

Thermomagnetic Sorting of NdFeB Magnets for Heavy Rare Earth Detection in Urban Mining and Critical Raw Materials Recovery from Hard Disk Drives

Roman Szewczyk^{1, a)}, Jakub Szalatkiewicz^{2, b)}, Michał Nowicki^{1, c)},
Marzena Szalatkiewicz^{2, d)}, and Piotr Gazda^{1, e)}

¹*Institute of Metrology and Biomedical Engineering, Warsaw University of Technology, sw. A. Boboli 8, 02-525 Warsaw, Poland.*

²*Phoenix Surowce Sp. z o.o., Michałowice-Wieś, Poland*

^{a)} *Corresponding author: roman.szewczyk@pw.edu.pl*

^{b)} *jakub.szalatkiewicz@phoenixsurowce.pl*

^{c)} *michal.nowicki@pw.edu.pl*

^{d)} *marzena.szalatkiewicz@phoenixsurowce.pl*

^{e)} *piotr.gazda@pw.edu.pl*

Abstract. Sintered neodymium-iron-boron (NdFeB) permanent magnets can be divided into two categories based on their Heavy Rare Earth Element (HRE) content: HRE-free grades and HRE-rich grades alloyed mainly with dysprosium (Dy) and terbium (Tb). The two categories differ substantially in thermal stability and coercivity profiles. Hard disk drive (HDD) voice-coil actuators constitute one of the most accessible end-of-life streams of NdFeB material in the urban mine, yet current European recycling lines treat all magnet fractions uniformly, diluting the valuable HRE content and leading to its loss or downcycling. This work proposes a non-destructive thermomagnetic sorting method, coupled with rapid magnetovision inspection, intended for industrial-scale classification of HDD magnets based on their HRE content prior to chemical processing. The NdFeB magnets are being dismantled in good condition using robotised HDD disassembly technology developed by Phoenix, so the nickel protective layer remains intact and the magnets do not degrade. Two such representative actuator magnets dismantled from end-of-life HDDs were characterised on a custom thermal stand. The HRE-rich specimen retained 50% of its room-temperature flux density at 132.7 °C, whereas the HRE-free specimen reached the same threshold already at 60.5 °C. Magnetovision images obtained on a magneto-optical viewer confirmed the structural integrity of the magnetisation patterns in both specimens, while thermomagnetic measurements revealed significant differences in HRE content. An urban-mining assessment for the EU-27 indicates that decommissioned HDDs could yield about 16.8 t Nd, 2.5 t Pr and 1.8 t Dy annually at the prevailing collection and recovery efficiencies (54 % collection, 70 % recovery), corresponding to a meaningful share of recorded direct EU consumption of these elements. The proposed thermomagnetic protocol is designed to operate within the robotised HDD disassembly station previously developed by the authors, which is equipped with vision-based screw detection and unscrewing operation. The full chain from drive ingress through grade-resolved magnet output is consistent with the principles of the EU Critical Raw Materials Act and contributes a meaningful early-stage share toward the 2030 recycling targets.