Removal of phosphorus from BOF-slag

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Abstract

The project aims at the separation of useable substances from BOF-slag for utilisation in different application. Fractions rich in phosphorus and calcium can be used as fertiliser or in cement and V-rich fraction as raw material for vanadium production. Remaining slag is low in phosphorous and hence no restrictions exist for internal recycling via sinter plant or blast furnace. Advantages will be significant savings of iron ore, limestone, CO_2 and energy.

Project partners are Swerea MEFOS AB, Sweden, SSAB Merox AB, Sweden, VDEh-Betriebsforschungsinstitut GmbH, Germany, voestalpine stahl GmbH, Austria, FEhS – Institut für Baustoff-Forschung e.V., Germany, ILVA SPA, Italy, and Scuola Superiore di Studi Universitari e di Perfezionamento Sant'Anna, Italy.

Slag cooling and separation for P-recovery has been investigated in laboratory scale as well as in national projects containing industrial tests. The industrial scale tests indicate difficulties in separation although the slag is cooled slowly. One of the key innovative content is the investigation of the influences of oxygen blowing and the conditioning of the slag with P- and Fe containing dusts on the cooling process, the crystal size and the phase composition, which will be essential for an economical separation process as well as for the utilisation of the separated fractions. Conditioning of the liquid BOF slag with Fe- and P-bearing residues/dusts is to further add value to the phosphor-rich and the iron-rich fraction by increasing the concentration of these elements in the corresponding fraction. The PSP-BOF proposal aims to use the enriched P fraction not only as cement, but also as fertiliser material which would be more beneficial use of the phosphorus. A positive effect of this approach is that non-recyclable by-products can be used instead of being land filled. Fe-bearing dusts are available throughout all steel shops, some of these dusts being hardly recyclable due to physical and/or chemical properties. P-bearing residues are generated for example by incineration of sewage sludge. In Germany alone, an annual amount of 250kt is generated and authorities discuss to ban disposal of these ashes with high P-contents. Conditioning of the liquid BOF slag with Fe- and P-bearing residues/dusts must be seen in the context of oxygen blowing as the formation of magnetite will generate heat to melt these materials. Use of slag fraction with low P- and high Fe content will be investigated for recycling to the sinter plant in form of pellets or directly in the sinter mix, as the slag will be grind to fine mesh to liberate and separate the P-rich fraction from the slag matrix.

Another key innovative part is the investigation of a method of liquid slag separation in industrial scale. Earlier studies have shown that by slow cooling C_2S crystallizes out and floats through the residual melt. The molten slag separated into a top layer, which was high in C_2S, and a bottom layer, high in Mn and Fe which were separated upon total solidification of the slag by mechanical means. In this novel approach, the residual melt high in iron and manganese will be separated from the solid C_2S phase by separating out the residual melt from the ladle. The Fe- and Mn-rich slag fraction has the potential of being recycled directly to the blast furnace after crushing of the slag aggregates. Separation of a V-rich fraction could make it possible to also recovery vanadium from BOF-slag, for use directly as raw material in the production of vanadium. Based on the slag treatment process that was developed in the IPBM project, production of a V-rich intermediate metal alloy will also be investigated for use as raw material for V-production. By separating out a V-rich slag fraction from BOF-slag will compared to "normal" BOF-slag improve the economic

conditions and facilitate an industrial commercialization of a vanadium recovery process based on the IPBM concept.

The proposed research project covers a wide range of activities from slag treatment and cooling to the separation and the utilisation of slag and goes beyond the "normal" metal separation processing of BOF-slag which is the state of the art.

One focus will be laid on the transfer of laboratory results into industrial scale at the sites of the industrial partners. An additional focus will be laid on the economical evaluation of the process chain on the basis of a flow sheet model as well as the impact assessment on the steel production chain for recycling the slag fraction depleted with phosphorus to the blast furnace and for use in external applications.

The project proposal is feasible because similar techniques, utilised in project for slag treatment, i.e. oxygen blowing and dust conditioning, as well as for the slag separation, grinding, separation processes and floating separation of C_2S, have already been shown/applied at different areas of the steel making, although they have to be modified within the project to make use of all valuable substances in the BOF-slag.

The aim of the project will be achieved by developing and evaluation of new slag treatment processes in laboratory and industrial scale. Within the project the entire chain from slag processing to slag application shall be investigated, comprising the following steps:

- Selection of available slags and definition of quality targets for products, the aim is to develop a zero waste concept for the different types of BOF-slags within the consortium.

- Development of a liquid slag treatment in laboratory scale and transfer it into industrial scale.

- Development of optimised strategies for BOF-slag to increase crystal size in laboratory scale and transfer the methodology into industrial scale.

- Investigation of a procedure for separation of treated slag into products and transfer it into industrial scale.

- Applications and investigation of the produced slag fractions.