Investigation of Temperature Effects on Microstructure and Contamination in the Recycling of NdFeB Magnets via Hydrogen Decrepitation

S. Bilgin
Turkish Energy, Nuclear and Mineral Research Agency (TENMAK), Rare Earth Elements Research Institute (NATEN), Ankara, Turkey

G. Zhang
School of Mechanical, Materials, Mechatronic and Biomedical Engineering, University of Wollongong, Australia

Abstract:

The growing demand for rare earth elements (REEs), especially neodymium and dysprosium, has raised the need of effective recycling techniques from end-of-life products. Although Hydrogen Processing of Magnetic Scrap (HPMS) is a promising route for direct recycling of NdFeB magnets, process optimization is required to lower contamination and maintain material integrity to recover magnetic properties. In this work, the influence of hydrogenation temperature on phase evolution, microstructure, and contamination levels in NdFeB magnets obtained from scrap hard disk drives is investigated.

Experiments were conducted at four selected temperatures, which were room temperature (RT), 100°C, 500°C, and 800°C under a fixed low hydrogen pressure and gas flow rate. The structural transformation was conducted via X-ray Diffraction (XRD), microstructural morphology through Scanning Electron Microscopy (SEM), and elemental composition and oxidation level by Energy Dispersive Spectroscopy (EDS). The results reveal that hydrogenation at 100°C has effective decrepitation with minimal contamination. XRD patterns confirm the formation of $Nd_2Fe_{14}BH$ at 100°C, while SEM indicates enhanced fragmentation and crack propagation beneficial for powder production. EDS analysis indicates the lowest oxygen concentration at this temperature, significantly lower than the peak level observed at 500°C.

At 800°C, dehydrogenation was observed, along with a significant decrease in oxygen content. However, elevated temperature processing poses the risk of grain coarsening and REE loss. The study concludes that 100°C is the optimal hydrogenation temperature for HPMS recycling, maximizing powder quality while minimizing oxidation. These findings provide a practical guideline to scale up sustainable REE recycling with improved material recovery efficiency.

Keywords:

NdFeB magnets, hydrogen decrepitation, recycling, contamination.