Hydrogen Plasma Smelting Reduction of Iron Oxide and its Process Up-scaling

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Summary

Laboratory scale experiments were conducted in previous works to reduce constant quantities of iron ore (batch-wise) by using transferred Ar-H_2 plasma arc. Continuous feeding of fines ore in recent experiments using a screw conveyor has been carried out to evaluate the reduction behaviour and the plasma stability. Moreover, an assessment for the potential of a process up-scaling and investigation of the encountered problems were conducted.

The process potential

Many of the current research and development programs are dedicated to find innovative solutions to decrease CO_2 emissions produced by the steel industry. In the post-Kyoto stage, a new perception is raised to shift from the conventional steel production route (BF-BOF) to new routes like smelting reduction processes, steel production by electrolysis and the use of biomass.

As an alternative to the BF-BOF route, hydrogen was selected for smelting reduction investigations in a plasma furnace at the chair of metallurgy, university of Leoben. The process is called "Hydrogen Plasma Smelting Reduction, HPSR". The defining characteristic of this process is no direct CO_2 emissions due to the replacement of carbon as a heat source and reducing agent by hydrogen plasma.

Recent experimental work

Within the current research work, a conceptual design for a **HPSR** up-scaled process was carried out. The feasibility of feeding the ore through the hollow electrodes used was not clear due to the uncertainty of the plasma stability and the change of the reduction behaviour. Continuous feeding of fines ore via a screw conveyor was conducted in recent experiments. Iron ore was melted and reduced (up to the divalent iron phase) by Ar-H_2 plasma in a very low carbon steel crucible. After reaching the divalent iron phase, assessed by gas analysis, constant rate of ore was fed to the surface of molten slag through the hollow electrode. The rate of oxygen removal during reduction by various concentrations of H_2 has been assessed and presented with respect to the batch-wise results, figure 1. It was found that the reduction rate in the continuous feeding experiments is higher due to the effect of trivalent iron existing in the ore fed. Moreover, the plasma stability did not deteriorate by the continuous feeding of ore.

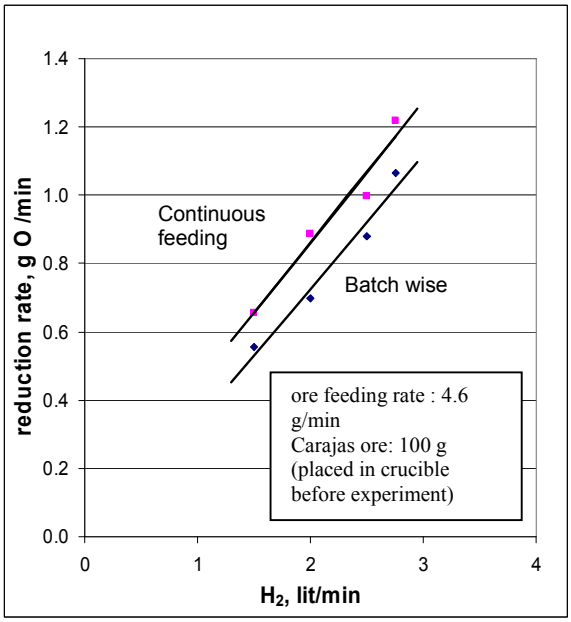

Fig. 1 Reduction rate of liquid iron oxide, continuous feeding vs batch-wise

Process up-scaling

A study to the potential of the process up-scaling of 1mt/y steel was recently carried out and sponsored by an EU project called ULCOS (Ultra Low CO_2 Steelmaking).

It was found out that the HPSR is characterised with the following strengths:

- Low CO_2 iron making process
- Simple flow sheet
- No need for a post combustion process
- Low slag generation

However, as a result of the immaturity of the process due to its early state of development (lab-scale results), it was found that further research work and expanding the furnace size is sensible for better understanding of the process parameters.