Alternate energy options for bulk production of DRI under Indian context – A green technology initiative

International Conference on Emerging Trends in Metal and Minerals Sector
5th to 7th September, 2014
at Pragati Maidan, New Delhi

R. Ranjan, A. K. Jha & A. K. Agrawal

MECON Limited
Ranchi-834002
Contents

❖ Steel production overview

❖ DRI production scenario in world & India

❖ Fuel demand-supply scenario for gas based DR plant

❖ Alternate energy options like
  ❖ Coal gasification
  ❖ Corex gas
  ❖ Coke oven gas
  ❖ Underground coal gasification
  ❖ Coal bed methane
  ❖ Shale gas

❖ Conclusion
Steel production overview

Steel production of the World in 2013
1606 Mt

Steel production scenario of India (In Mt)

- 2013 India Prod: 81.2 Mt
- 2016-17 (As per 12th year plan): 149 Mt
- 2025-30 (As per draft national steel policy 2012): 300 Mt

Steel consumption per capita (2013)

- World: 225 kg/capita
- India: 58 kg/capita
Crude steel prod. in India and world by process (2013)

Source: World steel association
Contents

- Steel production overview
- DRI production scenario in world & India
- Fuel demand-supply scenario for gas based DR plant
- Alternate energy options like
  - Coal gasification
  - Corex gas
  - Coke oven gas
  - Underground coal gasification
  - Coal bed methane
  - Shale gas
- Conclusion
Role of DRI in steel

DRI

- No tramp elements, hence no contamination of steel

As coolant

Main feed material

BOF

EAF

Limited use

Hot metal

IF

Limited use

No use

BF

- Target 300 Mt crude steel (2025-30)
- Role of EAF/IF process significant
- DRI required in huge quantity
Major sponge iron producing countries in 2013

<table>
<thead>
<tr>
<th>Country</th>
<th>Mt</th>
</tr>
</thead>
<tbody>
<tr>
<td>India</td>
<td>17.77</td>
</tr>
<tr>
<td>Iran</td>
<td>14.46</td>
</tr>
<tr>
<td>Mexico</td>
<td>6.13</td>
</tr>
<tr>
<td>Russia</td>
<td>5.33</td>
</tr>
<tr>
<td>T&amp;T</td>
<td>3.29</td>
</tr>
<tr>
<td>Egypt</td>
<td>3.17</td>
</tr>
</tbody>
</table>

Source: Midrex Technologiesc, Inc
World DRI production share by process in 2013

Total production: 75.2 Mt

- 63.20% Midrex (gas based)
- 21.20% Coal based
- 15.40% Hyl/Energiron (gas based)
- 0.20% Others

Source: Midrex Technologies, Inc.
Indian DRI plant capacity & percent production share

Total plant capacity (2013)
- 33 Mt Coal based (800 units)
- 10.67 Mt Gas based (11 units)

Total production (2013-14): 18.1 Mt
- 85.55% Coal based
- 14.45% Gas based

Source: Midrex Technologies, Inc.
Source: SIMA
# Rotary kiln DR Vs. Gas based DR plant

<table>
<thead>
<tr>
<th>Rotary kiln</th>
<th>Gas based DR plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small plant size 50 -500 tpd</td>
<td>Larger plant size 1200-7500 tpd</td>
</tr>
<tr>
<td>Space requirement is high</td>
<td>Plant is very compact</td>
</tr>
<tr>
<td>Energy requirement is high</td>
<td>Energy requirement is almost half of rotary kiln</td>
</tr>
<tr>
<td>Inferior quality products</td>
<td>Much cleaner product – suits in making good quality steel</td>
</tr>
<tr>
<td>Prone to environmental pollution</td>
<td>Clean technology</td>
</tr>
<tr>
<td>Very low carbon in the product: In the range of 0.1-0.3 % only</td>
<td>Carbon in the product varies from 1.5 – 2.5 %. Advantage in Steel making</td>
</tr>
<tr>
<td>Metallization : 86-90 %</td>
<td>Metallization : 92-94 %</td>
</tr>
<tr>
<td>Low capital cost</td>
<td>Investment required is high</td>
</tr>
<tr>
<td>Plant availability is low</td>
<td>Plant availability is much higher (8000 hrs or higher)</td>
</tr>
</tbody>
</table>
Contents

