Improved Reduction Kinetics of Low Grade Iron Ore Pellet : An overview

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TATA Steel

7th world DRI and Pellet Congress
Outline of Presentation

1. Influence of lean iron ore on quality of pellets

1. Method to control and enhance reduction kinetic of low grade pellets

1. Innovations for usage of low grade iron ore in pellet and DRI making
IRON ORE – SCENARIO IN INDIA

- Day by day high-grade iron ores are fast depleted
- Fines and low-grade iron ores, which are not utilised earlier, now they can be utilised by upgradation.
- Upgraded concentrates can be used as charge materials for pelletization.

The present scenario of iron ore reserves stated that out of total 28.53 BT [17.88 BT - Hematite & 10.64 BT – Magnetite]

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Grades</th>
<th>Amount of resources (Bt)</th>
<th>Low-grade resources (Bt)</th>
<th>% low-grade resources (w.r.t. total resources)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Fines</td>
<td>3.82</td>
<td>1.19</td>
<td>6.66</td>
</tr>
<tr>
<td>2.</td>
<td>Lumps</td>
<td>9.93</td>
<td>1.62</td>
<td>9.06</td>
</tr>
<tr>
<td>3.</td>
<td>Lumps &amp; Fines</td>
<td>2.33</td>
<td>0.73</td>
<td>4.08</td>
</tr>
<tr>
<td>4.</td>
<td>Unclassified</td>
<td>1.8</td>
<td>1.8</td>
<td>10.07</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>17.88</strong></td>
<td><strong>5.34</strong></td>
<td><strong>29.87</strong></td>
</tr>
</tbody>
</table>

Table 2: Threshold Values of Iron Ore

- Iron Ore
  - i) Hematitic Iron Ore: 45% Fe (Min.)
  - ii) Hematitic Siliceous Ore: 35% Fe (Min.) [For ore of Goan origin]
**PELLET SCENARIO - INDIA**

- India being rich in iron ore deposits did not feel the need for setting up pellet plants.
- The growth of pellet industry in the country was very slow with a capacity of 20 Mt in 2010.

**Major Pellet Producers in India**

<table>
<thead>
<tr>
<th>Company</th>
<th>Capacity (Mt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Essar Steel India Ltd</td>
<td>14.0</td>
</tr>
<tr>
<td>JSW Steel Ltd</td>
<td>13.2</td>
</tr>
<tr>
<td>JSPL</td>
<td>9.0</td>
</tr>
<tr>
<td>Tata Steels</td>
<td>6.0</td>
</tr>
<tr>
<td>Bhushan Power &amp; Steel</td>
<td>-3.85</td>
</tr>
<tr>
<td>Bramhi River Pellet</td>
<td>4.0</td>
</tr>
<tr>
<td>KIOCL</td>
<td>3.5</td>
</tr>
<tr>
<td>MSPL Ltd</td>
<td>2.4</td>
</tr>
<tr>
<td>Monnet Ispat</td>
<td>2.0</td>
</tr>
<tr>
<td>Others</td>
<td>29</td>
</tr>
</tbody>
</table>

Total capacity – 87.0 Million Tons (Mt)
NEED OF PELLETIZATION FOR LOW GRADE IRON ORE FINES

- Characteristically Indian iron ore are soft and fragile in nature by mining and processing combined generate fines
- 10-12% lumps become fines while handling. The Proportion of lumps to fines generally around 2:3
- Processing of iron ore as per specification for Sinter, DRI generates lots of fines (-6mm) and slimes
- Huge quantity of iron ore slimes/Fines at mines sites containing iron 55-60%, Size -150 micron
- Fines available in tailing ponds (accumulate around 10 Mt per year in India)
- Apart from this most of the fines thrown away waste for land filling and create pollution to the environment

Growth in Indian Pellet production capacity

- Continuous increasing
- Excess iron and coal bearing waste generated from iron and steel making units
CONCERNS IN IRON ORE PELLETIZATION

- Bed permeability
- Induration Cycle
- Blaine number of pellet feed
- Raw material characteristic
- Silicate slag and porosity distribution
- Basicity ($B_2$ and $B_4$) Fluxes and Binders
- RDI, RI and Swelling
- High LOI iron ore fine

PELLET PROPERTIES
PELLETIZATION OF HIGH LOI IRON ORE FINES

- During beneficiation of these low grade hematite iron ores, vitreous goethite comes with hematite and partly ochreous goethite along with kaolinite and gibbsite which contribute to the loss on ignition (LOI) in iron ore concentrate.

