

Use and Exploitation of Rare Earth Metals

D. Ananthapadmanaban*, N. Arun, Jaya Arun Prashanth

Department of Mechanical Engineering, SSN College of Engineering, Chennai-603110, India

*Corresponding author email: ananthapadmanaband@ssn.edu.in, Tel. : +91 9940050472

ABSTRACT

Rare Earth metals are being used to a very large extent in today's challenging environment. This paper discusses the sources of rare earth metals and their applications. The paper especially focuses on 4 rare earth metals-Lanthanum, Cerium, Dysprosium and Neodymium. Mining scenario is discussed and the current state of the art technology has been brought out.

Keywords - Cerium, Exploitation, Lanthanum, Mining.

1. INTRODUCTION

Rare Earth metals are a unique set of 17 elements in the modern periodic table. The effect of these metals on properties of materials is quite drastic even when added in small quantities. For example, Lanthanum addition of around 0.015% gave increased toughness in steels. A minor addition of Scandium refines grains. Table 1 shown below shows the position of rare earth metals in the periodic table. Rare earth metals are been used in recent times in many applications like cell phones, batteries, Computers and in all aspects of the electronics Industries. Usage is catching up fast in Mechanical oriented Industries where they are used in small quantities as additives to improve the properties.

Table 1 Position of rare earths in periodic table

2. PRODUCTION AND DEMAND OF RARE EARTHS

About 22 kg of Lanthanum is used for the production of batteries in each Toyota Prius, which is the latest version of the Toyota Automobile.

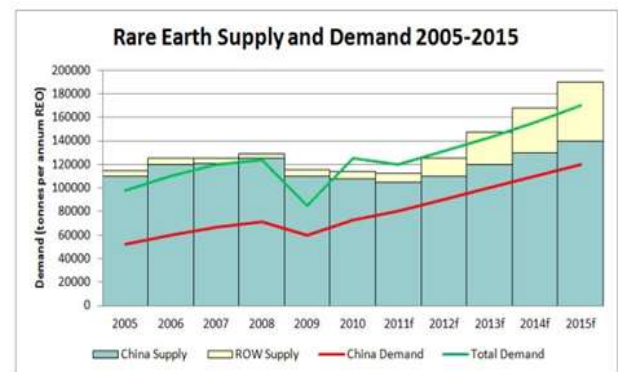


Fig. 1 Supply and demand of rare earths

2.1. Mining Scenario

During the 1950s, most of the rare earths were mined from India, Brazil and parts of Africa. From 1960 to the 1980s, Californai in U.S.A was producing most of the rare earth metals.

Most of the rare earth ores are available in China from the beginning of this century. Baotou which is a village in China is the world's largest supplier of rare earth minerals. But, it has become totally uninhabitable.

This land which was once full of minerals has turned completely barren and poisonous. This is due to the rank consumerism culture prevalent in the world.

In 1950 Baotou had a population of just 97,000. In a span of about 70 years, there has been a big increase in population due to the very lucrative mining culture which developed there.

95% of rare earth production is done by China and two thirds of this comes from Baotou. For example a smart phone has 8 different rare earths in it. Most of the

material used in its memory and the glossy appearance used on its glass consist of rare earths. They are also fundamental ingredients in green energy source industries, for example, wind turbines are one of the largest consumers of neodymium magnets,” says Young. Hence, even for production of green energy, which is supposed to be environmentally friendly, man is still exploiting nature to some extent.

For a long time, China controlled 95% of production (Chakhmouradian, 2012). But, now new deposits have been found in USA, Afganistan and India. Hence, the monopoly that they held in the world market, especially regarding unfair pricing may come down. [1]. China has set a target of 52,500 tonnes of production in 2016 which is unchanged from last year’s target.

India has been mining rare earths through the Indian Rare Earths Ltd. During Prime Minister Narendra Modi’s visit to Japan, Toyota group firm Toyota Tsusho Corporation and India are believed to have talked over the possibilities of jointly investigating mixed rare earth chloride - the starting commodity used to extract individual rare earths. This venture opens up possibilities of closer ties both in civil and defence sectors.2].This step may bring India and Japan closer and balance the huge monopoly enjoyed by China.

U.S has reserves of 13 million tonnes as compared to China which has 36 million tonnes The fact that China is increasingly focussing attention on mining and processing of rare metals in the last decade has also helped China become a leading producer of rare earths. Environmental clearance has become an issue for rare earth producing companies. Many NGOs and Environmentalists have raised genuine concerns on effects of mining on the common man due to the presence of radioactive materials in the slurry left behind while mining. [4].

