Rare-earth Magnet Recycling

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OVERVIEW: The ongoing depletion of limited underground resources means that resource recycling has become an inescapable issue. In particular, the concentration of production of neodymium and dysprosium in certain countries has created a need for risk reduction measures in order to ensure security of supply. These two elements are used in rare-earth magnets, which are considerably stronger than conventional magnets. Hitachi has developed technology that can efficiently separate rare-earth magnets from used products. The company is currently working to bring this recycling system into full commercial operation, while also emphasizing the CSR aspects of the project.

INTRODUCTION

HUMANITY'S progress since the industrial revolution has been underpinned by fossil fuels such as oil and gas, and by iron, copper, aluminum, rare metals, and other mineral resources. With increasing populations, however, ever greater quantities of these resources are needed to deliver prosperous lifestyles in emerging economies and other regions. While fossil fuels extracted from the earth release carbon dioxide (CO_2) into the atmosphere when burnt, there is no corresponding reduction in the total quantity of mineral resources after they are mined and put to use. In cities with a high population density, in particular, quantities of rare or precious metals such as gold, silver, or platinum lie hidden inside electrical, mechanical, and electronic products. The term "urban mine" is used to refer to this resource. The energy-efficient air conditioner is a familiar example of a low-carbon product, while hard disks are used for data storage inside the computers that support the information age.

Hitachi has published an Environmental Vision that designates the sustainable society as the goal of its environment management, and is pursuing activities aimed at the "Prevention of Global Warming," "Conservation of Resources," and "Preservation of Ecosystems." As part of Hitachi's resource recycling initiatives, these activities also include the recycling of rare-earth magnets. This article focuses on rare-earth magnets that contain neodymium and dysprosium.

Rare-earth magnets are a key material in energy saving and digital equipment such as hard disk drives (HDDs), high-efficiency air conditioners, hybrid vehicles, and wind power generators. They also play a role in preventing global warming. However, a dependence on overseas suppliers for raw rare-earth metals means that securing an alternative supply of these materials is essential for the steady and sustainable production of these products.

Fig. 1 shows short-, medium-, and long-term measures for ensuring a secure supply of rare earths. The short-term measures consist of increasing stockpiles and decreasing consumption, the medium-term measures involve recycling, and the long-term measures involve the development of new mines and alternative materials. Recycling means separating the rare-earth magnets from used products so that they can be reused as raw materials, making it a measure that companies can conduct for themselves, independently of underground resources. Rather than simply being

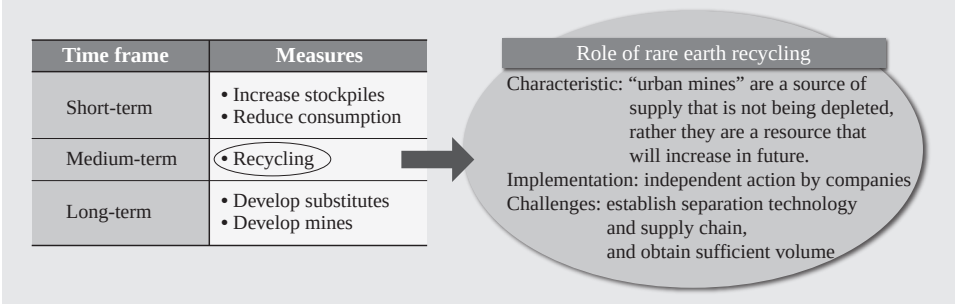


Fig. 1—Measures for Ensuring a Secure Supply of Rare Earths. Initiatives aimed at ensuring a secure supply of rare earths include short-, medium-, and long-term measures. Recycling is not dependent on underground resources and provides a sustainable supply based on recovery from "urban mines."

about the recycling of resources, this can also be seen as something that companies ought to be doing to help achieve a sustainable society.

This article describes Hitachi's involvement in the recycling of rare earths from "urban mines."

TECHNOLOGIES FOR RARE EARTH RECYCLING

Hitachi has developed magnet recovery machines designed for use with specific products that contain rare earths, namely HDDs and air conditioner compressors.

