is used. So the statement that C.R.G.O. is used for cores of rotating machines is False.

Q.4 Write the properties and applications of iron-silicon alloy. Why is silicon added?

Ans. Iron-silicon alloy (silicon steel) is iron with about 0.5 to 4% silicon (transformer grades about 3 to 4%).

Why silicon is added:

1. It increases the electrical resistivity, so eddy current loss falls.
2. It reduces hysteresis loss and improves permeability.
3. It stops the ageing of iron.

Too much silicon makes the steel brittle and lowers its saturation flux density a little, so the amount is limited.

Properties:

High permeability, low hysteresis loss, high resistivity, low cost, supplied as thin insulated laminations (about 0.35 to 0.5 mm).

Applications:

Cores of transformers, stators and rotors of motors and generators, chokes and relays.

Q.5 Write the properties and applications of nickel-iron alloy.

Ans. Nickel-iron alloys (permalloy) contain about 35 to 80% nickel with iron.

Properties:

1. Very high permeability, much more than silicon steel.
2. Very low coercivity and hysteresis loss.
3. Lower saturation flux density.
4. Costly; properties are spoilt by mechanical stress.

Applications:

Small audio and communication transformers, sensitive relays, magnetic amplifiers, magnetic shields and cores for small signal circuits.

Q.6 Write the desirable properties of soft magnetic materials and name four soft magnetic materials with one use each.

Ans. Soft magnetic materials are easy to magnetise and demagnetise. Desirable properties: high permeability, low coercivity and retentivity, narrow hysteresis loop, high resistivity and high saturation flux density.

Material	Use
Silicon steel	Cores of motors and transformers
C.R.G.O.	Cores of power transformers
Mu metal	Magnetic shielding
Soft ferrites	Cores of high-frequency transformers

Long Answer Question

Q.7 Discuss soft magnetic materials (iron-silicon alloy, C.R.G.O., nickel-iron alloy, Mu metal and soft ferrites) with their properties and applications.

Ans. Soft magnetic materials are ferromagnetic or ferrimagnetic materials that can be magnetised and demagnetised very easily and keep very little magnetism when the magnetising force is removed. They have high permeability, low coercivity, a narrow hysteresis loop and low loss. They are used for cores of transformers, motors, generators, relays and chokes.

Material	Properties	Applications
Iron-silicon alloy	Silicon raises resistivity and lowers eddy and hysteresis loss; high permeability; low cost	Cores of motors, generators and transformers
C.R.G.O.	Grains lined up in rolling direction; very low loss along it; poor across; costly	Power transformer cores

Nickel-iron alloy	Very high permeability, low loss, low saturation; costly	Small audio and signal transformers, relays
Mu metal	Extremely high permeability, low saturation, soft and costly	Magnetic shielding, sensitive instruments
Soft ferrites	Very high resistivity, low loss at high frequency, brittle	High-frequency transformer cores, inductors, antenna rods

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

Points to Remember (for MCQ and True/False)

1. Iron is a soft magnetic material. Tungsten steel and Alcomax are hard magnetic materials.
2. High-frequency transformer cores are made from ferrites.
3. C.R.G.O. is used for transformer cores, not for cores of rotating machines (that statement is False).
4. Mu metal is a nickel-iron alloy with very high permeability.
5. Silicon is added to steel to increase resistivity and reduce losses.
6. Soft ferrites have very high resistivity, so eddy current loss is almost nil.
7. Soft magnetic materials have a narrow hysteresis loop.