Most recently, world-class concentrations of rare earth elements have been identified in the deserts of Afganistan .Many of them have potential uses in windmills, solar panels and electric cars. Going by statistics, geologists say, that with the help of advanced mapping techniques, they have identified about one million metric tons of these elements.

2.1.1 Scenario in India

India, which is spruced up by its Make in India idea has identified a potentially profitable and useful plan to

increase its output of rare-earth minerals used in electronics manufacturing. This could thwart the designs of China, which is aggressively marketing its own rare earth metals in the International market.

State-owned Indian Rare Earths Ltd has four plants at Chavara, Manavalakurichi, OSCOM and Rare Earths Division at Aluva, which suspended mining in 2004 due to its inability to compete with China on price. It is also building a rare-earth processing plant in the eastern state of Orissa. The government has also deputed two ships for research activities off the southern coast of India for reserves on the seabed. Rare-earth deposits are abundant on the ocean floor but have never been mined on an industrial scale.

There are some who say that India's ambitions are unlikely to be fulfilled in the near term. Indian Rare Earths plans eventually to produce 11,000 metric tons a year from its new plant. Even if successful, this would leave India well behind China, which produced 130,000 tons of the minerals in 2010, according to the U.S. Geological Survey. In the same year, India, a very distant No. 2, had only 2,700 tons of output. At present, India accounts for 2% of world production. India may have reserves of about 3.1 million tons of rare earths according to a survey made by the United States.

Louis James, a leading metals investment strategist says that India, having a reputation of corruption and red tapism may have difficulties in doing business in the area of rare earth metals. Advances in technology and a clear cut plan to exploit rare earths is a must in order to exploit the vast reserves available in India. [3].

Among these reserves, special mention must be made of the mineral Monazite, which is available in abundance in Kerala. Our Ex-President Dr. Abdul Kalam had talked about the exploitation of Thorium from Monazite for making India self sufficient in Nuclear Energy. Monazite is available in Tamil Nadu, Andhra Pradesh, Kerala, Odissa, West Bengal and Jharkhand. Earlier Australia was producing a lot of Monazite, but monazite mining has been reduced due to public outcry [4].

Monazite is a combination of three minerals, each may be called a different type of monazite.. The three monazites have differences in the percentages of their chemical makeup and these differences are reflected in their respective names.

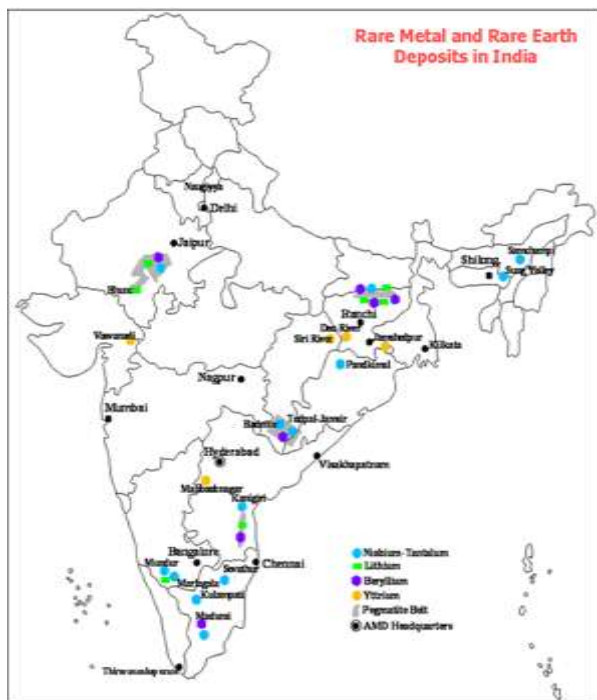


Fig. 2 Distribution of rare earth metals in India

3. COMMONLY USED RARE EARTHS

3.1. Cerium

Cerium is used in lighter flints [5]. Cerium is used to remove sulphur and oxygen impurities from aluminium and Iron alloys due to its high affinity for sulphur and oxygen.. In steels, cerium is used as a degassifier and can help to reduce sulfides and oxides. It also increases the hardness of steel by the mechanism of precipitation hardening. Adding cerium to cast irons opposes graphitization. Hence, cerium is added to produce malleable cast iron. Cerium metal is sometimes added to aluminum to improve aluminum's corrosion resistance [6, 7].