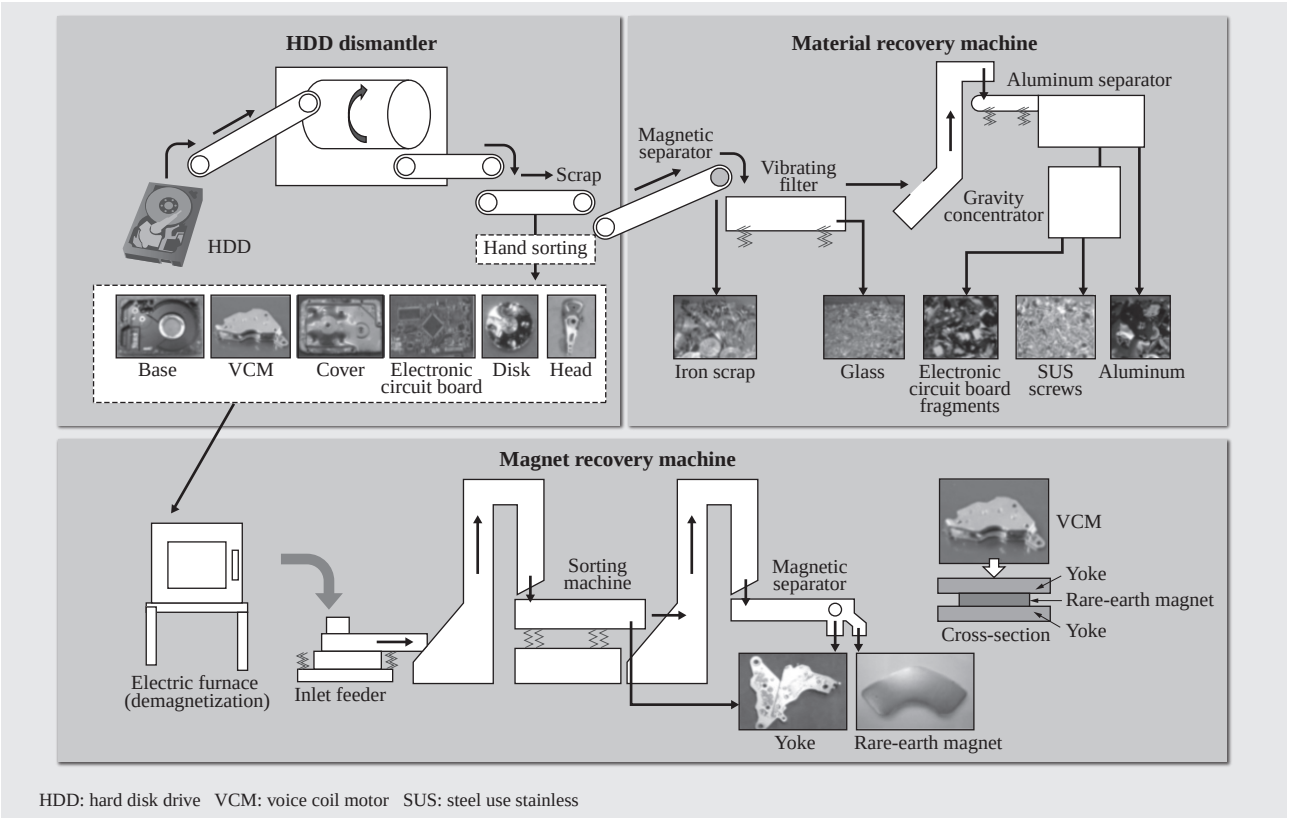
Rare Earth Magnet Recovery Machine for HDDs

The electric motors in HDDs contain rare-earth magnets. These are called voice coil motors (VCMs). Fig. 2 shows the process used to separate and recover the rare-earth magnets. While development of an HDD dismantler[(1)] that removes VCMs from HDDs and demagnetizes them has already been completed, Hitachi also developed new recovery machines for the magnets and other material respectively. The magnet recovery machine automatically removes and separates the magnets from the demagnetized VCMs, and the material recovery machine efficiently recovers the different materials from the scrap left over by the HDD dismantler. The VCMs disassembled by the HDD dismantler are then demagnetized in an electric furnace, but the external yoke and rare-earth magnets that make up the VCM remain joined by a carbonized adhesive. The magnet recovery machine then separates the rare-earth magnets from the yoke, using a machine for performing the process.

The scrap from the HDD dismantler contains iron, glass, electronic circuit board fragments, steel use stainless (SUS), and aluminum. The material recovery machine uses a combination of techniques, including a magnetic separator, vibrating filter, and gravity concentration, to separate and recover the different materials from this mixture. As electronic circuit board fragments, in particular, contain precious metals, this process acts as a form of precious metal recovery.

Rare-earth Magnet Recovery Machine for Air Conditioners

Rare-earth magnets are used in the compressors of energy-efficient air conditioners. The process used to recover these includes a mechanical unit for cutting



HDD: hard disk drive VCM: voice coil motor SUS: steel use stainless

Fig. 2—Process Used to Separate and Recover Rare-earth Magnets from HDDs.
Hitachi has developed and commercialized a process that separates the rare-earth magnets from HDDs and also sorts the other scrap to automatically separates fragments of precious metals or other valuables.

open the casing, a rotor removal machine that extracts the rotor from the motor, a demagnetizer that operates at room temperature using resonance damping demagnetization, and a magnet removal machine with a drop impact mechanism (see Fig. 3). The basic technologies for these already exist[1]. However, while all compressors may have the same basic design, there are minor differences in the shapes and structures used by different manufacturers that the system must be able to cope with. Accordingly, the practicality of the machines was enhanced through improvements that increased their operational performance and processing speed. This included modifying the process to work with compressors whose section shapes are elliptical, for example.

