The HIsarna Ironmaking Process

Together we make the difference
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1. Introduction

- In 2004 several European steelmakers proactively started the ULCOS project with the objective to achieve 50% reduction of the CO$_2$ emissions of steelmaking.
- HISarna is one of the four process development that originate from the ULCOS project.
- Since 2007 Tata Steel, Rio Tinto and ULCOS have been active developing this coal-based smelting reduction process.
- The HISarna process offers a combination of environmental and economical benefits.
2. The benefits of HIsarna

Comparison BF route - HIsarna

Iron ore → Coal → Coking/Agglomeration → Ironmaking → Hot metal

Direct use of fine ores and coal (no agglomeration and coking)
2. The benefits of HIsarna

HIsarna offers a combination of **environmental** and **economic** benefits

**Economic benefits**
- Ironmaking with low cost raw materials, non-coking coals and low grade ores
- Recycling of waste oxides, slags and galvanised scrap
- Higher energy efficiency
- Lower steelmaking costs because of low Si, P in hot metal
- Greenfield developments with much lower CAPEX

**Environmental benefits**
- CO$_2$ emission reduction 20% without CCS
- CO$_2$ emission reduction 80% with CCS
- Lower emissions SO$_X$, NO$_X$, dioxines and fine dust
- Avoidance of dumping slags and dusts
3. HIIsarna Pilot Plant
Over 10 Years of Development

Target: 1st Commercial Scale Demonstration Plant by 2022

Campaign F
Integration with CO2 Capture (2018)

Campaign E
(On-going)

Major Upgrade to the Pilot Plant
2015 - 2017
3. Hlsarna pilot plant

Achievements

2011
• First metal tap

2012
• First long operating period

2013
• High energy efficiency
• First metal delivered to BOS plant

2014
• Recycling of high Zn waste oxides
• Recycling of scrap

2015 - 2017
• Major plant expansion (20 M€ investment)
• CO₂ reduction target of 35 %
• Long duration testing of process and equipment
• Financial support from EU Horizon2020
• Dutch Government DEI (Demonstratie Energie Innovatie)
Hlsarna Pilotplant

1. Alternative raw materials storage silos
2. Off-gas duct
3. Gas cooler
4. Coal and lime storage silos
5. Cooling towers
6. Bag filter
7. Secondary dedusting
8. Smelting cyclone
9. Smelting reduction vessel
10. Fore hearth
11. Control room
12. Coal grinding, drying and screening
13. Ore drying and screening
14. Raw materials storage
15. Offices
16. Workshop
Raw materials preparation
Hot metal production
Regular slag tap and slag sampling
3.1 Campaign C & D: Raw Materials

- **Standard Ore:**
  - Campaign C: high quality hematite (65% Fe), finer granulometry
  - Campaign D: high quality hematite (63% Fe), coarser granulometry

- **Alternative Ores:**
  - Ironstone: Low quality (33% Fe)

- **Coal Types:**
  - Standard: Low-volatile 8% VM
  - Alternative 1: Mid-volatile coal 22% VM
  - Alternative 2: High-volatile coal 39% VM

- **Fluxes**
  - Lime
  - BOF sludge (high lime content)
3.2 Coal requirement

Coal rate achieved during the 4 campaigns

- Target operation for pilot scale
3.3 Overall results Campaign C & D

- Stable operation at ~ 90 % nameplate capacity (~ 7 tHM/h)
- Successful operation with hematite ores, low-vol, mid-vol and high-vol coals
- Cyclone capture efficiency and pre-reduction in line with earlier experience
- Coal rates reached expectation (design 750 kg/tHM at pilot scale)
- Post Combustion Ratios > 90% achieved for long stable periods
- Successful tapping into torpedo ladle cars, subsequently used for steel making at BOS plant
4. Further development

Demo plant preparation:
- Scale up
- Demo plant engineering study

Further technology development at the pilot plant:
- CO₂ capture at the pilot plant
- Recycling of galvanised steel scrap
- Zn recovery from steel plant waste oxides
- Partial replacement of coal by natural gas and/or biomass
4. Further development

4.1. Towards the Demo plant

- Hlsarna pilot plant campaigns
- TRL 3
- TRL 4
- TRL 5
- TRL 6
- TRL 7
- TRL 8
- TRL 9

- Operational knowledge
- Scale up

Responsibility R&D
Responsibility MLE Ironmaking
4.2 Scale up

Small size ironmaking but industrial size recycle plant

Pilot plant

Industrial size ironmaking

60,000 thm/year
Atmospheric
1.0 bar abs

400,000 thm/year
Pressurised
1.8 bar abs

1,000,000 thm/year
Pressurised
1.8 bar abs
Bigger plants are more efficient
4.3 Industrial scale HIsmelt

- A HIsmelt furnace with a hearth diameter of 6.5 m operated in Kwinana, Australia and now in Molong, China.
- An engineering package (12,000 documents) of this facility is owned by Rio Tinto.
4.4 Engineering study

- Study made for 1 Mt/y HIsarna plant at Tata Steel IJmuiden site
The HIsarna process is very suited for a combination CCS or with CCU because:

- The CO$_2$ concentration in the HIsarna off gas is $> 85\%$
- With the HIsarna process the emissions are concentrated at a single stack
Integrated site until HRC

[Diagram showing flow of processes and CO₂ emissions through various steel plant components such as Coke plant, Sinter plant, Pelet plant, Blast Furnaces, BOS plant, Hot Blast Stoves, and Flares.]
Integrated site until HRC
4.6 HIsarna pilot plant with CO₂ capture unit

**Diagram Description:**
- **Existing pilot plant**
- **CO₂ capture unit**
- **New in campaign F** de-SOx
- **Vent gas**
- **Compressor**
- **Reducer**
- **Cooler**
- **Water**
- **CO₂ storage**
- **60 bar**
- **35 bar**
- **100 kt-CO₂/y to greenhouses**

**Details:**
- CO₂ capture unit
- CO₂ storage
- 100 kt-CO₂/y to greenhouses
4.7 By-product recycling

HIsarna can use Fe rich process dusts and sludges from other process as a raw material.

These include BOF sludge and BF dust, also those with a high Zn fraction. This was successfully done for the first time in campaign D (2014)

The objective is to reach sufficient Zn rich dusts for use in Zn smelters
5. Conclusions

- HIsarna is a new coal-based ironmaking process offering both economical and environmental benefits
- The environmental benefits include a 20% reduction of CO$_2$ emissions without CCS/CCU
- 80 – 90% CO$_2$ reduction with CCS/CCU
- Experimental results of the plant in IJmuiden have confirmed the:
  - High energy efficiency
  - Raw material flexibility
  - Good start/stop abilities of the process
- Conceptual engineering for the first industrial scale plant, 0.5 to 1.0 M t/y, has started