Oral | Raw materials

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[O8] Raw Materials & Recycling II

Session Chair: Prof. Gopalan Raghavan(International Advanced Research Centre for Powder Metallurgy and New Materials)

3:50 PM - 4:05 PM JST | 6:50 AM - 7:05 AM UTC

[O8-3] Tailoring the Fraction of the RE rich Phase in Recycled Powders Obtained via Jet Milling

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As the world seeks to keep in pace with the increasing demand for NdFeB magnets, the efficient use of rare earth resources is becoming a key part of the production chain (1). A rise in demand means a significant availability of scrap magnets soon. In fact, recovering magnets from end of life equipment and recycling them is a strategy pointed out to mitigate the shortage in rare earth supply in the following years (2). One recycling method is the magnet to magnet approach (3), where the scrap is reintroduced in the production chain, following the same steps used on commercial alloys. Previous works have shown that a challenge is the pickup of oxygen during reprocessing (4), which adds up to the pre existing oxygen levels. The oxygen incorporation causes a depletion of the Nd rich phase, which plays a crucial role in obtaining an adequate microstructure. This issue can be tackled by mixing rare earth alloys with the scrap (4). On the other hand, we propose an alternative strategy: by adjusting jet milling parameters, we show that it is possible to segregate the rare earth rich phase from the ferromagnetic phase. Hence, one can carefully engineer a recycled powder controlling the volume fraction of the rich phase without the addition of any new rare earth. N42 scrap magnets were subjected to hydrogen decrepitation, and the HD powder was transferred to a glovebox, where a Hosokawa Alpine Picoline Jet Mill was used to obtain recycled powders (different classifier speeds and milling times were explored). Chemical analyses were conducted using an Arcos Spectro ICP OES to assess how rich in rare earths each grade was. Magnetic measurements were performed using a Quantum Design PPMS to determine the magnetization of powder samples under 14 T, and a laser diffraction Malvern Mastersizer 3000 and a Hitachi TM3030 SEM were used to evaluate the particle size after each milling condition. Magnets were obtained from the powders using the Pressless Processing (PLP) (5). Stainless steel moulds were filled using a filling factor of 2.6 g/cm^3. A pulse of 2.5 T was applied to align the particles, and then the samples were transferred to a furnace. The whole process was carried out in an argon containing glovebox. The magnets were characterized using a Brockhaus HG 200 hystograph and a Helmholtz coil. By adjusting the classifier speed and milling time, it was possible to enrich the milled powder in rich phase. For example, under 30 krpm of classifier speed, collecting an aliquot milled between 2 and 4 minutes lead to a powder containing 35% wt. of total rare earths, 17% higher when compared to the starting scrap (6). A careful tailoring of the rare earth

content of the recycled powder allowed for the obtention of dense magnets (7.4 g/cm3) with coercivities even 15% greater than the starting magnet. However, the enrichment with rare earths caused a dilution in remanence, which is being circumvented by mixing recycled powders containing different fractions of rich phase, leading to an increase in remanence of the PLP magnets, and by optimizing the degree of alignment. References: (1) J. W. Heim II, R. L. Vander Wal. Minerals, 2023. vol. 13. (2) J. Ormerod, et. al. Sustainability, 2023. vol. 15. 14901. (3) S. Rivoirard, et. al. Proc. 16th Int. Workshop on Rare Earth Magnets and Their Applications (Sendai Japan), 2000. p. 347. (4) M. Zakotnik, I.R. Harris, A.J. Williams. Journal of Alloys and Compounds, 2009. vol. 469, p. 314 321. (5) M. Sagawa and Y. Une, 2008 Proc. 20th Int. Workshop on Rare Earth Permanent Magnet and their Applications (Knossos Crete, Greece) ed D Niarchos (Greece: Admore) p. 103-105. (6) H. Sepehri Amin et al. Scripta Materalia, 2011. vol. 5. pp. 369 399.