Direct Reduced Iron (DRI) and CO₂ Capture
(Review of Current State of the Art)

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Meeting with European Commission
13th July 2012
Presentation Outline

• Background
• Gas Based - Direct Reduced Iron
  • Midrex
  • Hyl-III and Hyl-ZR
  • ULCORED
• Hybrid System
  • Corex-DRI Scheme
  • Gasification-DRI Scheme
• Coal Based – Direct Reduced Iron
  • SL/RN
  • ITmk3
  • Others…
## Background

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2011 World DRI Production by Process

Total World Production: 73.3 Mt

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<td>59.9%</td>
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<td>26.9%</td>
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Source: Midrex Technologies, Inc.
Background

• **Product**
  - Hot Briquetted Iron (HBI)
  - Cold Directly Reduced Iron (c-DRI)
  - Hot Directly Reduced Iron (h-DRI)

• *In addition to good alternate to scrap, it is a potential raw material input to Blast Furnace could lead to reduction of CO₂ emissions. (i.e. reduced coke, sinter requirement)*
Midrex
(Conventional without CO₂ Capture Option)
Midrex (Conventional with CO₂ Capture Option)
HYL-III (Energiron DR)
Plant Configuration with SMR

- Electricity optimization
- Hot and/or Cold DRI production
- Carbon content: 0.8% - 3.5%, depending on the extent of “in-situ reforming” with NG
HYL-ZR (Energiron ZR-DR)
Plant Configuration without Reformer

- The Scheme w/o Reformer is characterized by the following features:
  - Partial combustion of the reducing gas.
  - “In-situ” reforming of CH₄ in the lower part of the reactor’s reduction zone.
  - Adjustable composition of the reducing gas to control DRI metallization and carbon.
  - Natural gas optimization
  - Hot and/or Cold DRI production
  - Carbon content: 2.0% – 4.0%
CCUS Application
(Currently Operational)

• **Arcelor Mittal – Lazaro Cardenas (Mexico)**
  - HYL-III Technology (4 x 0.5 mtpy c-DRI)
  - Upgraded in 2007 to include CO₂ capture – Sold to food industry (Operational since 2008)

• **Welspun Maxsteel – Raigad (India)**
  - HYL-III (0.9 mtpy DRI/HBI) and HYL-ZR (0.55 mtpy DRI/HBI)
  - Upgrade & New Build in 2006. (Operational since 2008)
  - Capture of CO₂ from HYL-ZR – Sold to food industry.
CCUS Application
(Under Construction or In Planning)

• **Emirate Steel - Abu Dhabi (UAE)**
  - HYL Energiron DR (2 x 1.6 mtpy h-DRI)
  - Upgrade for CO2 Capture for EOR application
    (Expected by 2013/2014)

• **Nucor – Louisiana (USA)**
  - HYL Energiron ZR (1 x 2.5 mtpy c-DRI)
  - Under construction – operational by 2014/2015
  - With CO2 Capture for EOR application
  - Note:
    - Original permit – was to build a BF/BOF integrated steel mill. But due to Shale Gas, Nucor switch DRI plant.
ULCORED Technology

(Information from ULCOS)

- **Claimed to reduce 20% energy consumption as compared to other DRI Technology.**

- **Key Features**
  - 100% use of oxygen instead of air
  - Based on partial oxidation. POX, reactor instead of a reformer
  - With CO shift reactor to convert CO to H₂ and CO₂ – therefore maximise CO₂ removal
  - CO₂ cleaning of the off gas stream after shifter by
  - pressure swing adsorption, PSA/VPSA or amine wash to produce a clean CO₂ for storage and a hydrogen stream to be recycled to the reactor
Coal Based DRI -

- **SL/RN – Rotary Kiln with Rotary Cooler**
  - Status – Commercially Operated
  - Largest Capacity ~0.3 mtpy per module
  - Issue with Pollutant Emissions
  - India (22 units), South Africa, Brazil
  - Not considered viable to incorporate CO₂ capture
SL/RN Process Configuration
Gasifier – DRI Scheme

This scheme is also applicable to
• Midrex Technology
ULCORED Coal Based DRI
COREX-DRI Scheme

This scheme is applicable to:
- Midrex Technology
- HYL Technology
- ULCORED Technology
COG – DRI Scheme

Steam → CO₂ - removal → CO₂ removal → BF Gas → O₂ → DRI

Tail Gas → Ore → COG

H₂O
ITmk3 – Iron Nuggets

Fuel: Coal

Feed: Fine Ore
Concluding Remarks

• *Different CO₂ capture options for production of DRI/HBI or other iron sources to steelmaking has been reviewed.*

• *Expected growth in Gas Based DRI/HBI Production.*
  
  • As important source of metal alternate to scrap steel in EAF production
  
  • Could be a good substitute metal input to the Blast Furnace (therefore reducing coke consumption)

• *Growth in coal based DRI/HBI should be expected in India where coking coal supply is limited.*