4.6 Ferrites

It is a special class of magnetic material and it is composed of two sets of different transition metal ions having different values of magnetic moment with antiparallel alignment.

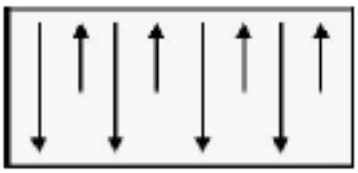


Fig:4.6.1 Magnetic moment alignment

Hence these materials are anti parallel magnetic moments of different magnitudes, giving rise to a fairly large magnetic moment in the presence of external magnetic field.

Properties

(i) The susceptibility is very large and is positive represented by,

$\chi = \frac{C}{T \pm \theta}$ When $T > T_{N.}$

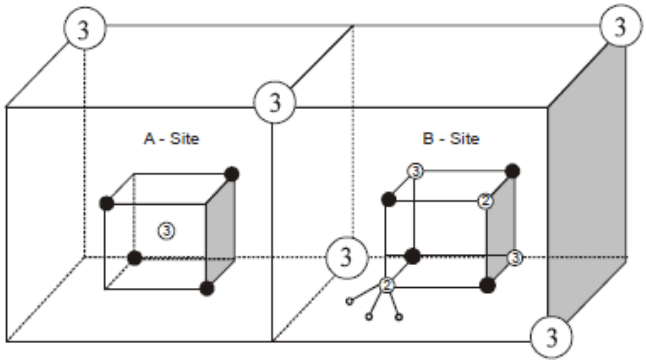
(ii) Beyond the Neel temperature, χ decreases.

(iii) These materials have low eddy current losses and low hysteresis losses.

(iv) They have hysteresis loop in the form of a square and will have low coercivity.

Structure of Ferrites

Ferrites are the magnetic compounds consisting of two or more different kind of atoms. Generally ferrites are expressed as $X^{2+}Fe_2^{3+}O_4$. Where, X^{2+} stands for suitable divalent metal ion such as, Mg^{2+}, Zn^{2+}, Fe^{2+}, Mn^{2+} etc.



Example

1) If X^{2+} is replaced by Ni^{2+}, then the ferrite ($Ni^{2+}Fe_2^{3+}O_4$) is formed, thus named as nickel ferrite.

2) If X^{2+} is replaced by Fe^{2+}, then the ferrite ($Fe^{2+}Fe_2^{3+}O_4$) is formed, thus named as ferrous ferrite.

Ferrites formed usually have a face centered cubic structure of ions closely packed together with the divalent and trivalent metal ions in the interstitial sites. This structure is called *spinal structure*. There are two types of ferrite structure.

- ❖ Regular spinal structure
- ❖ Inverse spinal structure

Regular spinal structure

In this type each metal ion is surrounded by four O^{2-} ions in a tetragonal fashion. For example, if the metal ion is Mg^{2+}, then the structure is shown in below figure and it is called 'A' site. Totally in a unit cell, there will be 8 tetrahedral sites.

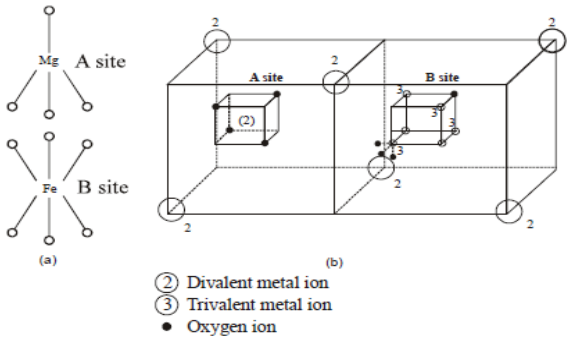


Fig:4.6.2

Each Fe^{3+} is surrounded by six O^{2-} ions and forms an octahedral fashion, which is shown in above figure. Totally there will be 16 such octahedral sits in the unit cell. This is indicated by 'B' site.

Thus in a regular spinal, each divalent metal ion exist in a tetrahedral form and each trivalent metal ion exist in an octahedral fashion. Hence the sites are A and B continue together to form a regular spinal ferrite

Inverse spinal structure

In this, the Fe^{3+} ions occupies all the A sites and half of the B sites also. Thus the left out B sites will be occupied by the divalent (Fe^{2+}). The inverse spinal structure is shown in given figure.

Type of interaction present in the ferrites

The spin arrangement between the A site and B site is an antiparallel manner and it was explained by Neel. According to him, in ferrites, the spin arrangement is antiparallel and there exist some interaction between the A site and B sites which is represented as AB interaction.

The tendency of AB interaction is to align all spins parallel to each other and antiparallel to all B spins, but the tendency of AA and BB interaction is to spoil the parallel

arrangement of A and B spins respectively.

Since AB is very strong as compared with AA and BB, the effect of AB interaction dominates and gives rise to antiparallel spin alignment.

Applications of Ferrites

- It is used to produce ultrasonic waves by magneto striction principle
- It is used in audio and video transformers
- It is used in radio receivers
- It is used to amplifier input signals with low noise

- It is used to as a power limiters
- It is used in computer and data processing circuit
- It is used as Gyrators, circulator and Isolator