TREM 2011

Michael H Walmer

22 March 2011

China Dominates Magnet Materials

WW Total Market Size $7B 2010, $15B by 2020 – good growth

NdFeB magnets 75%

Japan, US, European producers close plants, move production, US employment 500 vs 6000 in 1990, academic research groups - 5

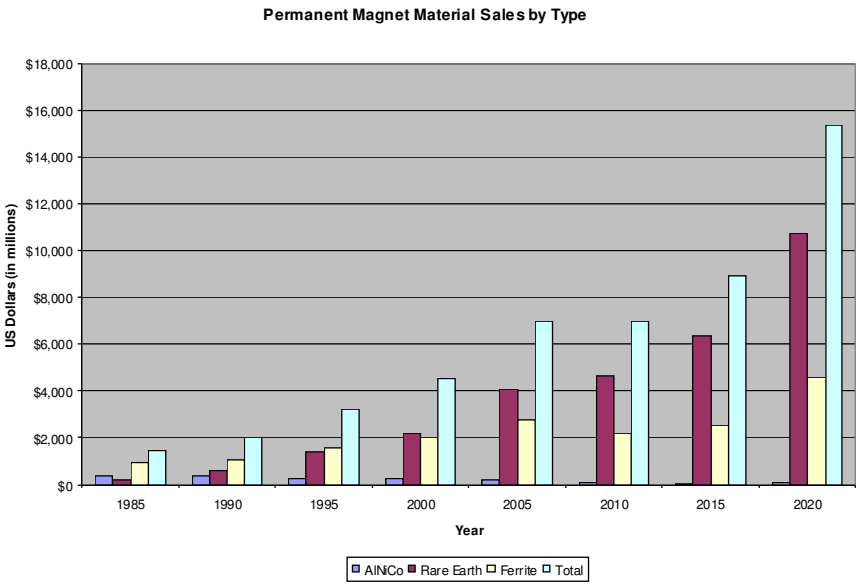
Approx ½ WW Alnico & SmCo production

Rare Earth Oxide Ore production 97%

Rare Earth pure Metals nearly 100%

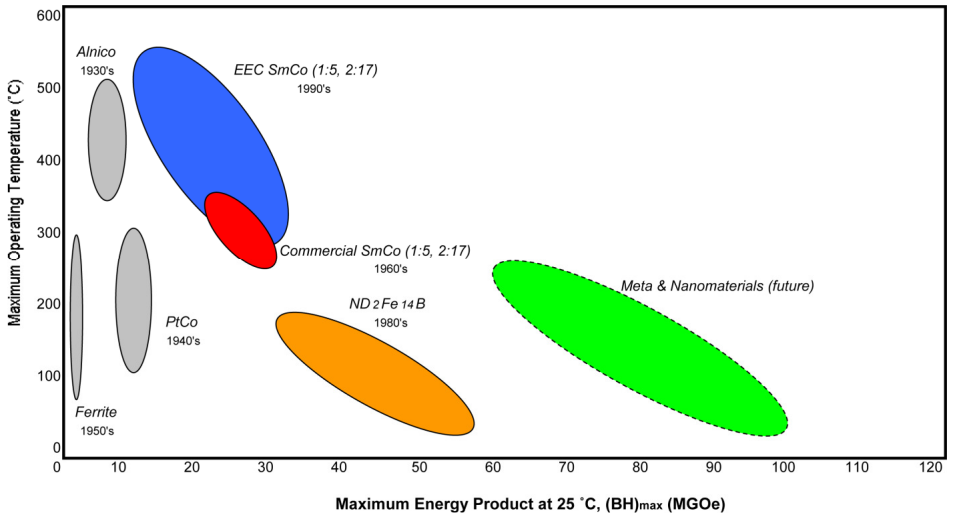
Hard ferrites 85+ %

Magnet Sales Worldwide



Data courtesy of Webmagnetics.com

- Market is growing due to automotive & more uses, miniaturization
- People pay lots more for better magnet performance ($5.4/kg Ferrite, $90/kg Nd)
- Smaller magnets make smaller less costly systems
- Lower systems costs will increase market
- “More electric” means more magnets



DOD Applications Requirements

SM3

- Light weight, small
- Tough environments
- Customized materials
- Smaller quantities
- US solutions, flexibility

DOD Platforms

- Army
  - M1A1Tanks, Bradley A3 and FIST, Paladin Howitzer
  - AH-64 Apache, Stryker, Humvee

