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IIM
Metallurgy
Materials Engineering

HIsarna Ironmaking process

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Agenda

1. History of HIsarna technology
2. HIsarna process concept
3. HIsarna development status
4. HIsarna and sustainability
5. Scale up
6. Conclusions

1. History of HIsarna technology

HIsarna is merger of two technologies:

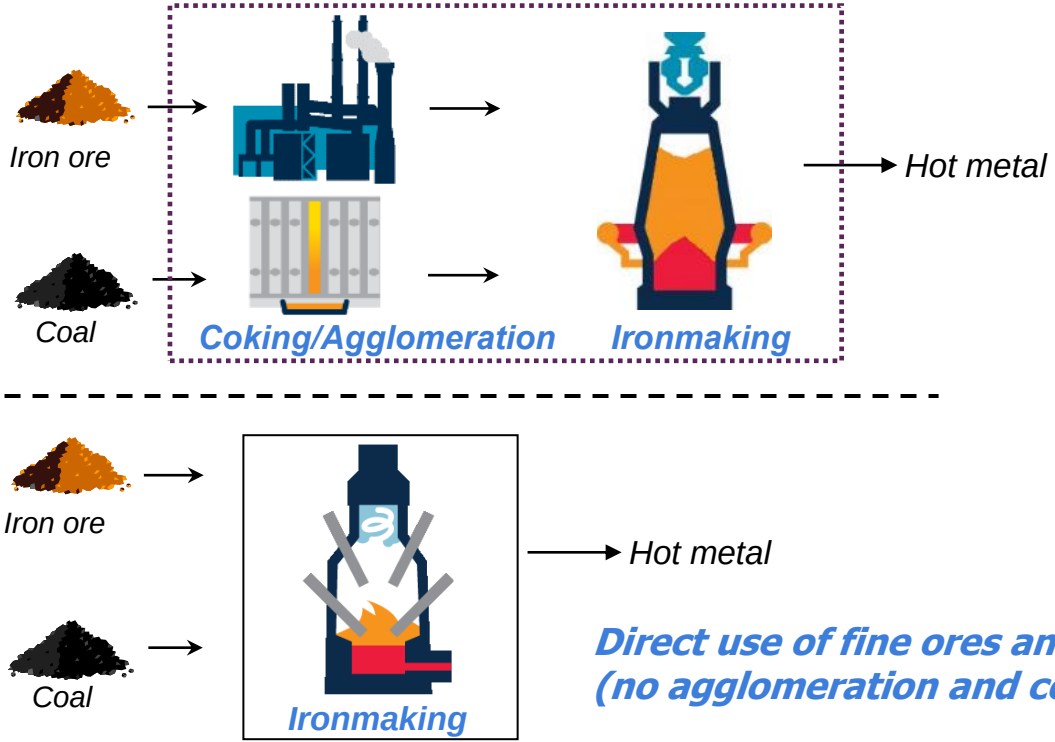
- HIsmelt development, Germany and Australia, Leading party Rio Tinto
- CCF development, Netherlands, Leading party Tata Steel Europe

Milestones

2008	HIsarna development started under EU project “ULCOS (Ultra Low CO_2 Steelmaking)
2011	HIsarna pilot plant located at Tata Steel Europe site in the Netherlands
2017	Tata Steel acquired patent portfolio from Rio Tinto
2018	Pilot plant expanded with raw material preparation and new control system
2020	Demo plant conceptual study started, location Jamshedpur

