ULCORED SP 12
Concept for minimized CO_2 emission

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ULCORED is the concept suggested by SP 12 to meet the demand of reduced CO2 emission using iron ore and gas based direct reduction for steelmaking. The concept includes the use of 100 % oxygen, POX (partial oxidation) instead of reformers, shifter for production of CO2 free reduction/excess gas and the reducing agent being either natural gas or syngas from coal/biomass.

Introduction

Direct reduction in combination with melting in electrical furnaces is today the most CO_2-lean way to produce steel from iron ore. The emission from the DR-EAF route is already today close to the ULCOS 50% target compared to the blast furnace route and work to improve this route is strongly motivated since it might promote a faster transfer to a CO_2 lean steel sector.

Direct reduction plants are predominantly situated in countries with low cost natural gas but considering the environmental advantages it can be expected as an attractive alternative also in a future Europe. Natural gas is expected, by several experts, to be available and a competitive fuel both in a short and a long term perspective[ ].

Direct reduction can also be made by syngas from coal which in some scenarios is considered very competitive to natural gas. Coal gasification is thus an interesting alternative and the possible integration between both processes is an obvious research task. The direct development of gasification is driven by the energy sector and the chemical industry who are interested to substitute oil and natural gas in their respective processes. It is important that the steel industry is kept updated on this development and to understand how technical progresses in gasification can be utilised in the steel industry.

Other alternatives are syngas-production based on bio-mass, bio-waste and reduction by hydrogen.

CCS (CO_2 Capture and Storage) is expected to be a key technology to reduce CO_2 emissions. Direct reduction has excellent prerequisite for use of CCS in combination with oxygen and the CCS technology is foreseen to be an integrated part of the DR-process itself.

In the first phase of the ULCOS project (ULCOS Subproject 3) careful investigation of several concepts for natural gas based steelmaking was made and the production of DRI and melting in electric furnaces was found to be the most CO_2-effective route.

The dominating CO_2-emissions in the DR – EAF route arises from the Direct Reduction plant. Thus a new DR-concept, **ULCORED** was proposed to minimize CO_2 emissions and cost.

The new DRI process, **ULCORED**, was designed mainly at the end of the first 18 months phase by a team led by LKAB, Voestalpine and MEFOS [1]. The new process is based on a number of features, which constitutes an original proposal when put together [2].

The concept is characterized by an effort to adopt gas based Direct Reduction to a minimized emission of green house gases, using CO_2 capture and storage technology and at the same time to a minimized use of energy.

ULCORED also constitutes the possibility to be used with syngas from coal and biomass as well as the option to produce a CO_2-free hydrogen for use in other parts of a steel plant.

Part 1 – Basic features of the ULCORED concept

The flow sheet layout is shown in Figure 1.

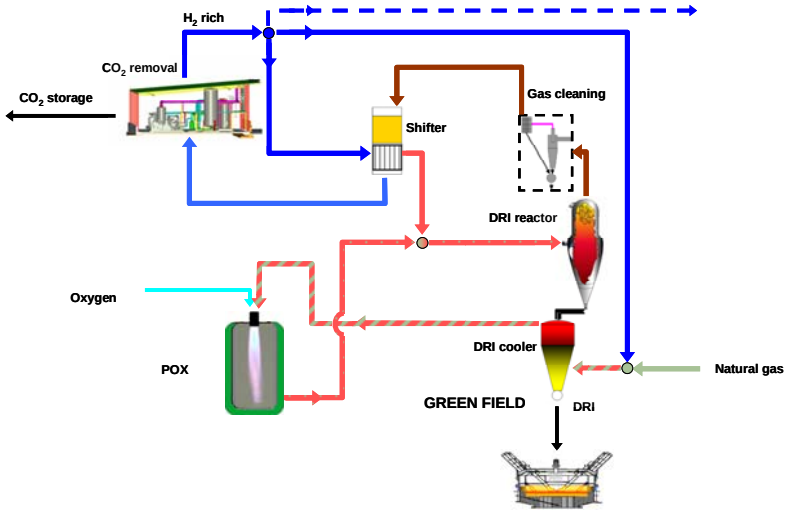

Figure 1. Flow sheet of **ULCORED** with natural gas

The main features are:

- 100 % use of oxygen instead of air

- A partial oxidation. POX, reactor instead of a reformer

- The use of shifters to transform the CO in the top gas into hydrogen and CO_2

- CO_2 cleaning of the off gas stream after shifter by pressure swing adsorption, PSA/VPSA or amine-washers to produce a clean CO_2 for storage and a hydrogen stream to be recycled to the reactor

- A minor part of the hydrogen stream for bleeding out nitrogen and used in the steel plant

- The main stream of hydrogen, together with make up natural gas, fed to the cooling zone of the DR-reactor in order to use the latent cooling heat to preheat the gas to the POX-reactor

The resulting energy need is estimated to be reduced by around 20 % compared to state of art DR-processes, there is only one stream of CO_2 for compression and storage and the shifters give a flexibility to make CO_2 free hydrogen for other users.

This is especially interesting for the case when using syngas from coal instead of natural gas, compare fig 2.

The syngas from the coal gasifier is cleaned and then fed to the DR-reactor. The gas can also be bypassed directly to the shifter to produce a CO_2 free gas for use in rolling mills, lime plant and even for production of electricity. This challenging option is further discussed in [0].

