Manufacturers Case Study

Using the Rare Earth Elements

Introduction

The rare earth elements have become crucial to technologies that define our contemporary world. While consumers most commonly encounter the rare earths in electronic devices such as smartphones, manufacturers also use rare earth metals for military applications, pollution control, and specialized medical applications. The rare earths are an essential part of technologies that reduce climate change, such as offshore wind turbines and electric vehicles. Participating in sustainability certification demonstrates manufacturers’ commitment to being socially responsible and may help to make supply chains more stable.

Industrial Uses of the Rare Earth Elements

Although a mineral containing rare earth elements was identified in 1788, it took more than 100 years for the first significant rare earth industrial product to appear. In the 1890s chemist Carl Auer von Welsbach developed a mantle made of a mixture of thorium and cerium for use with gas streetlights. More than five billion mantles were sold worldwide through the 1930s. Welsbach also developed mischmetal, a mixture of rare earth elements cerium, lanthanum, neodymium, and praseodymium. When alloyed with iron, mischmetal produced a metal that sparked when struck. It was widely used in pocket cigarette lighters as well as automobile ignition switches.

Military Uses

The race to develop new kinds of weapons during the Cold War between the United States and the Soviet Union (1947–1991) led to various uses of the rare earth elements. Basic scientific research, often funded by the military, revealed that adding a small amount of rare earth elements could make more common metals stronger, lighter, or more powerfully magnetic. U.S. Air Force researchers developed a new magnet made of samarium and cobalt in the mid-1960s, which was used in radar sets. Further research led to the development of the yttrium-aluminum-garnet (YAG) laser, which is used to measure distances and guide missiles. Soviet metallurgical research led to the development of a new alloy of scandium and aluminum, used in the MiG-29 fighter plane
developed in the 1980s. When the Soviet Union suddenly cut off exports of scandium, rare earth prices briefly spiked before new supplies of the metal could be developed.

Today, defense applications account for about 5% of U.S. consumption of the rare earth elements, according to the Congressional Research Service. Lockheed Martin’s F-35 stealth fighter uses 920 pounds of rare earths per plane in its electronic warfare systems, targeting radars, and electric motors that move the plane’s rudders. The rare earth elements are also used in night-vision goggles for soldiers, communications equipment, and the propulsion systems of nuclear submarines.

China’s near-monopoly on rare earth production has been especially problematic for weapons manufacturers. Federal regulations generally forbid buying parts built by potentially hostile countries for use in U.S. weapons, but exceptions have been made. In an effort to get the massively over-budget F-35 combat plane program back on schedule in 2015, the Office of the Secretary of Defense allowed Lockheed Martin to use four-dollar neodymium magnets purchased from a Chinese supplier. The U.S. government’s Defense Logistics Agency has sought to reduce the nation’s vulnerability to supply shortages by creating a strategic reserve of critical materials for use in times of national crisis.

**Magnets**

Magnets are one of the most important products manufactured using rare earth elements. The samarium-cobalt magnets developed by the U.S. Air Force in the 1960s did not demagnetize when exposed to high temperatures as other magnets did, thus allowing for new uses, such as in brakes, high-energy motors, and high-energy radar sets. During the 1970s about 60% of all cobalt mined came from one province in Zaire (now the Democratic Republic of Congo). When separatist fighters attacked the area in 1978, the price of cobalt increased from about $8.50 per pound to as much as $45 per pound. Concern that the Soviet Union might be hoarding cobalt and supporting the rebels gave increased urgency to research exploring other materials that might be substituted in magnet production. By 1982 magnets made of neodymium, iron, and boron (NdFeB) had been developed by Sumimoto Special Metals in Japan and General Motors in the United States. Each developed a different manufacturing process. The magnets were very brittle, however, and it took several years before the discovery of a process of coating NdFeB magnets made it possible to use them easily in manufactured products.

General Motors created a subsidiary company, Magnequench, to make rare earth magnets. These magnets were first used in automatic windows and locks in cars. But a growing market in electronics transformed the significance of rare earth magnets. Magnequench produced NdFeB magnets for desktop computer hard drives, helping to make personal computers ubiquitous during the 1990s.
**Consumer Electronics**

Probably the most widely known use of rare earths today is in consumer electronics. The release of the first iPhone in 2007 showed how far advances in rare earth applications had developed. Neodymium magnets in the phone power the vibrating motor and enable the earbuds’ tiny speakers to make loud, clear sounds. Lanthanum reduces distortion in the glass camera lens. Yttrium and erbium make bright colors in an energy-efficient screen.