2. Hlsarna process concept

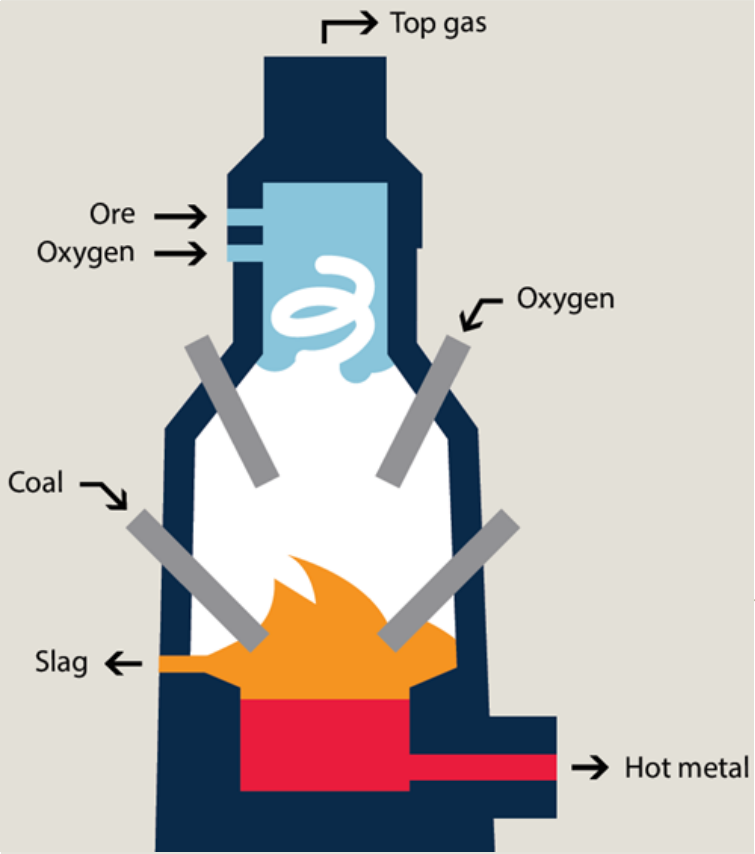
Comparison BF route - Hlsarna



2. Process concept

Ironmaking in one single step

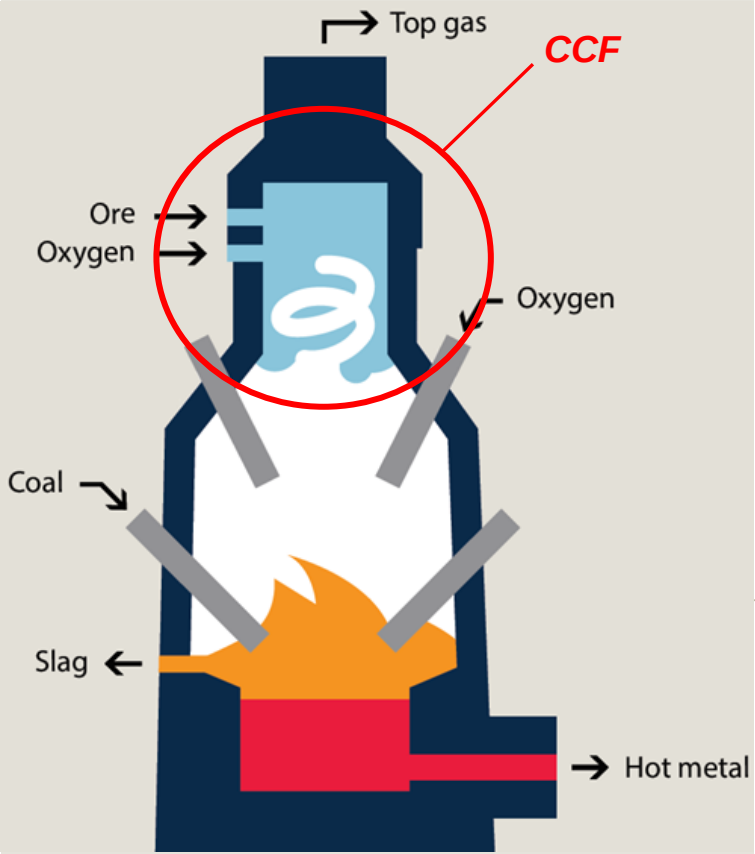
- No coke ovens - Direct use of fine coal
- No agglomeration - Direct use of fine ore
- No stoves - Use of pure oxygen



2. Process concept

Two stages in a single reactor

- Cyclone Converter Furnace (CCF)
  - Melting of fine ores
  - Pre-reduction $Fe_2O_3 + CO \rightarrow FeO + CO_2$
  - Final combustion of process gas $2\ CO + O_2 \rightarrow 2\ CO_2$



