For a given ferromagnetic material, the spontaneous magnetization can occur only below a certain critical temperature T_c, called **Ferromagnetic Curie temperature**. Well above the Curie temperature, such materials behave like a paramagnetic material and have well defined susceptibility given by Curie-Weiss law,

7.9.1 Temperature Dependence on Ferromagnetism

The properties of ferromagnetic materials are quite different at above and below the Curie temperature. Below the Curie temperature, the ferromagnetic materials show spontaneous magnetization and above this temperature, they obey Curie-Weiss Law.

Below Curie Temperature ($T < T_c$)

Below the ferromagnetic Curie temperature, ferromagnetic materials show a marked increase in susceptibility and exhibit the well known B-H characteristics.

Hysteresis Curve

Refer Fig. 7.6, starting with a virgin specimen (B = H = 0), if H is increased, B at first increases reversibly (oa). As the field H is increased further, B starts increasing rapidly until at point c on the curve, where saturation sets in. When position d is reached further increase in H causes negligible change in B, and at that point $B = B_{sat}$, called the saturation field. At saturation, if now, H is decreased the curve 'd e' results and a remanent flux density B_r is observed with H = 0. Since, there is no longer an external excitation, the specimen has become spontaneously magnetized. The magnetization corresponding to B_r (Remanent polarization or remanent flux density) is equal to $M_r = \frac{B_r}{\mu_0}$ as H = 0.

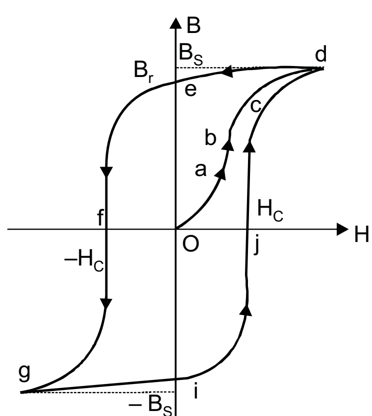

Fig. 7.6: Hysteresis Curve

A field $-H_c$ is required (in the opposite direction) to reduce the flux density to zero is called the **coercive force** or **coercive field**. Further decrease of H creates curve f g, with reverse saturation of B field occurring at g. Another reversal of H traces out 'gijd'. The portion of the curve e f is called the **demagnetizing curve**.

> The coercive force and remnant flux density vary widely over a range of ferromagnetic materials.

Weiss Theory of Ferromagnetism

Weiss suggested that, interaction could be expressed in terms of virtual internal field which he called the **molecular field,** was thought to be in some way caused by the magnetization of the surrounding material.

He assumed that the intensity of the molecular field was directly proportional to the magnetization, such that

$$H_m = \gamma M$$

where γ is called the molecular field constant. Therefore, the total internal field which acts in the material is

$$H_i = H + H_m = H + \gamma H \qquad \ldots \text{(i)}$$

γ is also referred as internal field constant, and it determines the strength of the interaction between the magnetic dipole moments in a material

Above Curie Temperature ($T > T_c$)

Even in case of ferromagnetic materials at very high temperatures ($T > T_c$), the thermal agitation is so great that internal field is not sufficient to maintain alignment of magnetic dipole moments. The behaviour becomes analogous to a paramagnetic material except that the field acting on the dipole is the internal field given in equation (i).

The value of internal field constant (γ) for a ferromagnetic material is of the order of 10^3.

The molecular field is in no sense a real field, it is rather a force which tends to align or disalign the atomic or magnetic moments, and the strength of the force depends on the amount of alignment already attained, because the molecular field is proportional to magnetization. This force is also called exchange force.

Ferromagnetic Domains

Normally in ferromagnetic materials, the individual atomic spin magnetic moments align within a small region called magnetic domains. A ferromagnetic