Cerium alloys are used in permanent magnets, and in tungsten electrodes for gas tungsten arc welding. Cerium is used in carbon-arc lighting, especially in the motion picture industry.

3.2. Lanthanum

Lanthanum is used in production of nickel-metal hydride batteries. These batteries find use in the present day hybrid car.. A typical hybrid automobile battery for a Toyota Prius requires 10 to 15 kg (22–33 lb) of lanthanum. As engineers make use of better and better technology to increase fuel efficiency, the amount of lanthanum required could be twice as much [8, 9].

Lanthanum (III) oxide (La_2O_3) improves the alkali resistance of glass. Hence, it is used in environments which require corrosion resistance. Lanthanum oxide is also used as a grain-growth additive during the liquid-phase sintering of silicon nitride and zirconium diboride. Lanthanum oxide additive to tungsten is used in gas tungsten arc welding electrodes. This improves the weldability. Earlier, thorium was used which can now be replaced by Lanthanum. We are also using Tungsten coated with Lanthanum oxide in our friction stir welding studies at SSN College of Engineering, Chennai.

3.3. Dysprosium

Dysprosium, along with vanadium is used in making laser materials. Dysprosium has high thermal neutron ability. Hence, it is used in neutron absorbing materials in the nuclear industry.. [10].

Dysprosium–cadmium compounds emit infrared radiation. Hence, they are useful for studying chemical reactions. Further, dysprosium and its compounds are highly susceptible to magnetization. They are employed in various data-storage applications, such as in hard disks

3.4. Neodymium

Neodymium magnets (actually an alloy, $\text{Nd}_2\text{Fe}_{14}\text{B}$) are the strongest permanent magnets known. A neodymium magnet of a few grams can lift a thousand times its own weight. This property could be very useful for practical applications. Rare Earths are not traded like other metals in Stock exchanges like London Stock Exchange. Hence, it may not be possible to exactly determine their prices [11].

In speaking about heavy REE dysprosium, for example, Peter Kelemen of Columbia University explained that “Ninety-nine percent of the current supply comes from clay deposits that can be easily mined in Jiangxi, China [12]. Similar to the United States, Japan is dependent on foreign suppliers for REEs, and as of mid-2012, Japan received 82 percent of its imports from China [13].

4. CONCLUSION

Rare earth metals are available in abundance in India. If properly mined, it could be the gateway to India becoming a superpower. New technologies to mine rare earths should be discovered and pollution due to mining should be minimized. The use of rare earths should be restricted to places where it is absolutely required.

REFERENCE

- [1] A.R. Chakhmouradian, F. Wall, Rare earth elements: minerals, mines, magnets, (and more), *Elements*, 8(5), 2012, 333-340.
- [2] <http://indianexpress.com/article/india/india-others/eye-on-china-india-and-japan-look-at-rare-earth/#sthash.6p8u83tT.dpuf>
- [3] Finding a place in the rare earths race-Varun Sood, Live Mint e-paper, November 14, 2015
- [4] B. Mukherji, T. Wright, India Bets on Rare-Earth Minerals, *The Wall Street Journal*, 2012.
- [5] T. Gray, *The Elements*, Black Dog & Leventhal Publishers, New York, 2010.
- [6] J. Emsley, *Nature's Building Blocks: An A-Z Guide to the Elements*, Oxford University Press, 2011.
- [7] K. Reinhardt, H. Winkler, Cerium Mischmetal, Cerium Alloys and Cerium Compounds, Ullmann's *Encyclopedia of Industrial Chemistry*, 2000
- [8] S. Gorman, As hybrid cars gobble rare metals, shortage looms, *Reuters*, 2009.
- [9] P. Bauerlein, C. Antonius, J. Loffler, J. Kumpers, Progress in high-power nickel-metal hydride batteries, *Journal of Power Sources*, 176 (2), 2008, 547-554.
- [10] A. Sinha, B.P. Sharma, Development of Dysprosium Titanate Based Ceramics, *Journal of the American Ceramic Society*, 88 (4), 2005, 1064-1066.
- [11] Roskill, Roskill data. Available online: <http://www.roskill.com>, September 2013.
- [12] R. Cho, Rare Earth Metals: Will We Have Enough?, *State of the Planet*, September, 2012.
- [13] M. Humphries, Rare Earth Elements, The Global Supply chain, *Congressional Research Service*, July 28, 2010.