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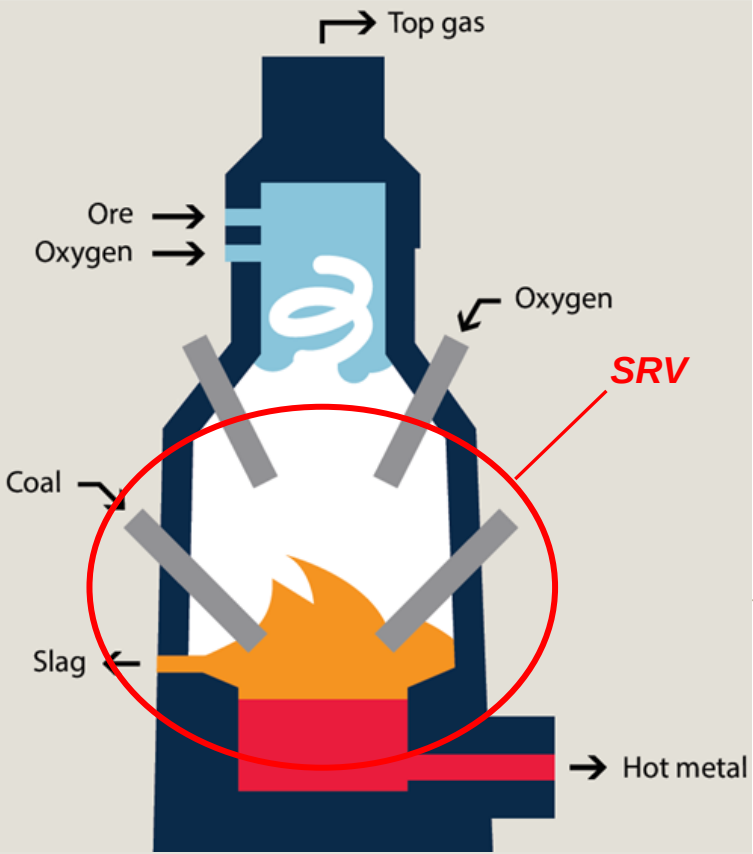
- Smelting Reduction Vessel (SRV)
  - Final reduction of iron oxides $FeO + C \rightarrow Fe + CO$
  - Gasification of coal $2\ C + O_2 \rightarrow 2\ CO$
  - Partial post combustion of gas $2\ CO + O_2 \rightarrow 2\ CO_2$
  - Carburisation of hot metal
  - Separation of metal and slag