The optical properties of rare earths also make them important for the data networks that connect phones and computers around the world. In the early 1990s Bell Labs developed erbium-doped amplifiers for fiber-optic cables, which move internet data and long-distance phone calls around the world.

Concern about the supply of rare earth metals has led some manufacturers to commit to developing recycling programs. In 2018 Apple introduced a prototype robot, named Daisy, that can disassemble iPhones to improve recycling. Since Apple is a well-known brand that counts on repeat sales, the company is particularly exposed to consumer and activist concerns about electronic waste. The company’s critics have noted that designing products to be more easily repaired and upgraded rather than replaced or even recycled would have a more significant positive impact on Apple’s environmental footprint.

**Batteries and Electric Vehicles**

The nickel–metal hydride (NiMH) battery became the primary battery type for electric and hybrid automobiles developed during the 1990s. (It should be noted that the first electrically powered vehicles were produced in the early 1900s by the likes of Henry Ford and Thomas Edison, before car makers abandoned them in favor of cars powered by internal combustion engines.) Early in the 1990s General Motors pioneered this market with its EV-1 electric car. Opposition by oil companies and a lack of government support for building electric charging stations led to the car’s cancellation.

Much more commercially successful were hybrid vehicles, which, like the Toyota Prius introduced in 2001, can go much farther on each gallon of gas. They combine a small gasoline-fueled internal combustion engine with an electric motor, powered by batteries that recover energy using magnetic brakes. High gasoline prices in the early 2000s, along with government regulations about fuel efficiency, helped establish hybrid cars in the market.

Concern about climate change, coupled with steadily improving battery performance, created a market for fully electric vehicles (EVs) during the 2010s. U.S. federal tax policy implemented under the Obama administration created a substantial rebate that helped consumers afford the higher cost of new EVs compared with similarly sized and styled vehicles powered by internal combustion engines. China has subsidized and developed
the market for EVs even more extensively, purchasing electric buses for public transportation and speeding up licensing for EVs to push consumers to buy them rather than gas-powered cars. In 2019 electric vehicles accounted for more than 2% of the world’s auto sales, with China having by far the largest number of EVs on the road.

Wind Turbines

Wind turbines represent one application where rare earth use might grow dramatically in the years to come. Generating electricity from wind energy produces no carbon dioxide emissions, so it will be an essential part of reducing climate change. Not all kinds of wind turbines use rare earths. But direct-drive turbines use neodymium and dysprosium permanent magnets. These turbines are lighter and easier to maintain, thus making them the preferred choice in offshore installations, such as those in the North Sea off the coast of Europe. China’s stated plan to rapidly expand wind power installation is also likely to increase demand for neodymium and dysprosium in the future.

Catalysis

One of the largest industrial applications of the rare earth elements cerium and lanthanum is as catalysts, materials that enable desired chemical reactions to happen more easily. In the 1980s cerium became a key component in the three-way catalytic converters that reduce nitrogen oxide and carbon monoxide pollution from automobiles. Oil refineries use lanthanum-based catalysts in fluid catalytic cracking, the process of converting crude oil into petroleum products such as gasoline. According to the U.S. Geological Survey, approximately 60% of the rare earths used in the United States in 2018 went into catalytic applications, while catalysis accounts for about 15% of all use of rare earth elements worldwide. (The United States is a major oil refiner and large producer of automobiles, while it does relatively little of the manufacturing of other products that use rare earths.)

Conclusion

The rare earth metals are important to a wide range of manufactured products. It can be challenging to substitute other materials in place of rare earths, though ways can sometimes be found to reduce the amount of rare earth metal needed for particular applications.

Manufacturers have sought to participate in sustainable certifications for a variety of reasons. Joining with activists and other stakeholders can help a company demonstrate its commitment to social responsibility and protecting the environment. Some consumers actively seek to buy from companies they see as socially and environmentally responsible. A corporate reputation for acting responsibly may also make it easier to recruit employees, as well as open the company to investment funds that seek out companies with good track records of...
social and environmental responsibility. Participating in a Sustainability Seal can help insulate a manufacturer from protests by consumers or activist organizations.