Modelling and validation of an ammonia-ammonium carbonate hydrometallurgical flowsheet for recovering zinc from electric arc furnace dust (EAFD)

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Abstract:

Electric arc furnace dust (EAFD) is a hazardous byproduct of steelmaking, estimated globally at 500 Mt/year.[1] EAFD contains Zn (2-30%), Fe (15-80%), heavy metals (Pb, Cr, etc.), etc.[2] The recovery of most metal content is investigated within the Horizon Europe HEPHAESTUS project (https://hephaestus-horizon.eu/), using a combination of hydrometallurgical, pyrometallurgical, and integrated technologies (CO_2 capture, wool fiberization). To prolong the lifespan of the pyrometallurgical units, e.g. the CleanTech furnace®, preliminary zinc removal is advantageous, decreasing the carbon and energy footprint of the metallic fraction's reuse (Fe, Ni, Mn, Cr, etc.).[3,4] To achieve that, leaching with an ammonia/ammonium carbonate solution, exploiting the selectivity against iron was combined with the zinc precipitation as zinc sulfide (ZnS), using ammonium sulfide $(NH_4)_2S$. This may be economical for treating EAFD with an intermediate ZnO content (10-20%), whereby established technologies such as Ezinex® may be impractical.

After characterizing the EAFD samples, modelling with OLI studio 11.5 and OLI flowsheet 11.5 was performed, using the best matching thermodynamic databases, corroborated by experimental results. Validation experiments and flowsheet simulation agreed on the recovery of 45-50% of the zinc (≈10% ZnO), the recovery of more than 99% of leached zinc as ZnS and no wastewaters emerge due to the recirculation loop. Control of the ZnS precipitation is pivotal to ensure the circularity of the process. Sulfide ions in the recirculation stream constrain the leaching efficiency due to the re-precipitation of Zn as ZnS during leaching. $(NH_4)_2S$ must be dosed by taking the Zn concentration into account to a sulfide-to-zinc ratio of 1 to ensure the complete consumption of sulfide ions by coprecipitating minor Cu, Fe, and Pb. Mass balances indicated the production of 0.11-0.12 kg of ZnS per kg of EAFD and the only chemical consumed is 0.08 kg of $(NH_4)_2S$ per kg of EAFD. Technical economic assessment (TEA) and life cycle assessment (LCA) studies are ongoing. The integration of the washing of EAFD, leach residue and ZnS is under investigation to evaluate the water recirculation to maintain the water balance.

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