Investigation of a slag system for a Li-ion battery recycling process in the EAF

Dipl.-Ing. Tim Georgi, Prof. Dr.-Ing. Bernd Friedrich

RWTH Aachen, IME–Institut und Lehrstuhl für Metallurgische Prozesstechnik und Metallrecycling
Intzestraße 3
52056 Aachen, Germany

Extended Abstract

Within a research project, which is funded by the German Federal Ministry of Education and Research, the development of a recycling process for Li-ion-batteries is planned. The recycling process aims on the recovery of the metallic components in a metallic form as well as the valuable organic components of the batteries prior to the metallurgical treatment. Several mechanical processing techniques and suitable pyro- and hydrometallurgical steps are combined. In contrast to existing pyrometallurgical recycling processes the Li-ion-batteries are crushed and the components are separated before they are melted down. The aims of the new recycling process are the economical and ecological recovery of materials as well as the implementation of a minimum recycling rate of 50 % which is prospectively prescribed by the European Union.

In a first step sorted battery scrap which besides waste Li-ion-batteries also includes scraps from battery production is treated in a mechanical processing line. The electronic parts and the plastic casings are removed in a mill. After this process step a vacuumthermic treatment is accomplished serving a thermal deactivation of the battery cells in a resistance heated retort furnace. The battery cells are heated up which leads to an increase of the inner pressure of the cells until the safety valve opens and the electrolyte components are vaporized selectively. The latter is caught in a downstream condenser.

The thermal deactivated cells are crushed riskless in a second mill and in a disintegrator. After crushing a classification and sorting is done by means of vibrating screen, of magnetic separation in a drum separator and of air separation in a zigzag classifier. Thereby different metal fractions, a plastic fraction and an electrode material fraction are recovered which all are treated in separate subsequent processing steps.

Depending on the battery system respectively the cathode material the powdery electrode material fraction contains lithium, cobalt and manganese in metallic form as well as in form of oxides. It also contains the graphite of the anode material. For the pyrometallurgical treatment the electrode material is agglomerated to pellets and then melted down in an electric arc furnace (EAF) under reducing conditions to recover the cobalt and manganese content in form of an alloy using an appropriate slag. Lithium is partly recovered in the slag, but mainly in the flue dust forming marketable lithium concentrates. The development of the process slag is a major part of the project. On the one hand the slag should show a minimum solubility (capacity) for cobalt and manganese and on the other hand it should show a maximum solubility (capacity) for lithium. A large amount of metal-slag equilibrium tests were conducted to prove theoretical thermochemical calculations that were done before. Afterwards the selected slags were tested in a lab- and a pilot-EAF while reducing the electrode material fraction. If necessary the main cobalt manganese alloy product is refined in a vacuum induction furnace and then planned to use as prealloy for the production of cobalt based super alloys. Lithium can also be recovered by leaching so the end product of the hydrometallurgical treatment can be lithium carbonate.

This paper which will be divided into two parts is going to be published in “World of Metallurgy” within 2007. It will show metal yields, recycling efficiencies, distribution coefficients and physical properties of the process slags, which will be discussed versus the chosen process parameters.