3. HIsarna development status

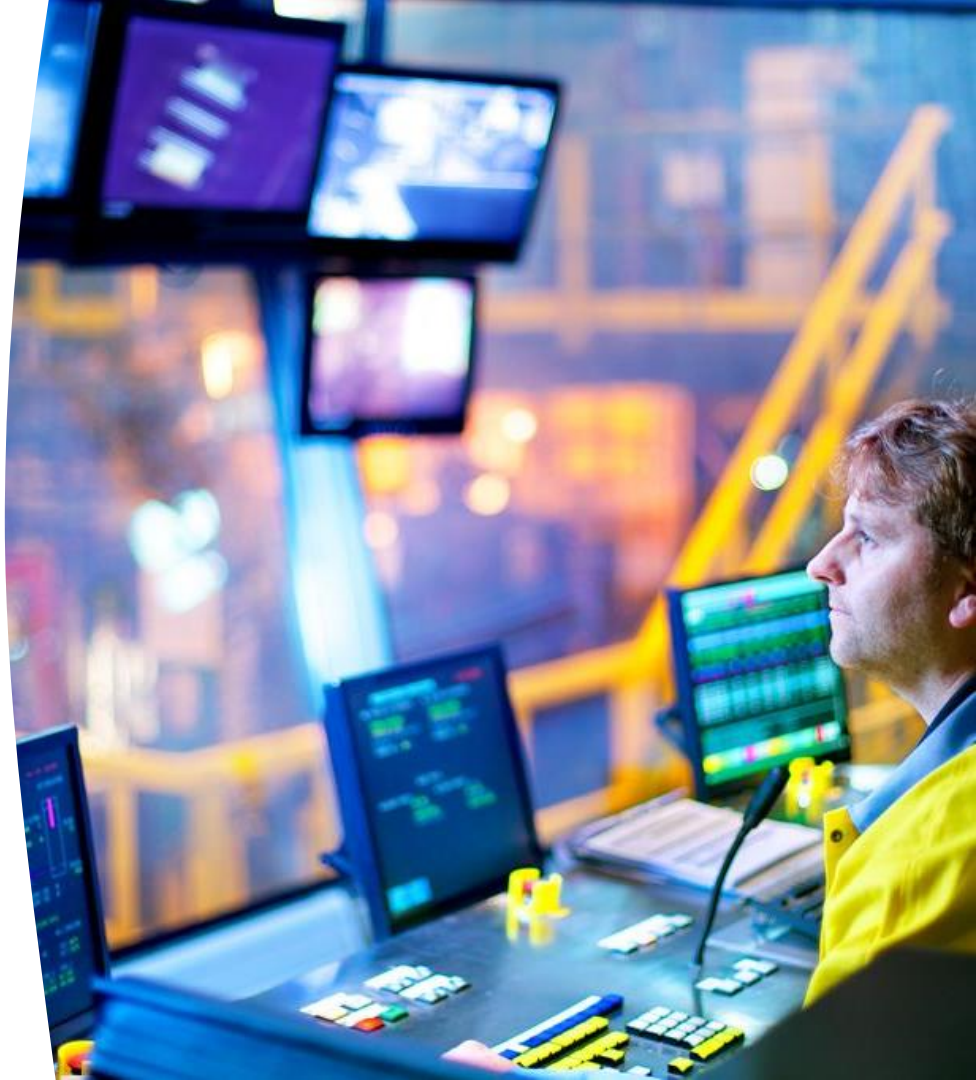
HIsarna pilot plant

- Design capacity, 8 ton hot metal per hour
- Full continuous operation in 5-shift schedule
- Dedicated raw material drying and storage
- Hot metal tapping in torpedo cars, metal to BOS plant
- Meets environmental regulations, de-SOx and de-NOx installations
- Fully instrumented for operation and research purposes
  - Various gas analysis systems
  - Bath level measurements
  - On-line metal and slag weighing systems

HIsarna pilot plant

Safety systems

- Warning and trip levels determined for main process parameters
- All cooling members monitored for temperature, water flow and heat flux
- Off gases monitored for O_2 and CO concentrations
- Leak detection system developed for closed water cooling system
- In case of trip the process is automatically steered to safe process conditions



Pilot plant operation

Hot metal

- Hot metal is continuously tapped from the pilot furnace at a temperature of 1400-1425^{o}C
- Composition