- Steel production overview
- DRI production scenario in world & India
- Fuel demand-supply scenario for gas based DR plant
- Alternate energy options like
  - Coal gasification
  - Corex gas
  - Coke oven gas
  - Underground coal gasification
  - Coal bed methane
  - Shale gas
- Conclusion
Natural gas main feedstock for gas based DR plant

- Natural gas has been the primary fuel for gas based DR Plant
- Several constraints related to natural gas availability & price.
Natural gas scenario in India

Natural gas demand - supply scenario (mmscmd)

- LNG imports: 45 in 2012-13, 143 in 2016-17
- Domestic Production: 101 in 2012-13, 157 in 2016-17
- Natural Gas demand: 243 in 2012-13, 378 in 2016-17
- Deficit: 97 in 2012-13, 78 in 2016-17

48% in FY 16-17, 30% LNG imports to total natural gas in FY 12-13
Natural gas scenario for gas based DR Plant

Natural gas availability – Indian Scenario

• The domestic demand is far ahead of domestic production.
• Increased dependency on imported LNG
• Inadequate gas transmission & distribution infrastructure
• Govt.’s policy of priority sector allocation viz. power, fertilizers, city gas distribution (CGD)
• High price of imported LNG questions viability for its use in steel industries
• Therefore, only option to explore alternative fuel for gas based DR plant
Contents

- Steel production overview
- DRI production scenario in world & India
- Fuel demand-supply scenario for gas based DR plant
- Alternate energy options like
  - Coal gasification
  - Corex gas
  - Coke oven gas
  - Underground coal gasification
  - Coal bed methane
  - Shale gas
- Conclusion
Alternate energy options for DRI production

- Synthesis gas (from coal gasification)
- Corex export gas
- Coke oven gas
- Coal bed methane
- Shale gas
India is the 3rd largest producer of coal in the world

India has 5th largest reserves of coal in the world
Alternate energy option – Syn gas

Why coal gasification is required in India?

• It is due to huge deficit of natural gas
• High price (US$12-17/MMBTU) of imported LNG
• Makes Gas based DR operation uneconomical.
• India has abundance of non-coking coal
• Coal gasification produces synthesis gas (syn gas)
• Syn gas contains mostly reducing gases \( \text{H}_2 \) and CO used for iron ore reduction.

What is coal gasification?

• Partial oxidation process at high temperature and pressure with oxygen and steam to produce synthesis gas.
Alternate energy option – Syn gas

Objective of coal gasification

- Gasification technology can be coupled with DR shaft furnace
- Low rank Indian coals can be used in gasifiers to produce syn gas
- Using indigenous non-coking coal, continuous supply of syn gas at economical price can be met
- The requirement of key parameters for the reducing gas is effectively met by the syn gas.

Types of coal gasification
a) Surface coal gasification
b) Underground coal gasification
Alternate energy option – Syn gas

COUPLING OF COAL GASIFICATION WITH DR PLANT

A House of Engineering Excellence

Gasification Plant

MIDREX® Plant
World’s first syn gas based DR plant

Furnace Type : MIDREX Hot Discharge
Reductant : Synthesis gas from coal gasification
Products : Hot DRI (0-100%) and/or Cold DRI (0-100%)
Hot DRI Transport: Mechanical Conveyor (AUMUND)
Capacity : 1 x 1.8 million t/yr DRI [225 tph]
Location : Angul, Odisha
Company : Jindal Steel & Power Ltd.
Alternate energy option – corex export gas

- Corex export gas can be a feedstock for production of DRI
- Mittal Steel, South Africa (Saldanha) set up in 1999 using this gas
- JSW commissioned 1.2 Mt production capacity Corex export gas based Midrex direct reduction plant in 2014.

