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More sustainable e-mobility

Magnet recycling pays off

Magnets are valuable components. Although functional magnet recycling methods have been developed in recent years, they have not yet been applied in practice and magnets continue to be melted down into steel scrap. Researchers at the Fraunhofer Research Institution for Materials Recycling and Resource Strategies IWKS provide good arguments for why this should change in the future. Their “FUNMAG” project demonstrates that recycled magnets can be used to power engines in the e-mobility sector, without any loss of power. It also shows that establishing a value chain for large-scale magnet recycling will pay off.

The world is betting on electromobility. This sector is seeing continual growth while also gaining political significance as part of the energy transition. The German federal government, for example, plans to approve seven to ten million electric vehicles for use in Germany by 2030. There’s one component that is simply essential for an electric motor to function properly — a neodymium-based magnet (also known as an Nd-Fe-B or a high-energy permanent magnet). They are currently the most powerful magnets available on the market and account for around half of the costs of the motor, containing, as the name suggests, rare-earth elements including neodymium or dysprosium. The most significant supplier for rare-earth elements is China, which meets over 90% of the global demand while mining under critical conditions. The mining releases poisonous by-products which can pollute the groundwater if not handled correctly, resulting in harm to both people and nature.

In spite of the expensive and problematic production process, magnets are usually simply heaped on the scrap pile at the end of their useful life and melted down together with scrap steel. And this continues to happen despite the availability of proven functional magnet recycling methods. The scientists at the Fraunhofer Research Institution for Materials Recycling and Resource Strategies IWKS, in Hanau, want to close the gap between theory and practice with their “functional magnet recycling for sustainable e-mobility” project, “FUNMAG” for short. Sponsored by the Hessen Agentur, the research team aims to prove that electric motors that use recycled magnets can generate the same power as those using original new magnets and that, therefore, commercial recycling at large scale is a viable endeavor.

Contact

Roman Möhlmann | Fraunhofer-Gesellschaft, München, Germany | Science Communications | Phone +49 89 1205-1333 | presse@zv.fraunhofer.de
Dr. Katharina Hendrich | Fraunhofer Research Institution for Materials Recycling and Resource Strategies IWKS | Phone +49 6023 32039-862 | katharina.hendrich@iwks.fraunhofer.de
Brentanostrasse 2a | 63755 Alzenau, Germany | www.iwks.fraunhofer.de

Working with “a real mixed bag”

For the corresponding experiments, the Fraunhofer IWKS procured, among other things, an electric bike, electric scooter and a hoverboard. Konrad Opelt, Project Head and material scientist explains: “First of all, we looked at the characteristics of the electric motors in each of the new vehicles to determine the relevant key data we would later use to compare the power of the motors with recycled magnets.”

The electric vehicles form the framework for the project. The key part, however, is the work with the scrap magnets. These were procured by the ton from existing industry partners and vary greatly in terms of power, type and condition. “It was extremely important to us to build a realistic case,” Opelt explains. “If scrap dealers decide to separate the magnets from engines that have been disposed of, it will generally be a real mixed bag of various magnets, the precise characteristics of which nobody is sure of. Therefore, our aim was to show that the recycling process can also cope with undefined base materials, with these unknowns in the process. And nobody has done this before us.”

Making new from old

For years, teams at the Fraunhofer IWKS have been working on the production and recycling of magnets. Appropriate spaces and devices allow the entire production process to be produced on a pilot-plant scale. When producing a new magnet, the starting materials are initially melted at around 1400 degrees and then quenched, creating metal flakes. These are added to a hydrogen atmosphere and the penetration of the hydrogen causes the material to break down into a granulate. This is crushed again in a jet mill, and the resulting metallic “flour” can then be put into molds and sintered — or “baked” — into magnets. To recycle a magnet, it is sufficient to put the old magnet in contact with the hydrogen atmosphere and then follow the remaining steps in the process. “We can simply skip the environmentally damaging mining of raw materials and energy intensive fusing process,” Opelt summarizes.

The recycling process allows thousands of magnets to be processed simultaneously. “It is almost impossible to prevent the magnets from picking up some oxygen during this process, which leads to a slight deterioration in quality. But we can counteract this, for example, by adding 10 to 20 percent of new material or by further processing the microstructure of the magnets,” Opelt explains. The power of the recycled magnets can be determined from the end product or at the powder stage. Eventually, these experiments should allow the establishment of a portfolio of characteristics. This will provide future users with recommendations on how to modify the recycling process to achieve the desired target characteristics for the magnets based on the starting composition.

Building a new value chain

The researchers are currently working on further optimizing the treatment process during the recycling process. Konrad Opelt is confident, however, that the recycled magnets can soon be incorporated into the electric motors and is already looking forward to whizzing around the institute yard on his hoverboard.

Once this step is complete, it would be tangible proof of the success of recycling. “In order to be able to build a robust value chain for magnet recycling in the long-term, all the actors in the chain need to be able to rely on one another,” Opelt emphasizes. “With FUNMAG, we’re demonstrating that the idea actually works and that we are making a decisive contribution to building this value chain.”

The political and industry interest in the approach is great, because it promises both improved sustainability and less resource dependency. Konrad Opelt hopes that this encourages manufacturers in the future to think ahead when producing electric motors and ensure that the magnets are easy to remove and reassemble, with recycling in mind. The same applies beyond the e-mobility sector to all our electrical devices, from lawn mowers to cordless screwdrivers to cell phones. They all contain neodymium magnets which could also be recycled economically.

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Fig. 1 Old magnets can differ greatly in type and condition, but all of them can be recycled the same way.

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Fig. 2 The electric motor in an e-scooter is in the tires: The magnets are the silver cuboids on the edge of the copper coils.

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