  C 4.2 %

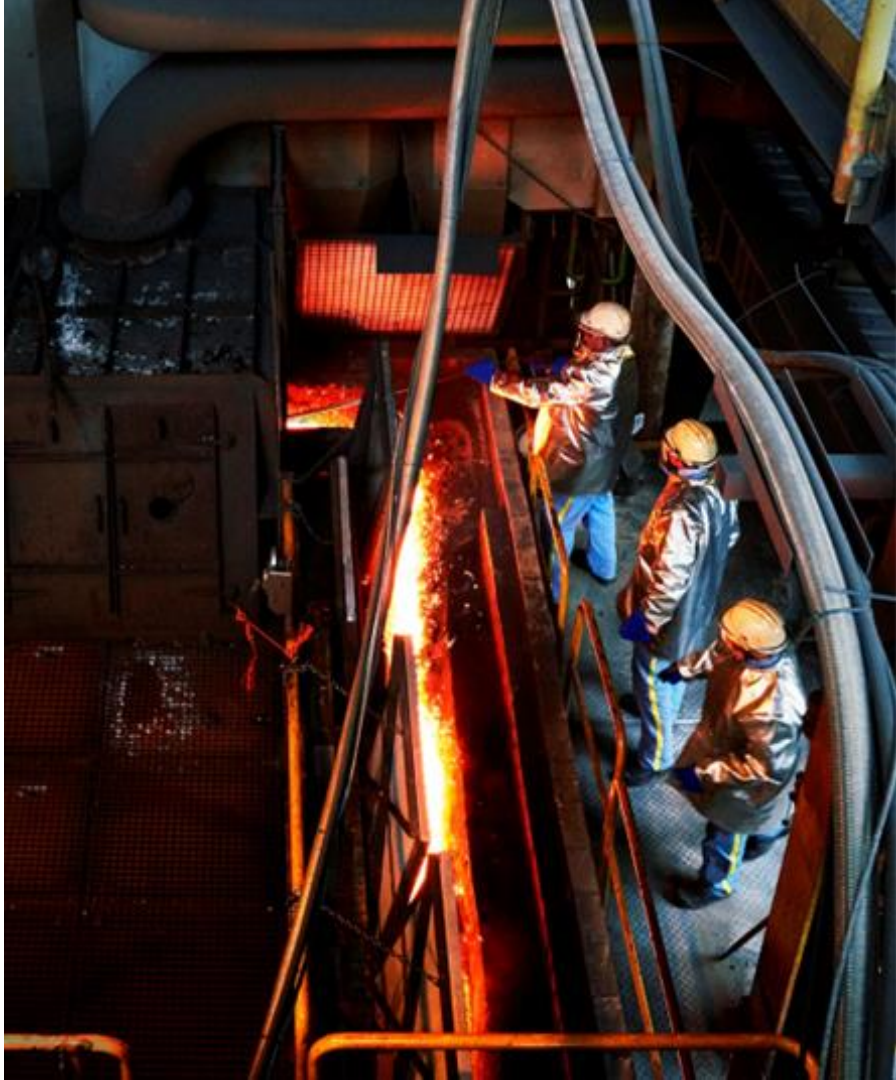
  P 0.01 %

  S 0.08 %

  Si 0.05 %
- Extremely low P in metal due to higher FeO in the slag (compared to BF)

Slag

- Slag is tapped through a separate taphole every 2 – 3 hours
- Basicity 1.15 – 1.25
- FeO 4 – 6 %



4. HIsarna and Sustainability

1. **Use of non-fossil carbon**
   - No coking coal required
   - Use of pyrolyzed biomass (bio-coal or char) possible

2. **Circularity**
   - Recycling of steelmaking slag and waste oxides
   - Can use lower grade raw materials (avoidance of mining waste)

3. **CO_2 capture**
   - Nitrogen free process gas, high CO_2 concentrations well suited for CO_2 capture

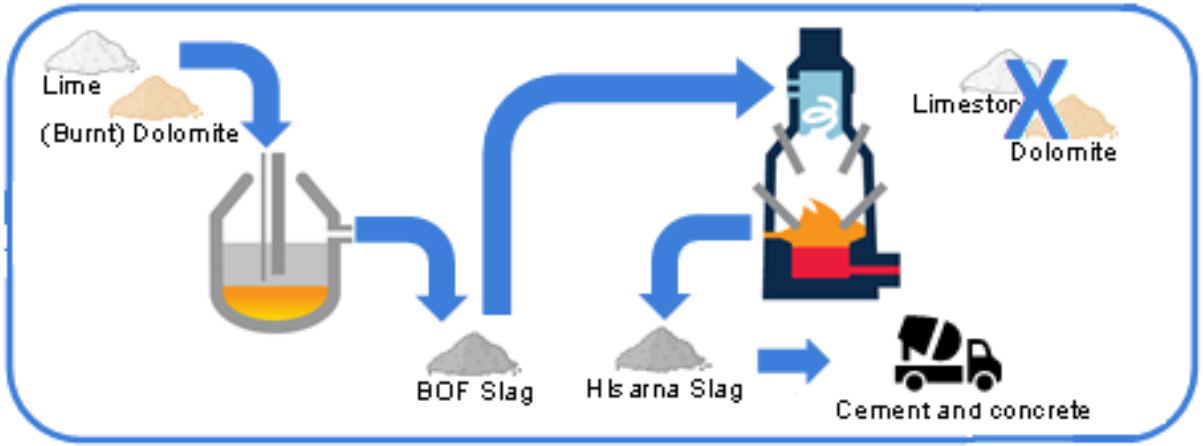
4.1. Use of bio-char

- Trial with 50 % fossil carbon replacement by bio-char has been successfully carried out in the pilot plant
- Trial with 100 % fossil carbon replacement is planned for this year