Arcelor Mittal Saldanha Steel Plant at South Africa
Alternate energy option – coke oven gas

Reducing gas sources:
- Natural Gas
- Reformed Gas
- Coal Gasification
- COG
- Others

Optional DR products:
- DRI
- HBI

Iron Ore

ENERGIRON Reactor

CO$_2$ Removal

Process Gas Compressor

Top Gas Scrubber

H$_2$O

fuel

O$_2$

HYTEMP® Iron

EAF
Alternate energy option – coke oven gas

- COG can be used as reducing gas in DR plant
- JSW Ispat, Dolvi is planning to use coke oven gas to their existing gas based DRI plant (Midrex technology) in India, due to non-availability of natural gas
- JSPL at Angul is also considering use of coke oven gas in their 2\textsuperscript{nd} DRI plant, at least partially.
## Comparison of gas quality

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>H₂</td>
<td>55.0</td>
<td>73.0</td>
<td>18.0</td>
<td>54.0</td>
<td>52.0</td>
</tr>
<tr>
<td>2</td>
<td>CO</td>
<td>33.5</td>
<td>15.0</td>
<td>40.0</td>
<td>7.5</td>
<td>31.5</td>
</tr>
<tr>
<td>3</td>
<td>CH₄</td>
<td>3.1</td>
<td>5.0</td>
<td>1.0</td>
<td>25.0</td>
<td>12.0</td>
</tr>
<tr>
<td>4</td>
<td>CO₂</td>
<td>2.6</td>
<td>1.0</td>
<td>35.0</td>
<td>3.5</td>
<td>3.0</td>
</tr>
<tr>
<td>5</td>
<td>H₂O</td>
<td>5.0</td>
<td>5.0</td>
<td>3.0</td>
<td>Trace</td>
<td>1.0</td>
</tr>
<tr>
<td>6</td>
<td>N₂</td>
<td>0.8</td>
<td>1.0</td>
<td>4.0</td>
<td>7.5</td>
<td>0.5</td>
</tr>
<tr>
<td>7</td>
<td>H₂/CO</td>
<td>1.64</td>
<td>4.87</td>
<td>0.45</td>
<td>7.2</td>
<td>1.6</td>
</tr>
<tr>
<td>8</td>
<td>Reductant/Oxidant</td>
<td>11.8</td>
<td>14.67</td>
<td>1.53</td>
<td>17.57</td>
<td>20.87</td>
</tr>
</tbody>
</table>
## Comparison of fuel in production cost of DRI

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Unit</th>
<th>Coke Oven gas</th>
<th>Corex export gas</th>
<th>Syn gas</th>
<th>Natural gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calorific value</td>
<td>kCal/Nm³</td>
<td>4200</td>
<td>1800</td>
<td>3400</td>
<td>8700</td>
</tr>
<tr>
<td>Market eqv. Unit price</td>
<td>Rs./Nm³</td>
<td>10</td>
<td>2.5</td>
<td>8.5</td>
<td>31.1 (USD 15 /mmbtu)</td>
</tr>
<tr>
<td>Sp. Cons./t DRI</td>
<td>Nm³</td>
<td>580</td>
<td>1600</td>
<td>650</td>
<td>270</td>
</tr>
<tr>
<td>Cost of reductant/ fuel / t DRI</td>
<td>Rs./t</td>
<td>5800</td>
<td>4000</td>
<td>5525</td>
<td>8397</td>
</tr>
<tr>
<td>Eq. in USD/t</td>
<td>USD/t</td>
<td>97</td>
<td>67</td>
<td>92</td>
<td>140</td>
</tr>
</tbody>
</table>

1 USD = Rs 60
Futuristic option-Underground coal gasification (UCG)

- Conversion of solid coal into gas in the mines themselves
Advantages of underground coal gasification

- No need for coal to be mined, handled and transported
- No need for disposing of ash or slag
- Significantly lower capital cost for project development than that of above ground plants
- Minimal land use
- Significantly minimum use of groundwater or freshwater as underground saline water is used
- No environmental impacts traditionally associated with coal mining and handling
Status of UCG in world