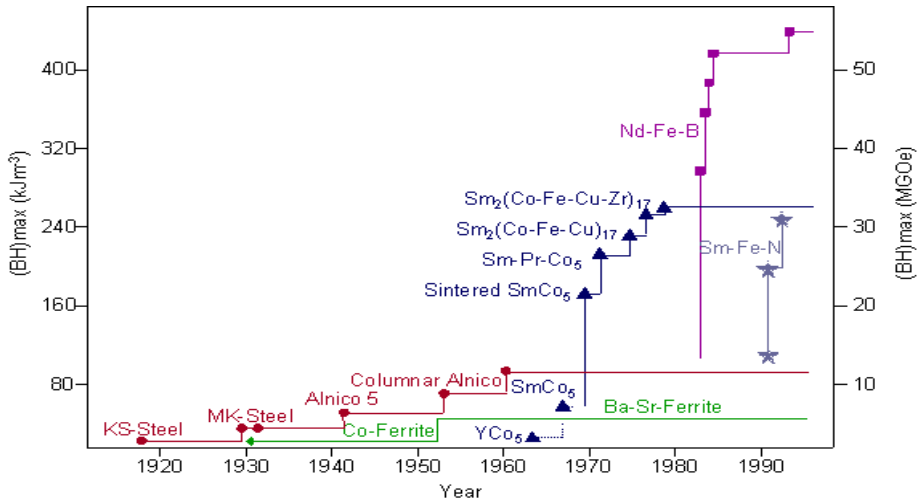
ALQ131 – F15

- Air Force
  - F-15, F-16, F-18, B-52, Towed Decoys, Joint Strike Fighter
  - Predator, Unmanned Aerial Vehicles

Recent Case Study: Magnets and Innovation

- **"Offshoring technology innovation: A case study of rare-earth technology", Fifarek, Veloso and Davidson, Journal of Operations Management, Vol. 26, 2008**
  - **Shows that once the domestic bonded neo magnet industry went to China, innovation by US industry involving bonded neo magnets decreased dramatically.**
  - **number of patents involving bonded neo magnets dropped precipitously.**
  - ***Bottom Line: Without the ability to manufacture, we lose the ability to innovate***

270 Years of Progress in Magnet Technology, --its not over



In the last 100 years, the strength of the magnets [(BH)max and Hc] increased dramatically (by a factor of 100)

Each magnet produces half a Joule of magnetic energy, yet the size has decreased by a thousand fold.

Where is workforce requirements to produce current and future materials? Challenges of manufacturing vs. R&D

Forecast Global Demand for Individual Rare Earths in 2014 (±15%)
(Im)balance of Supply-Demand

Rare Earth Oxide	Demand		Supply/Production	
	REO Tonnes	%	REO Tonnes	%
Lanthanum	51,050	28.40%	54,750	26.90%
Cerium	65,750	36.50%	81,750	40.20%
Praseodymium	7,900	4.40%	10,000	4.90%
Neodymium	34,900	19.40%	33,000	16.30%
Samarium	1,390	0.80%	4,000	2.00%
Europium	840	0.50%	850	0.40%
Gadolinium	2,300	1.30%	3,000	1.50%
Terbium	590	0.30%	350	0.20%
Dysprosium	2,040	1.10%	1,750	0.90%
Erbium	940	0.50%	1,000	0.50%
Yttrium	12,100	6.70%	11,750	5.70%
Ho-Tm-Yb-Lu	200	0.10%	1,300	0.50%
Total	180,000	100%	203,500	100.00%

- Air Products O_2, N_2 -steel

-Reduce use of higher demand

-Increase use of lower demand (Ce, Pr, Sm) – unsold material = cost, wildcard

-Thorium?

Source: Dudley J Kingsnorth IMOCA 2009

REE Supply Core Strategies
-Market Driven-

- Ability to produce more REE from sustainable, trustworthy supplies
- Mitigate/Replace REE usage (short-long term)
  - Incremental Process improvements (Kaizen – Japan NdFeB)
  - Better magnet technology (same flux with less material) => mitigate
    - Nanocomposites (NdFeB, SmCo) add 30% Fe
  - Leapfrog, disruptive technologies (non REE ??)
  - Result = more growth overall
- Develop applications for Ce, Sm, Pr and others in over supply
  - turn costs into assets
- Develop & recruit people to innovate
- Multi faceted, balanced, realistic public policy approaches & expectations
- Be EFFECTIVE in providing CUSTOMER VALUE