3.1 Permanent Magnets Material

NdFeB – Neodymium – iron – boron has the highest energy product of all commercially available magnets at room temperature. It has high remanence and coercivity in the motor frame size for the same output compared with motors using ferrite magnets. But it is costlier. But both of the above stated magnets are sensitive to temperature and care should be taken for working temperature above 100˚.For very high temperature applications, alnico or rare earth cobalt magnets must be used.

B – H Loop

It is used for understanding characteristics hysteresis loop as shown.

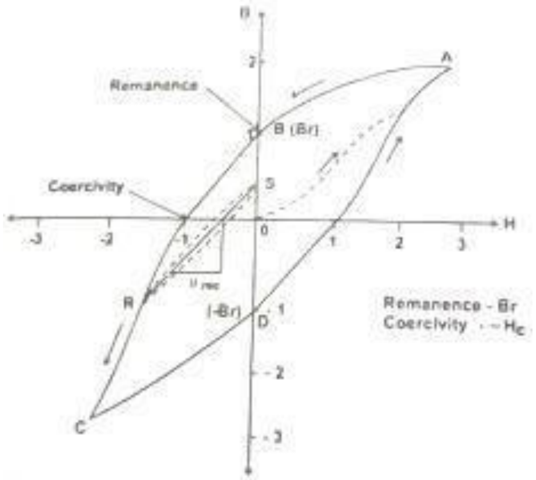

Figure 3.1.1 BH Hysteresis loop of hard permanent magnet
[Source: "special electric machines" by R.Srinivasan page:4.11]

Material X – axis – Magnetizing force or field intensity H.

Y – axis – Magnetic flux density B in the material.

An un-magnetized sample has B = 0 and H = 0 and therefore starts out at the origin.

Curve OA

If it is subjected to a magnetic field, magnetic fixture (an electromagnetic with shaped pole pieces to focus flux into the magnet), then B and H in the magnet follow the curve OA as the external ampere – turns are increased.

Curve AB

If the external ampere – turns are switched off, the magnet relaxes along AB. The operating point (H, B) depends on the shape of the magnet and permanence of the surrounding magnetic circuit. If the magnet is surrounded by a highly permeable magnetic circuit, that is if it is keepered then its poles are effectively shorted together so that H = 0 and then the flux density is the value at point remanence Br.

Permanence: Maximum flux density that can be retained by the magnet at a specified temperature after being magnetized to saturation.

Curve BC

External ampere turns applied in the opposite direction cause the magnets operating point to follow the curve from B through the second quadrant to C.

Curve CD

If the ampere – turns are switched off at c the magnet relaxes along CD.

It is now magnetized in the opposite direction and the maximum flux density it can retain when keepered is – Br.

To bring B to zero from negative remanence point D, the field +Hc must be applied.

The entire loop is usually symmetrical and be measured using instruments such as hysteresis graph.

Soft PM

Soft PM materials have Knee in the second quadrant such as Alnico. Alnico magnets have very high remanence and excellent mechanical and thermal properties. But they are limited in the demagnetizing field they can withstand. These soft PM are hard when compared with lamination steels the hysteresis loop of typical non oriented electrical steel is very narrow when compared with Alnico.

Demagnetization curve

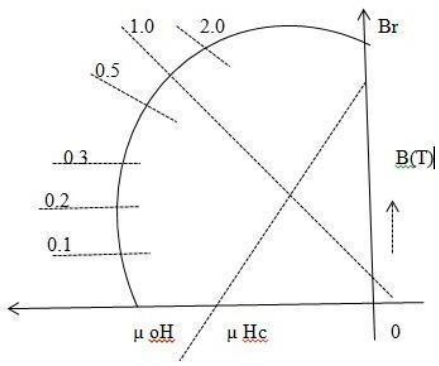

Figure 3.1.2 Demagnetization curve

[Source: "special electric machines" by R.Srinivasan page:4.11]

In the absence of externally applied ampere – turn, the magnets operating point is at the intersection of the demagnetization curve and the load line. The slope of the load line is the product of μ_0 and the permeance co efficient of the external circuit. In a permanent magnet, the relationship between B and H is

$$B=\mu_0 H+J$$

$\mu_0 H$ – flux density that would exist if the magnet were removed and the magnetizing force remain at the value H.

J – contribution of the magnet to the flux - density within its own volume.

If the demagnetization curve is a straight line, and therefore its relative slope and there by the μ_{rec} is unity, Then J is constant.

J – Magnetization of the magnet, unit T tesla

Hard magnets have $\mu_{rec} >= 1$,J decreases as the –Hc increases.

The magnet can recover or recoil back to its original flux density as long as the magnetization is constant. The coercive force required to permanently demagnetize the magnet is called the intrinsic coercivity and it is Hci.