• Demonstration projects and studies are under in number of countries like

  ❖ United State of America
  ❖ Western and Eastern Europe
  ❖ Japan
  ❖ Indonesia
  ❖ Vietnam
  ❖ India
  ❖ Australia
  ❖ Poland,
  ❖ UK and
  ❖ China
  ❖ South Africa
CMPDI has invited on-line bids on 20th January’2014 for the e-Tendering to select the developer for commercial development of UCG for

• Kaitha Block of Ramgarh Coalfield (CCL)

• Thesgora “C” Block of Western Coalfields Limited (WCL)
Futuristic option- Coal Bed Methane (CBM)

- Generated during coalification process
- Gets adsorbed in coal at higher pressure
- CBM in mine makes mining works difficult, risky and costly
- CBM production leads to de-methanation of coal beds
- Avoidance of methane emissions
- CBM exploration turning environmental hazard into clean energy resource
- CBM has at least 94% methane and heating value approximately 8500 KCal/kg
CBM reserves in the world

- Alaska: 1,037 Tcf
- Canada: 699 Tcf
- USA minus Alaska: 711 Tcf
- Russia: 1,730 Tcf
- China: 1,307 Tcf
- Australia: 1,037 Tcf
- UK: 102 Tcf
- Ukraine: 42 Tcf
- Kazakhstan: 23 Tcf
- India: 71 Tcf

Note: CBM activity, past or present is marked with red dots on the map.
CBM reserve status in India

- Total CBM reserve: 2600 Billion cubic meter
- Allotted for exploration: 1810 Billion cubic meter
- CBM reserve established: 280 Billion cubic meter

Unit: Billion cubic meter
## Status of CBM in India

- Commercial production of CBM began in India in 2007
- India become fourth after US, Australia and China in production
- CBM Production of India is 107 MMCM in the FY 12 -13
- Govt. of India allotted 33 CBM blocks for exploration mainly situated in following areas
  - Raniganj
  - Jhariya
  - Bokaro
  - Rajmahal
  - Karnapura
  - Barmer
  - Sohagpur
  - Wardha
Futuristic option- Shale gas

- Originates out of rocks that are mostly shale rock found 3000 meters below surface
- Its Composition is similar to natural gas
Shale gas scenario in the world

- Total Recoverable reserve of shale gas in world is 6,622 Tcf
- Challenges in Shale gas exploration
  - Level of technology
  - Lack of infrastructure
  - Political decision whether to go for drilling or not through hydraulic fracturing of reservoir rock
  - Some countries did not allow due to heavy population
  - Drilling is expensive
Shale gas scenario in India

- Recoverable Shale gas reserve in India is 63 tcf
- 26 basins have been identified in India
- The Ministry of Petroleum and Natural Gas (MoPNG) identified six basins as potentially shale gas bearing
  - Cambay
  - Assam-Arakan
  - Gondwana
  - Krishna-Godavari
  - Kaveri
  - Indo-Gangetic plain
- Shale gas related studies is going on by CMPDI
- Policies for Shale gas extraction being made by government by examining other countries policies.
Contents

- Steel production overview
- DRI production scenario in world & India
- Fuel demand-supply scenario for gas based DR plant
- Alternate energy options with emphasis on
  - Coal gasification
  - Corex gas
  - Coke oven gas
  - Underground coal gasification
  - Coal bed methane
  - Shale gas
- Conclusion
Conclusion

- With the current natural gas market price, operation of gas based DR plant becomes uneconomical.
- Alternate fuel like syn gas, CBM, shale gas, corex export gas and coke oven gas can be a good option to produce DRI
- Use of indigenous high ash, low rank non-coking coal has made generation of syn gas of desired quality a very cost effective
- Coal gasification & gas based DR plant are well proven and therefore, coupling is not a problem.
- As a futuristic scenario, shale gas, UCG and CBM can provide options for gas based DRI, once significant breakthrough is achieved in its bulk discovery through appropriate technology interventions and Govt. policy.
Metallurgical Wing

Thank you