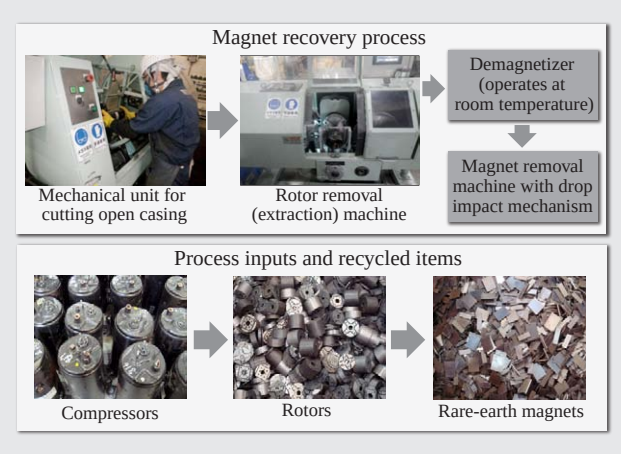


Fig. 3—Process Used to Separate and Recover Rare-earth Magnets from Air Conditioners.
The energy-efficient compressors used in air conditioners contain rare-earth magnets. Hitachi has developed a machine that damps the strong magnetic field and uses a mechanical process to separate and recover the magnets efficiently. High-volume production trials are currently being conducted on a commercial scale.

Preparations for Commercial Operation

Tokyo Eco Recycle Co., Ltd. is a Hitachi Group company based in Koto ward, Tokyo that was founded as a recycling business for recovering resources from home appliances and personal computers (PCs). It has been using the magnet recovery machines on HDDs and air conditioner compressors since FY2012 and a trial is proceeding smoothly with the quantity of magnets produced being in the order of tons. The plan is to increase plant utilization by ramping up the quantity of material collected from the market in step with the available processing capacity.

While the recovery of rare-earth magnets is the primary purpose of the newly developed machines, they are also designed to separate the other materials so that they can fetch a good price. The aim is to guard against fluctuations in the price of rare-earth magnets by augmenting the business through the sale of other materials.

FUTURE DEVELOPMENT

The security and pricing (economics) of raw material supplies pose a challenge for companies that produce products using rare earths. When recycled material is supplied to manufacturing, increasing plant utilization in accordance with material availability provides an effective way of enhancing the economics of the business. Nevertheless, the business is still influenced by fluctuations in the sale price not only of rare earths but also of the other materials produced by separation.

Meanwhile, companies that use PCs or other equipment with embedded computers also have growing concerns about non-economic considerations, including security concerns such as the erasure of data, compliance management by contractors when material is disposed of as industrial waste, and the recycling of rare-earth materials. In response to this, Hitachi seeks to collaborate on aspects such as recovery and business model design with companies that place a high priority on corporate social responsibility (CSR) considerations and include the creation of a society characterized by resource recycling and low carbon emissions in their environmental management policies. Fig. 4 shows a cycle of rare-earth recycling based on this sort of collaboration.

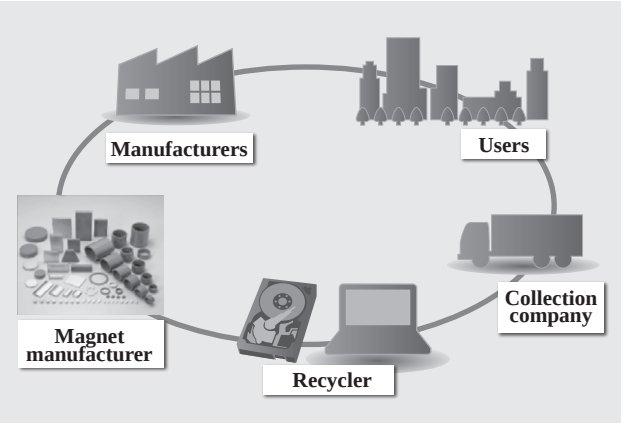


Fig. 4—Cycle of Resource Recycling (for HDD Rare-earth Magnets).
The creation of a network that recovers and recycles precious metal scrap as well as rare earths from the HDDs opens up the potential for obtaining a reliable supply of material from "urban mines."

CONCLUSIONS

This article has described Hitachi's involvement in the recycling of rare earths from "urban mines."

The development of technologies like those described here is not the only consideration associated with solving the sort of resource problems exemplified by rare earths. Factors such as economic viability and the sourcing of reliable supplies of used products are also important. Accordingly, because there is a limit to what the actions of a single company can accomplish, a contribution to making resource recycling part of society can be achieved by working with other interested parties and coordinating activities across a number of industrial groups.

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REFERENCE

(1) T. Nemoto et al., "Resource Recycling for Sustainable Industrial Development," Hitachi Review **60**, pp. 335–341 (Oct. 2011).

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