Process Integration of Production and Use of DRI and LRI

Carl-Erik Grip[1] and Mikael Larsson[2]

[1] SSAB Tunnplåt AB, Luleå, Sweden and [2] MEFOS, Luleå, Sweden

Carl-Erik.grip@ssab.com

A method for complimentary evaluation, developed by SSAB-MEFOS-LTU includes optimisation, meaning that also areas between predefined cases are searched for possible optima. Mixed integer linear programming (MILP), which allows for linearization of non-linear cases and discrete variables, is used. A model for the general ULCOS site was developed within SP9. A specified modelling and optimisation of production and use of DRI/LRI was carried out.

Introduction

During ULCOS phase 1 former SP3 developed different melting alternatives including PCBOF and melting in the BF (i.e. the LRI concept). During this time a MILP optimizing model was developed to model the DRI route. It includes the units existing in a conventional integrated steel plant (Coke making, BF, BOF CC etc), Additional units were included to make alternative route possible, e.g., LRI/DRI production, etc. The MILP optimizer was then used to find the most optimal parameter combination for each case. In SP12 the ULCORED process has been further developed and analyzed, Figure 1.

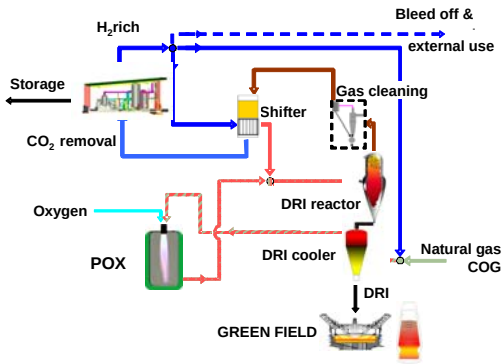

Figure 1. Schematic Layout of the ULCORED concept

What is Process Integration

Process integration is the internationally accepted name of techniques to optimize and analyse eg. energy economy and CO_2 emission of an industrial system.

Some definitions:

- Optimisation: given a system or process, find the best solution to this process within given constraints.
- Objective function: indicator of performance, e.g. CO_2, energy, costs.
- Decision variables: variables that influence process behaviour and can be adjusted for optimisation.

Calculation Results

Evaluation of the concepts, expressed in kg CO_2/ t HRC is summarized in table 1.

Table 1. Main results

	incl. ext. Power	excl. ext. Power	CCS at DR plant
	kg/tHRC	kg/tHRC	kg/tHRC
Reference	1917	1664	
DRI - BOF	1225	1124	690
DRI - EAF	968	764	433
LRI - BF, DRI - BOF	1245	1127	682
DRI - AMF, DRI - BOF	1034	916	471

A more detailed description of one of the alternative routes LRI and DRI in BOF and BF is shown in Figure 2. The model has chosen a metallization of 85 % on the DRI for the BF.

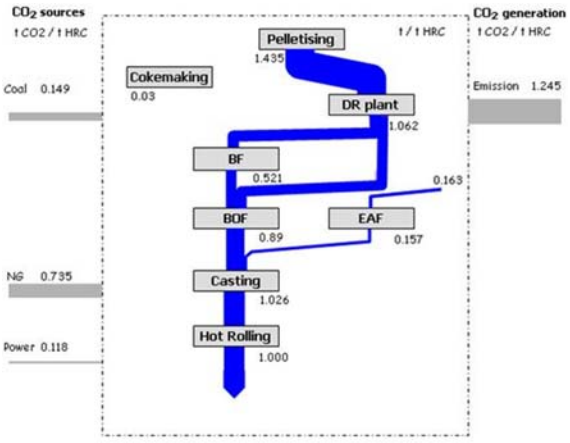

Figure 2. Detailed flowsheet for optimised combined use of DRI+LRI in BF and BOF. The BF/BOF route is operated without scrap (i.e. scrap is melted outside the route)

Discussion and Conclusion

The biggest uncertainty in the first study is the proper value of the parameters in production of LRI with lower metallization (including cost).

The ULCORED process concept can be implemented either as a green field or as a brown field installation. In the case of a Brown field installation, the ULCORED concept operated on coke oven gas for production of LRI seems to be an interesting alternative and should be further analyzed. Also melting DRI in the PCBOF shows potential to further improve the system. The built-in intelligence in the MILP model can simplify the evaluation of these different applications. If the MILP model is used with Pareto analysis, a simultaneous optimization of several parameters (e.g. CO_2-emission and cost) can be carried out

Acknowledgements

The present work is part of the ULCOS program, which operates with direct financing from its 48 partners, especially of its core members (Arcelor-Mittal, Corus, TKS, Riva, Voestalpine, LKAB, Saarstahl, Dillinger Hütte, SSAB, Ruukki and Statoil), and has received grants from the European Commission under the 6th Framework RTD program and the RFCS program[1].

[1] Priority 3 of the 6th Framework Programme in the area of "Very low CO_2 Steel Processes", in co-ordination with the 2003 and 2004 calls of the Research Fund for Coal and Steel