Reduction and Smelting of Magnetic Fraction Obtained by Magnetic-Gravimetric-Separation (MGS) of Electric Arc Furnace Dust

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Abstract : The EIT Raw Materials RIS-DustRec-II project aims to transform Electric Arc Furnace Dust (EAFD) into a valuable resource by overcoming the challenges associated with traditional recycling approaches. EAFD, a zinc-rich industrial by-product typically recycled by the Waelz process, contains complex oxides such as franklinite ($ZnFe_2O_4$), which hinder the efficient extraction of zinc, by also introducing other valuable elements (Fe, Ni, Cr, Cu, ...) in the slag. The project aims to develop a multistage multidisciplinary approach to separate EAFD into two streams: a magnetic and non-magnetic one. In this paper the production of self-reducing briquettes from the magnetic stream of EAFD with a reducing agent, aiming to drive carbothermic reduction and recover iron as a usable alloy, was investigated. Research was focused on optimizing the magnetic and subsequent gravimetric separation (MGS) processes, followed by high-temperature smelting to evaluate reduction efficiency and phase separation. The characterization of selected two different raw EAFD samples and their magnetic-gravitational separation to isolate zinc- and iron-rich fractions was performed by X-ray diffraction and scanning electron microscope. The iron-enriched concentrates were then agglomerated into self-reducing briquettes by mixing them with either biochar (olive pomace pyrolyzed at 350 and 750°C and wood chips pyrolyzed at 750 °C) and a Cupola Furnace dust as reducing agents, combined with gelatinized corn starch as a binder. Cylindrical briquettes were produced and cured for 14 days to ensure structural integrity during subsequent thermal treatments. Smelting tests were carried out at 1400 °C in an inert argon atmosphere to assess the metallization efficiency and the separation between metal and slag phases. A carbon/oxides mass ratio of 0.262 ($C/(ZnO+Fe_2O_3)$) was used in these tests to maintain continuity with previous studies and to standardize reduction conditions. The magnetic and gravimetric separations effectively isolated zinc- and iron-enriched fractions, particularly for one of the two EAFD, where the concentration of Zn in the concentration fraction was reduced by 8 wt.% while Fe reached 45 wt.%. The reduction tests conducted at 1400 °C showed that the chosen carbon/oxides ratio was sufficient for the smelting of the reducible oxides within the briquettes. However, an important limitation became apparent: the amount of carbon, exceeding the stochiometric value, proved to be excessive for the effective coalescence of metal droplets, preventing clear metal-slag separation. To address this, further smelting tests were carried out in an air atmosphere rather than inert conditions to burn off excess carbon. This paper demonstrates the potential of controlled carbothermic reduction for EAFD recycling. By carefully optimizing the $C/(ZnO+Fe_2O_3)$ ratio, the process can maximize metal recovery while achieving better separation of the metal and slag phases. This approach offers a promising alternative to traditional EAFD recycling methods, with further studies recommended to refine the parameters for industrial application.

Keywords : biochars, electrical arc furnace dust, metallization, smelting
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