Rare-Earth Permanent Magnets (REPMs)

Prelims: *Current events of national and international importance | Science & Technology*

Why in News?

Recently, the Union Mines Minister announced that India will begin rare-earth magnet production in 2026 and set up critical mineral parks in four states.

- **Rare-earth permanent magnets** – They are ***among the strongest variants of magnets.***
- Made from rare-earth element alloys with high magnetic strength and energy density.
  - ***Not geologically rare but difficult to mine and process***, making them strategically important.
- **Key Features**
- **High Magnetic Strength –** Ability to strongly attract or repel other magnets.
- Due to the unpaired electrons in rare earth elements, producing strong magnetic fields.
- **High Coercivity –** Resistance to demagnetization which is caused by high magnetocrystalline anisotropy (strong atomic alignment).
- **High Energy Product –** Indicates magnetic energy stored in the magnet, as they are compact but powerful magnets.
- **Types**

Types	Characteristics
Neodymium Magnets (Nd-Fe-B)	• Strongest rare earth magnets. • It is brittle and easily damaged.
Samarium-Cobalt Magnets (Sm-Co)	• Less strong but more durable and highly temperature-resistant.
Praseodymium Magnets	• Slightly weaker than neodymium, but improves coercivity and thermal stability
Dysprosium Magnets (Dy-based)	• Highly temperature-resistant; increases coercivity
Holmium Magnets (Ho-based)	• Magnetically soft but has the highest magnetic moment

Manufacturing Process of REPMs

- **Mining and Refining –** Rare earth minerals like bastnäsite, monazite and xenotime are mined and processed through crushing, grinding and chemical leaching to extract rare earth elements.

- **Alloying –** Rare earth elements such as neodymium, praseodymium and dysprosium are mixed with iron, boron and cobalt to form magnetic alloys.
- **Sintering –** The alloyed material is heated without melting to strengthen the magnet and improve corrosion resistance.
- **Magnetising –** The magnets are exposed to a strong magnetic field to align magnetic domains and make them permanently magnetic.

The critical mineral processing parks will be set up in Odisha, Andhra Pradesh, Maharashtra and Gujarat.

- **Applications –** EV and industrial motors, generators, wind turbines, ***aerospace and military systems, medical devices*** (MRI, NMR).
- In electronics (hard disks, speakers, headphones), robotics, cryogenic refrigeration, and specialised high-field magnetic applications.
- **Significance –** Rare earth magnets boost India's autonomy by powering EVs, defence, and clean energy, while supporting Make in India, Atmanirbhar Bharat, and a circular economy through recycling.

Quick Fact

Scheme to Promote Manufacturing of Rare Earth Permanent Magnets (REPMs)
• **Aim** – To set up 6,000 MTPA integrated REPM manufacturing with sales-linked incentives and capital subsidy. • **Nodal Ministry** – Ministry of Heavy Industries (MHI). • **Key features** – The scheme will select 5 beneficiaries through global competitive bidding (up to 1,200 MTPA each). • **Duration** – Run for 7 years with a 2-year gestation and 5-year incentive period • **Supports** – The entire value chain from rare earth oxides to metals, alloys and finished magnets. • **Significance** – Reduces import dependence and strengthens EV, renewable energy, electronics, aerospace and defence supply chains.

References

1. TH | Rare-Earth Permanent Magnet
2. Sathee | Ministry of Education | Physics Rare Earth Magnets