

Introduction to magnetism and magnetic materials

Chapman and Hall - Introduction to Magnetism and Magnetic Materials

Magnetic Materials: Hard Magnets

Hard magnets, also referred to as permanent magnets, are magnetic materials that retain their magnetism after being magnetized. Practically, this means materials that have an intrinsic coercivity of at least 1000 A/m.

It is believed that permanent magnets have been used for compasses by the Chinese since 2500BC. However, it was only in the early twentieth century that high carbon steels and then tungsten / chromium containing steels replaced lodestone as the best available permanent magnet material.

These were the first permanent magnets due to the pinning of domain walls by dislocations in the lattice. The movement of dislocations within a material is often hindered by the same factors that affect the motion of domain walls and as a consequence these steels are mechanically very hard and are the origin of the term hard magnetic. These magnets had an energy product of approximately B_{Hc}^m .

Alnico

In the development of permanent magnets the first improvement over steel came about in the early 1930s with the discovery of the group of alloys called the Alnico alloys. These alloys are based mainly on the elements nickel, cobalt and iron with small amounts of aluminum, copper and titanium. (Typical weights: Fe-85, Co-35, Ni-15, Al-7, Cu-4, Ti-4).

These alloys are still used today as they have a high Curie temperature ($>500^\circ\text{C}$) and as a result can operate at higher temperatures as well as having more stable properties around room temperature than some of the more modern alloys.

However, their main disadvantage is that they have low intrinsic coercivity ($<500\text{ A/m}$) and as a result cannot withstand high magnetic fields in households or long thin cylinders, when carried be exposed to significant demagnetizing fields. The magnets are either sintered or directionally cast and then annealed in a magnetic field.

This processing route develops an oriented microstructure consisting of rods of strong magnetic Fe-Co (α) in a matrix of weakly magnetic Ni-Al (α). The coercivity derives from the rod shaped nature of the α phase generating shape anisotropy along with the weak magnetism of the α phase.

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Magnetism

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Magnetism is a class of physical phenomena that are mediated by magnetic fields.

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