Poster | Raw materials

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[P2] Raw Materials & Recycling

Session Chair: Mr. Johann Fischbacher (University for Continuing Education Krems, Austria), Dr. Yusuke Hirayama (AIST, Japan)

[P2-28] Short loop recycling of sintered NdFeB magnets from auxiliary automotive motors utilising HPMS

*Abeshaa Mahendran[1], Joseph Gresle Farthing[1], Muhammad Awais[2], Robert Arnold[1], Viktoria Kozak[2], David Moule[3], Harvey Smith[3], Adrian Caden[2], David Brown[2], Allan Walton[2]
(1. HyProMag (UK), 2. University of Birmingham (UK), 3. ZF Automotive UK Limited (UK))
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Sintered magnets are ubiquitous in everyday life, being applied in technologies such as energy generation, automotive applications, loudspeakers and actuators. Rare earth elements such as neodymium, praseodymium, dysprosium and terbium, primarily used in the production of sintered magnets are considered to be critical materials by the UK, EU and US [1, 2, 3]. With exponential growth in demand predicted in the coming years, current supply may not be able to deliver the required amount of sintered NdFeB magnets. Recycling can be used as additional supply to supplement virgin material as well as mitigate the risk of supply shortages.Hydrogen processing of magnetic scrap (HPMS) is a recycling technique for sintered neodymium iron boron (NdFeB) magnets developed and patented by the University of Birmingham [4,5]. This technique combines hydrogen decrepitation and mechanical agitation to liberate NdFeB-alloy powder from end-of-life components. The nature of HPMS allows for the direct recovery of the magnet material from end-of-life components without the need for disassembly and separation of the magnets.
One application for NdFeB sintered magnets is in auxiliary motors in the automotive industry. The magnets in these units tend to be internally mounted and secured in place using organic glues, presenting a challenge for short loop recycling as the adhesives can become entrained in the separated alloy powder. The adhesive can raise the oxygen and carbon levels and result in deterioration of magnetic properties. Drive motors are designed in a similar way with ,in some cases, over 500 small magnets mounted inside the rotor.

In this work rotors from automotive auxiliary motors in various states of disassembly, including full rotor assemblies mounted on the shaft with no pre-processing were reacted inside the HPMS vessel at the University of Birmingham pilot facility to liberate the magnet material as a demagnetised powder, which was subsequently purified. The conditions used were 2 bar hydrogen over 16 hours with periodic damage cycles; these conditions were to ensure a full liberation of the magnets and can be reduced with optimisation to under 8 hours. It was estimated that 95% of the NdFeB material was recovered from the rotors. During HPMS the NdFeB material was stripped from the surface of the rotors resulting in a powder containing mainly hydrogenated NdFeB and small pieces of electrical steel.The composition of the material was analysed after HPMS and purification. The HPMS material had a carbon content of 0.48wt%, whereas post purification the carbon content was reduced to 0.12wt%, a reduction of 75%. The purified powder was further processed into sintered magnets using a conventional powder metallurgy route. The material was jet milled, blended with 5 wt.% of neodymium hydride powder, compacted and aligned before sintering.The recycled magnet had the following properties: B_r – 1.27 T and H_{cJ} - 1110 kA/m and BH_{max} -317 kJ/m^3.

For the first time it has been shown that it is possible to extract NdFeB magnets from end of life automotive auxiliary rotors with no pre-processing prior to loading the rotors into the HPMS vessel. This means that large volumes of scrap rotors can be processed efficiently with very limited manual pre-processing, and this has also been demonstrated for full electric drive motors. The sintering conditions have yet to be fully optimised for this composition of material, but it is clear that commercially viable magnets can be produced from this feedstock.

References:

[1] Mudd, G. et al., (2024). UK 2024 Criticality Assessment, British Geological Survey OR/24/047. 235pp. Available from: https://www.ukcmic.org/downloads/reports/ukcmic-2024-criticality-assessment.pdf, accessed on 27.02.2025.

[2] European Commission, Study on the critical raw materials for the EU 2023, March 2023, available from https://op.europa.eu/en/publication-detail/-/publication/57318397-fdd4-11ed-a05c-01aa75ed71a1, accessed on 27.02.2025.

[3] US Department of Energy. Critical Materials Assessment, July 2023. Available from https://www.federalregister.gov/d/2023-16611, accessed on 27.02.2025.

[4] Walton A, Yi H, Rowson NA, Speight JD, Mann VSJ, Sheridan RS, et al. The use of hydrogen to separate and recycle neodymium-iron-boron-type magnets from electronic waste. J Clean Production. 2015;104, Pages 236–241. Available from: http://dx.doi.org/10.1016/j.jclepro.2015.05.033

[5] Harris IR, Williams A, Walton A, Speight J. Magnet Recycling. United States patent US 8734714 B2. 27.05.2014.