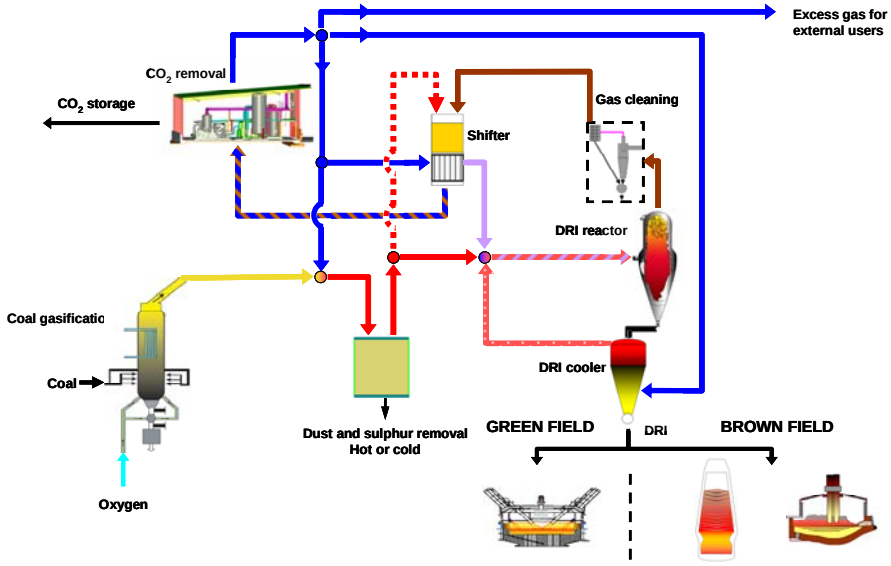

Figure 2. ULCORED with syngas from coal

The future and ULCORED

It is strongly believed that **ULCORED** will be one of the future alternatives to lower GHG from steelmaking. The price of natural gas will probably be very high compared to coal also in the future thus we foresee industrial units based on natural gas to emerge in countries with abundant resources of this reduction media such as Norway. Coal based **ULCORED** on the other hand should be a feasible choice in countries with steel plants based on coal, either as supplements using coke plant gas or with separate gasification units.

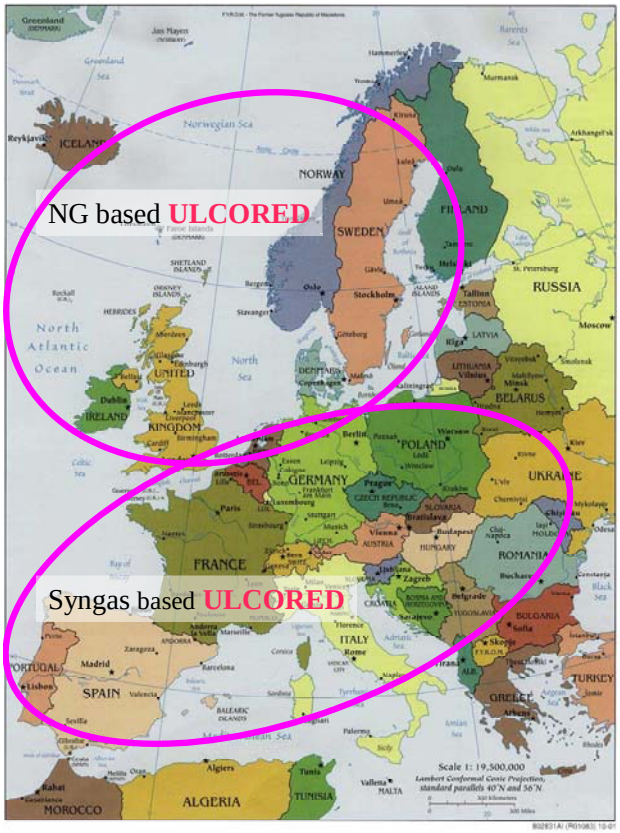

Figure 3. Possible DR **ULCORED** locations based on NG or syngas

The SP 12 vision is that the **ULCORED** technology will have a large share of technologies for steelmaking using iron ore in the future, being a "quick-fix" introduced as a choice for brown field improvements of CO_2 emissions. This is especially applicable in the near future for countries with low price natural gas.

The brown field solution inherits a lot of possibilities:

- the use of coke oven gas in a DR-plant coupled to the blast furnace as a melting unit, the reduction of coke and CO_2-emission by around 30 % per ton of steel

- the use of coke oven gas in a DR-plant and a Comelt [5, 6] or CRISP [7] melter with the potential of further reduction of CO_2 emission with increased steel production

- The most CO_2 saving option with **ULCORED** is of course the use of a coal gasifier producing syngas for the DR-plant and CO_2 lean hydrogen for all in plant users

- Another interesting option is a DR-plant using coke oven gas, production of LRI (Less Reduced Iron) and a conventional or nitrogen free blast furnace to produce the hot metal with an additional savings of CO_2-emissions

This means also the option for steelmakers in moderate investments and still being mainly coal based and in principle running the operation as usual.

LRI (Less Reduced Iron) should be the choice instead of DRI considering the successful tests made in the LKAB Experimental Blast Furnace [8].The LRI-test with a DR-product reduced to only 65 % metallization degree responded very positive in the blast furnace with remarkably stable furnace condition and low consumption of coke below 200 kg/THM.

Other usages of the **ULCORED** components, e.g. the POX unit, can be used also in other brown field applications. The POX could be used for reforming of COG before introduction to the blast furnace. This means a hot CO and H2 to the tuyeres with the possibility to reduce the overall fuel rate and the CO_2 emissions.

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