4.2. Circularity

- Low-grade iron ore (< 50 % Fe) successfully used in HIsarna pilot plant

- Recycling trials in HIsarna pilot plant with..
  - BOS slag pre-mixed with iron ore as flux replacement
  - BOS scrubber sludge injected
  - Various process dusts briquettes and charged

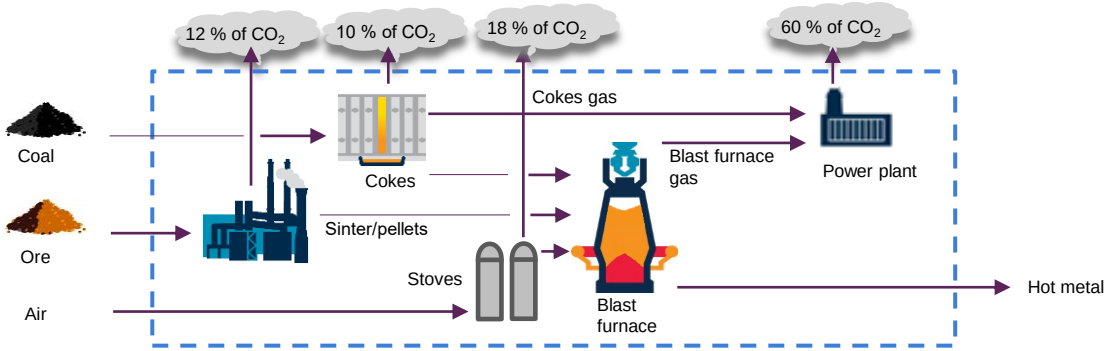


Cement quality investigation

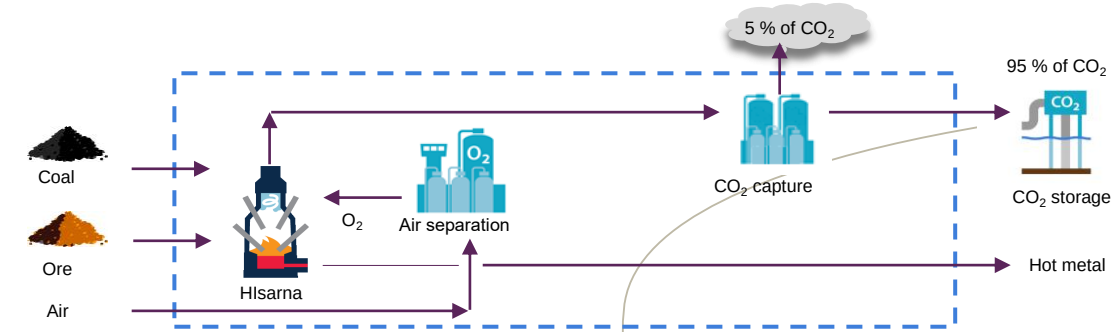
- Research together with Slag Institute and cement producer
- HIsarna slag granulated at pilot plant (wet granulation)
- Cement samples produced from HIsarna slag and tested
- Results so far show similar strength development as with BF slag

4.3. Capture of CO_2

- BF route: CO_2 emitted at several stacks
- CO_2 present in waste gas at low concentrations

