Magnetic Leakage and Fringing

The flux that does not follow the desired path in a magnetic circuit is called a **leakage flux.**

In most of practical magnetic circuits, a large part of flux path is through a magnetic material and the remainder part of flux path is through air. The flux in the air gap is known as useful flux because it can be utilised for various useful purposes. Fig. 1 shows an iron ring wound with a coil and having a narrow air gap. The total flux produced by the coil does not pass through the air gap as some of it **leaks through the air (path at ‘a’) surrounding the iron. These flux lines as at ‘a’ are called leakage flux.

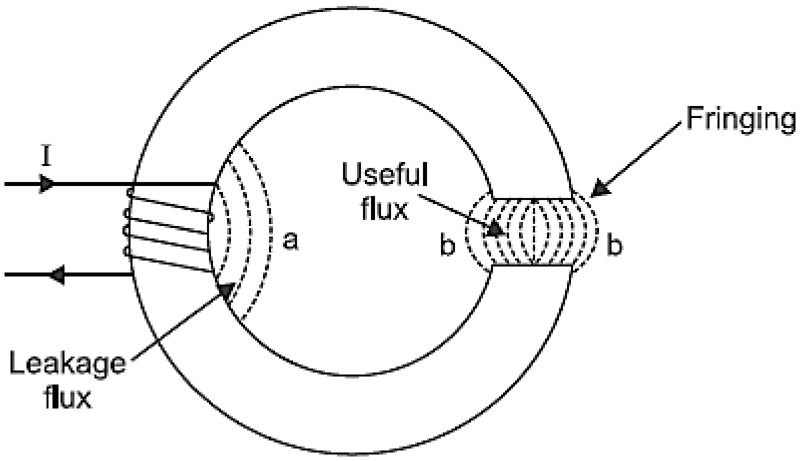


Figure: 1

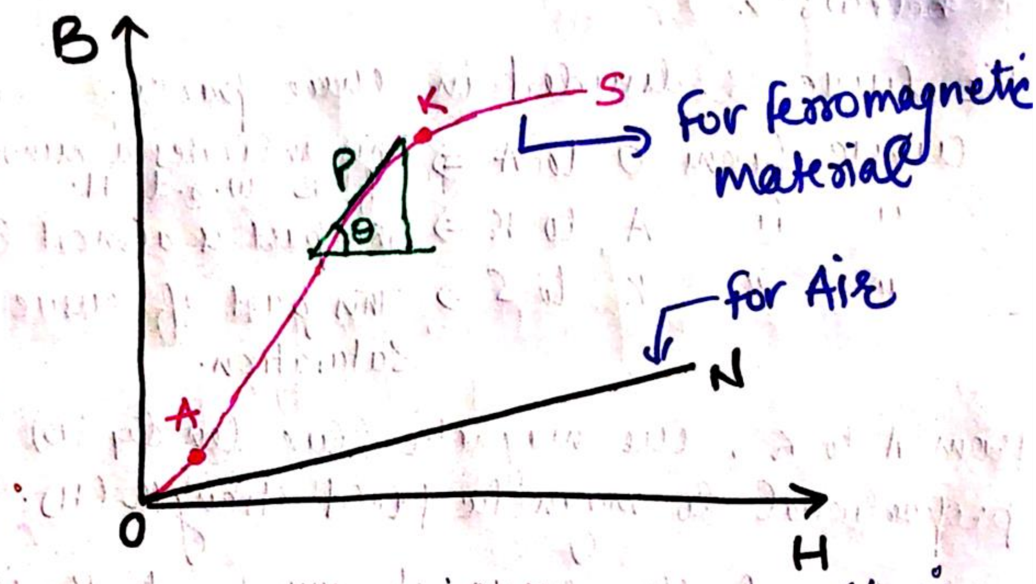
Magnetic leakage is undesirable in electrical machines because it increases the weight as well as cost of the machine. Magnetic leakage can be greatly reduced by placing source of m.m.f. close to the air gap.

Fringing

When crossing an air gap, magnetic lines of force tend to bulge out such as lines of force at bb in Fig. 1. It is because lines of force repel each other when passing through non-magnetic material such as air. This effect is known as fringing. The result of bulging or fringing is to increase the effective area of air gap and thus decrease the flux density in the gap. The longer the air gap, the greater is the fringing and vice-versa.

B-H curve :- B-H curve is the graph between magnetic flux density (B) and Magnetic field Intensity (or Magnetic field strength) (H).

