Success Story
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K1-MET
Competence Center for Excellent Technologies in Advanced Metallurgical and Environmental Process Development
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Phosphorus removal and metal recovery from BOF-slags

Iron from a blast furnace, the so-called pig-iron, contains carbon as well as a range of additional elements such as silicon or phosphorus, which must be removed in the steel works to achieve a certain steel quality. These elements are predominantly oxidised in a basic oxygen furnace (BOF) and transferred into a slag phase. Steelmaking slags contain not only mineral components but also valuable metals such as iron, chromium and manganese. Currently, steelmaking slag utilization is restricted. With the help of the InduRed-process, these metals shall be recovered to increase the potential of steelmaking slags as valuable secondary raw material.

Best available technology and challenges

Due to process-related reasons, valuable metals in pig iron are oxidised in a BOF i.e. they react with oxygen. These metals then exist in oxidic form, like their occurrence in ores. Regarding the goal of a material cycle closure, these metal oxides should be reduced again (remove of oxygen). During the reduction of iron, chromium and manganese oxides for instance in an electric arc furnace, phosphorus compounds are reduced simultaneously. Phosphorus is transferred in its elementary and gaseous form and reacts subsequently with liquid iron. The iron in turn is contaminated with phosphorus, like the pig iron from the blast furnace. A reuse in the steel works would create a cycle and enrichment of phosphorus in the steel. An innovative process called InduRed now offers a potential solution for metal recovery with simultaneous phosphorous removal.

InduRed-plant - Experiments

The InduRed-plant at the Chair of Thermal Processing Technology (Montanuniversität Leoben) uses an innovative concept for the treatment of steelmaking slags. In its core part, the reactor (cf. Figure 1), graphite cubes are inductively heated up to 1,650 °C.

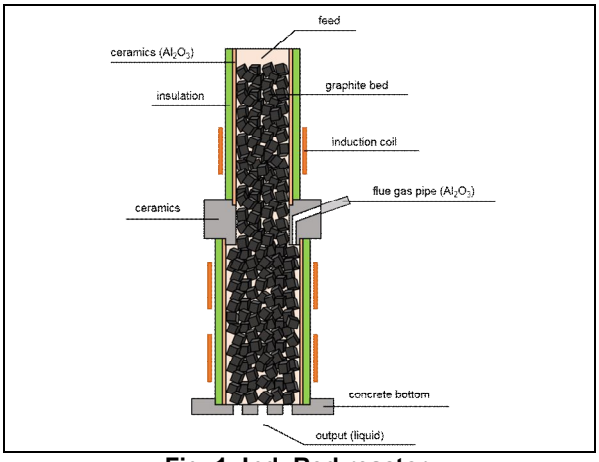

Fig. 1: InduRed-reactor.

bmwfw Federal Ministry of Science, Research and Economy
bmvit Austrian Ministry for Transport, Innovation and Technology

During the reduction process, a thin molten slag film is formed, in which phosphorus has a short transport distance out of the slag into the gas phase after the reduction step. In addition, phosphorus is continuously removed from the reactor via the off-gas stream, so that phosphorous has little contact with iron.

Afterwards, the phosphorus is reoxidized (post-combustion) and treated in a gas scrubber. Phosphoric acid is produced, which is a valuable by-product of the process.The main products are an iron alloy containing manganese and chromium as well as a slag, which is almost free from metals and metal oxides.

In several preliminary experiments, an optimal operating point for the treatment of steelmaking slags was defined. Figure 2 shows the products of the individual treatment steps.

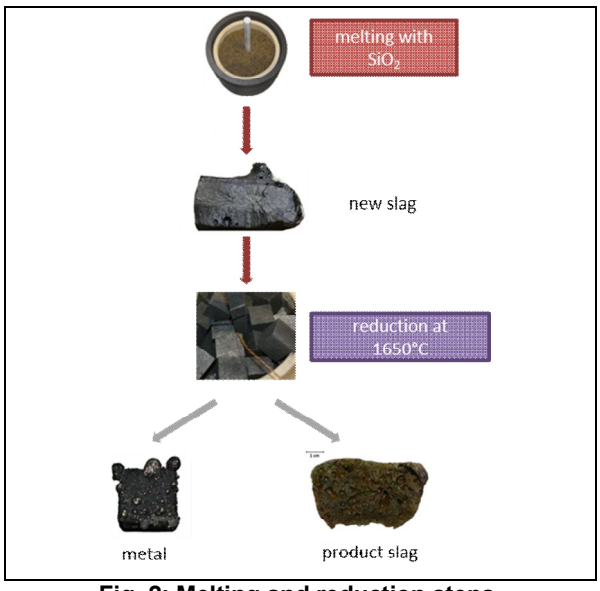

Fig. 2: Melting and reduction steps.

At 1,650 °C and a certain calcium oxide to silicon dioxide ratio (basicity B2), a slag could be produced that is free from iron, chromium and phosphorus. Furthermore, 80 % of the reduced phosphorus could be removed via the gas phase. At the time of its production in the BOF, the slag has a basicity of 3.2. Therefore, sand or blast furnace slag must be added in a first melting step to reduce the basicity.

Impact and effects

The gained results showed the proof-of-principle. On industrial scale, the treatment of steelmaking slags would have an enormous impact on several levels.

First, the disposal of slags on landfills can be avoided to the largest part due to the utilization of the slag components leading to an increased added-value. Therefore, costs can be saved as well as landfill volume.

Additionally, the recovered valuable metals help to save primary resources. Especially, phosphorus is becoming a highly important issue for the European Union. Phosphate rock and elementary phosphorus are listed as critical raw materials inducing the necessity of an almost 100 % import rate.

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