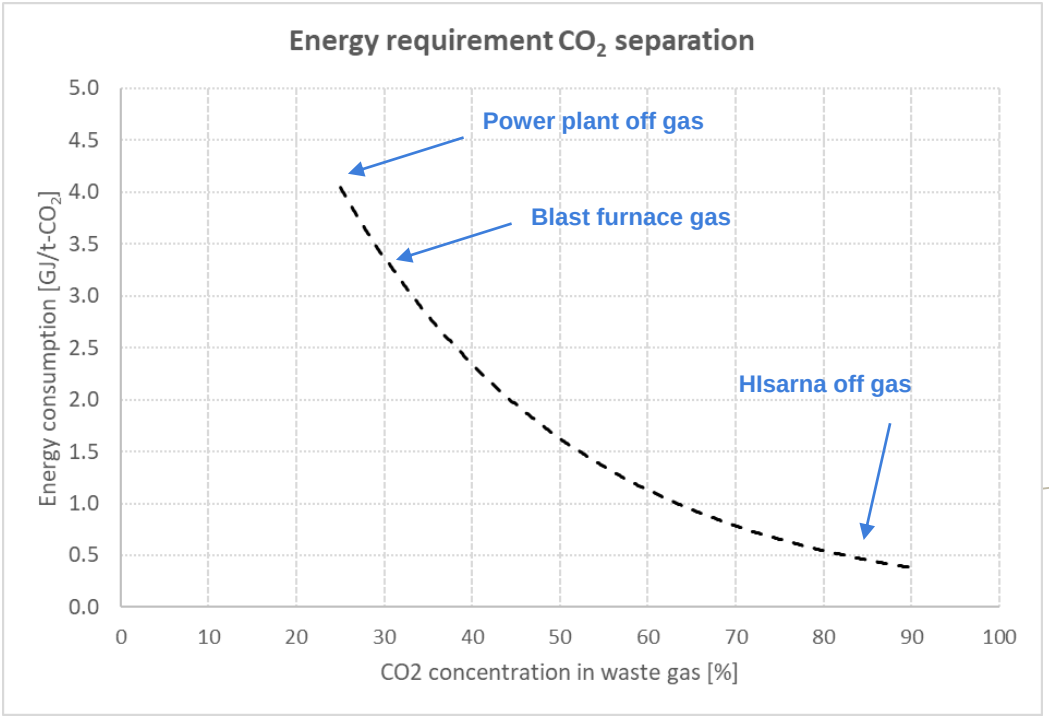


- HIsarna: All CO_2 concentrated at a single stack, less capture installations



4.3. Capture of CO_2

- High CO_2 concentration in the off gas, lower capture costs
  - Lower capital costs
  - Lower energy costs