The curve is shown below:



The graph shown above is BH curve. It is also known as magnetisation curve. This curve signifies the magnetisation of the magnetic material.

The above figure has two curves.

line ON → this curve indicates the graph between B and H for air or free space.

Because in case of air or free space, B and H are mathematically related to one another as.

$$\boxed{B = 4\pi \times 10^{-7} H}$$

∴ This means that $B \propto H$.

For air or free space, B is directly proportional to H. Hence, curve ON is a straight line.

The second curve (O-A-K-S) is associated with a ferromagnetic material. This curve is explained ~~Be~~ below :→.

The curve is divided in three parts.

curve from O to A ⇒ This indicates a minor change of B w.r.t H.

" " A to K ⇒ This part is almost linear

" " K to S ⇒ This part of curve indicates saturation.

From A to K, the magnetic flux density (B) is directly proportional to magnetic field strength (H).

The slope of this curve at any point P is given by

$$\tan\theta = \frac{B}{H}$$

But $B = \mu_0 \mu_r H$

or $\mu_r = \frac{1}{\mu_0} \frac{B}{H}$

or $\boxed{\mu_r = \frac{1}{\mu_0} \tan\theta}$

From K onwards, the slope starts decreasing gradually. This indicates that, B does not change anymore with H. This condition is known as magnetic saturation.

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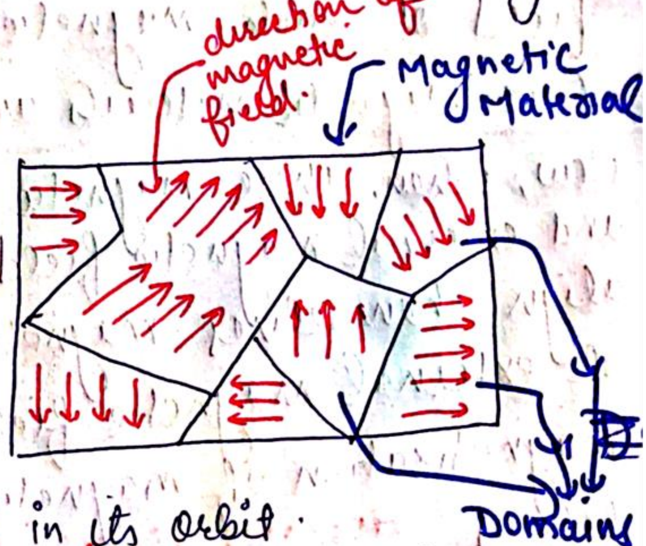
The B-H curve can be better understood through theory given below:



From Bohr's theory of atomic structure, we know that electrons have two types of motion in an atom:

→ rotation on its axis

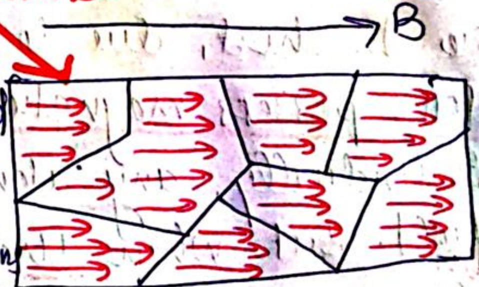
→ revolution around the nucleus of atom in its orbit.

In short, due to these motions of electrons, atoms possess magnetic field. Individually, any atom has very weak magnetic field. But when these atoms are clustered (i.e grouped) the magnetic field of each group of atoms become significant. However, grouping of atoms is based on the fact that all atoms must have magnetic field in same direction. The group of atoms is known as domain and each domain contains around 10^9 to 10^{15} atoms. These domains have significant magnetic field and have specific direction. But the magnetic fields of each domain are randomly aligned.

due to random alignment of the magnetic fields of each domain, the net magnetic field of each magnetic material is ZERO. (i.e. Magnetic materials are magnetically neutral).

Now; when, these magnetic materials are placed in and external magnetic field, all the domains align themselves magnetically with the direction of external magnetic field. This process is the magnetisation of magnetic material. (as shown below)

domains aligned with B.



Initially, the magnetisation process is slow. This is indicated by O–A (on the curve).

after some time when few domains align them selves with external field, the magnetisation process become fast. (This is Indicated By A to K on BH curve).

eventually, when ~~all the~~ almost all the domains align themselves with B; the process of magnetisation become slow and magnetic saturation reach. This is Indicated by K to S on BH curve.