## SOFT MAGNETIC MATERIALS

**Properties**:

- These magnetic materials can be easily magnetized and demagnetized, but they cannot be permanently magnetized
- Less energy is required to magnetize and demagnetize a soft magnetic material.
- These are used to make electromagnets.
- Eg: Iron silicon alloys, Ferrous nickel alloy, Iron-cobalt alloys, Ferrite and garnets • Low Hysteresis loss and low coercivity.
- These materials have large values of permeability and susceptibility

**Applications:**

- Soft magnetic materials have relatively small and narrow hysteresis loop and hence small energy loss per cycle of magnetization. They are widely used for the construction of cores of electrical rotating machines, transformers, and for making electro-magnets, reactors, relays
- Soft magnetic materials are mostly used where changing magnetic flux is associated, such as magnetic core of electric motors, alternators, DC generators, electrical transformers, protective relays, inductors.
- Used for making a path for flux in permanent magnetic motors
- Used for magnetic shielding, electromagnetic pole-pieces, to activate the solenoid switch
- Permanent magnet uses soft magnetic material to make a path for flux Examples:
- Nickel Iron Alloys - It is used in communication equipment such as audio transformer, recording heads and magnetic modulators. Since it has high initial permeability in feeble fields, low hysteresis and low eddy current losses.
- Grain oriented sheet steel: used to make transformer cores.
- Mu-metal: used in miniature transformers meant for circuit applications.
- Ceramic magnets: used for making memory devices for microwave devices and computer.

## HARD MAGNETIC MATERIALS

**Properties:**

- These magnetic materials cannot be easily magnetized and demagnetized, but they can be permanently magnetized.
- The reason is that the domain walls are motionless owing to crystal defects and imperfections.
- Hard magnetic materials have large hysteresis loss due to large hysteresis loop area
- These are used to make permanent magnets.
- High remnant magnetization
- The shape of BH loop is nearly rectangle.
- Small initial permeability.
- Relatively low permeability and susceptibility
- These materials have high Coercivity and retentivity. Hence, cannot be easily magnetized and demagnetized.
- High magnetizing force is required to attain magnetic saturation.
- Eg: Alnico alloy, Copper nickel iron alloy, Copper nickel cobalt alloy Applications:
- Hard magnetic materials (such as carbon steel, tungsten steel, cobalt steel and hard ferrites) have large hysteresis loop area and consequently large energy loss per cycle of magnetization and are used in making all kinds of instruments and devices requiring permanent magnets.

Various other applications are; • Automotive: motor drives for fans, wipers, injection pumps, starter motors, Control for seats, windows etc.

Telecommunication: Microphones, Loud Speakers, Telephone Ringers etc. • Data processing: Printers, Stepping Motors, Disc Drives and Actuators.

| *S. No* | *Hard Magnetic Materials* | *Soft Magnetic Materials* |
|---|---|---|
| 1. | Cannot be easily magnetized | Can be easily magnetized. |
| 2. | It can be produced by heating and sudden cooling | It can be produced by heating and slow cooling. |
| 3. | Domain wall does not move easily and require large value of H for magnetization. | Domain wall move easily and requires small value of H for magnetization. |
| 4. | Hysteresis loop area is large Susceptibility and Permeability values are small. | Hysteresis loop area is small Susceptibility and Permeability values are high. |
| 5. | Retentivity and Coercivity are large | Retentivity and Coercivity are small. |
| 6. | High eddy current loss | Low eddy current loss |
| 7. | Impurities and defects will be more | No impurities and defects |
| 8. | **Examples:** Alnico, Chromium steel, tungsten steel, carbon steel. | **Examples:** Iron-silicon alloy, Ferrous nickel alloy, Ferrites Garnets. |
| 9. | **Uses:** Permanent magnets, DC magnets. | **Uses:** Electro magnets, computer data storage. Transformer core. |