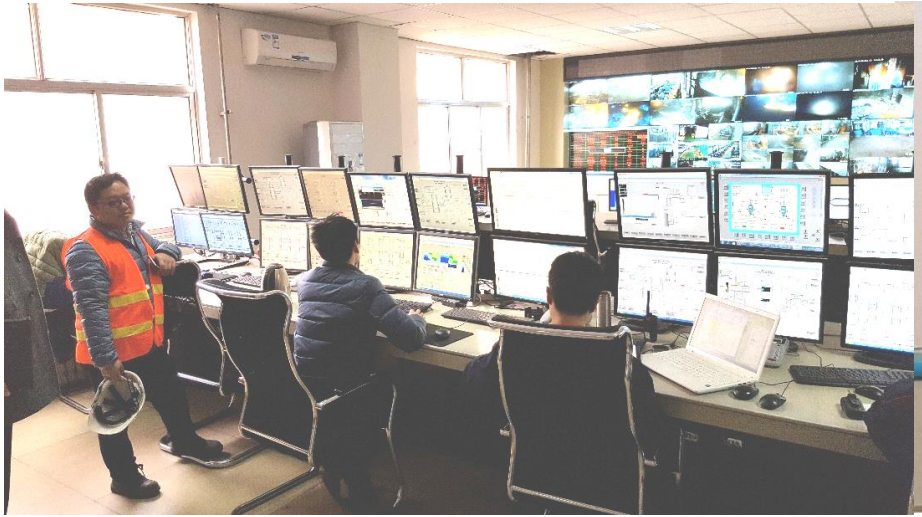


5. Scale up

- HIsarna process consists of two integrated process steps, CCF and SRV

SRV

- Scale up of the SRV is proven in the Hismelt plant in Molong, China

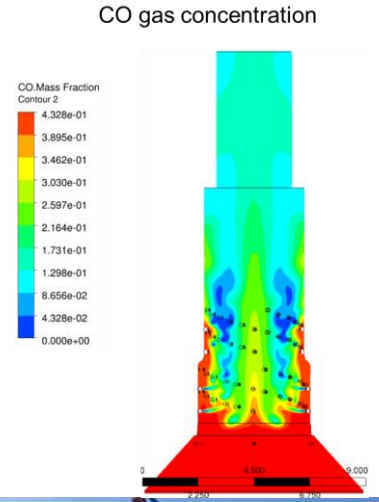


5. Scale up

CCF

- Scale up is studied with a combination of computational models and physical models
- Physical model to study the mixing of fine iron ore injected into a cross flow was built at Tata Steel Jamshedpur and is presently operated
  - Range of ore sizes
  - Range of injection conditions
  - Behaviour of ore “plume” under different conditions
    - Mixing
    - Dust losses

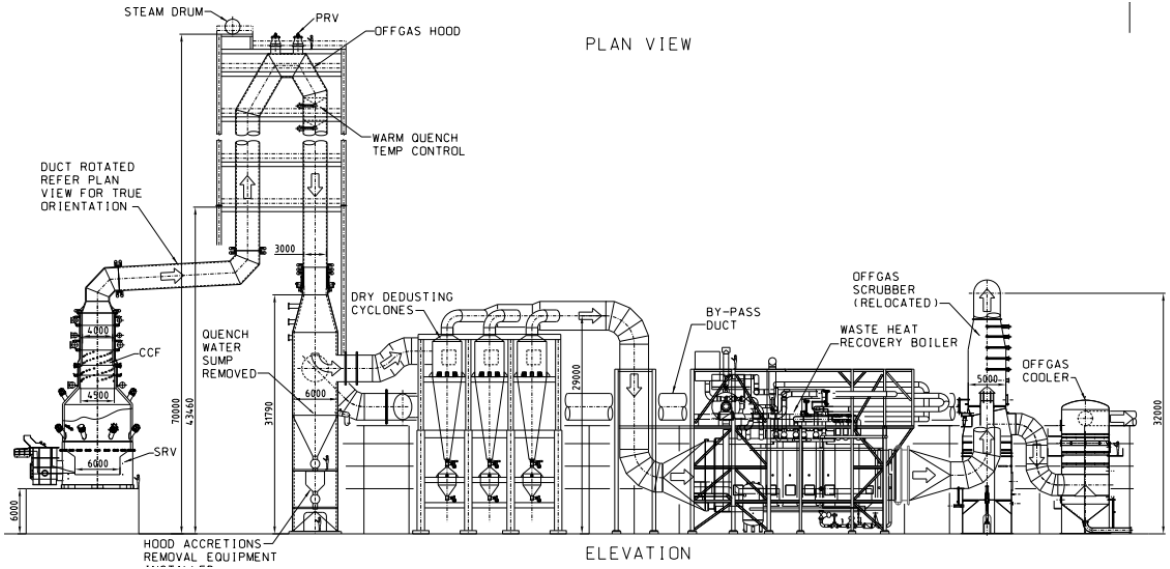
Computational model



Physical model

Demo plant Engineering, Jamshedpur

- Conceptual engineering of a Demo plant, 700 – 900 kt/y, is completed
  - Location has been selected
  - Cost estimate has been made
- After completion of pilot plant program with iron ore from India, the go/no-go decision for a Demo plant is expected



6. Conclusions

- HIsarna is a breakthrough technology offering significant environmental and economic benefits.

- It allows significant CO_2 emissions reduction
  - Combined with CO_2 capture technology
  - By using renewable carbon from biomass

- It reduces dependance on scarce raw materials (coking coal and high-quality ores)

- It enables building a circular economy
  - Reducing waste of steelmaking, slag, dust and sludge
  - Reducing mining reverts

Do you have any questions?

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