- The goethite associated with clayey materials i.e., kaolinite and gibbsite is called ochreous goethite.

- Gibbsite and goethite release their water molecules within the temperature of 300–400 °C, whereas kaolinite releases CM at temperature of 850 °C.

- Removal of matrix moisture leads to generate cracks inside the pellets.

- Due to the presence of chemically bound water in the matrix of high pressure Owing to steam is released at high temperature during Induration process.
PELLETIZATION OF HIGH LOI IRON ORE FINES

- Higher LOI iron ore fines results in increase MPS of green pellets
- Pellet drying is a process involving simultaneous heating and moisture release
- The crack generation in pellets in drying zone is largely controlled by temperature and residence-time.
- In UDD hot air will make the lower part of the bed dry quickly but the air will cool from its inlet temperature to its evaporation temperature which may lead to condensation in the upper part of the bed.
- Increasing soaking time will allow the inherent moisture removal slowly.

Effect of soaking time on cracking

<table>
<thead>
<tr>
<th>Temp range</th>
<th>Modified cycle</th>
<th>Modified with extra carbon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>Time(min)</td>
<td>Time(min)</td>
</tr>
<tr>
<td>0°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>180-230</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>280-380</td>
<td>15</td>
<td>12</td>
</tr>
<tr>
<td>450-650</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>1000-1320</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>800</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>first cooling</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>second cooling</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Total time</td>
<td>68</td>
<td>63</td>
</tr>
</tbody>
</table>

SEM image of green pellets
The input temperature and pressure play vital role to remove moisture from pellets in UDD zone.

The output temp from UDD zone is indication of proper moisture & steam removal from the bed.

Input temp and pressure has to optimize to transfer maximum heat to the pellet with steam condensation.
Higher gangue in iron ore pellets leads to decrease high temperature properties (RDI, RI, SI)

Most fluxes are olivine, Pyroxinite, Dunite, limestone and dolomite

Indian fluxes are higher in gangue and LOI

The proper combination of fluxes and its optimize dosage is the key to achieve desired pellet properties

TATA steel innovative step on using dual flux for improving high temperature properties
Usage of limestone + olivine/Pyroxinite in pellets

Controlling the size of fluxes helps in better assimilation of fluxes during slag formation and its bonding
Comparison of Pyroxenite, Olivine, Limestone and Dual flux pellets

<table>
<thead>
<tr>
<th></th>
<th>Pyroxenite pellets</th>
<th>Olivine pellets</th>
<th>Limestone pellets</th>
<th>Limestone pellets</th>
<th>Dual flux pellets</th>
<th>Dual flux pellets</th>
<th>Dual flux pellets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fe (t)</td>
<td>64.19</td>
<td>65.5</td>
<td>66.57</td>
<td>65.93</td>
<td>64.18</td>
<td>64.97</td>
<td>65.05</td>
</tr>
<tr>
<td>CaO</td>
<td>0.18</td>
<td>0.07</td>
<td>0.56</td>
<td>0.63</td>
<td>0.51</td>
<td>0.94</td>
<td>0.9</td>
</tr>
<tr>
<td>SiO₂</td>
<td>4.07</td>
<td>2.49</td>
<td>2.04</td>
<td>1.73</td>
<td>3.03</td>
<td>2.9</td>
<td>2.61</td>
</tr>
<tr>
<td>MgO</td>
<td>1.23</td>
<td>1.05</td>
<td>0.02</td>
<td>0.01</td>
<td>1.06</td>
<td>0.53</td>
<td>1.06</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>2.17</td>
<td>2.16</td>
<td>1.75</td>
<td>2.80</td>
<td>3.06</td>
<td>2.21</td>
<td>2.0</td>
</tr>
<tr>
<td>Ti (+6.3), %</td>
<td>92.33</td>
<td>90.4</td>
<td>94.5</td>
<td>86.7</td>
<td>93.13</td>
<td>94.27</td>
<td>94.04</td>
</tr>
<tr>
<td>Al (+0.5), %</td>
<td>5.87</td>
<td>7.6</td>
<td>4.1</td>
<td>12.2</td>
<td>6.27</td>
<td>5.33</td>
<td>4.76</td>
</tr>
<tr>
<td>CCS Avg. (Kg)</td>
<td>150</td>
<td>118</td>
<td>258</td>
<td>175</td>
<td>228</td>
<td>307</td>
<td>248</td>
</tr>
<tr>
<td>% &lt;50Kg</td>
<td>5.53</td>
<td>6.5</td>
<td>0</td>
<td>5.8</td>
<td>3.33</td>
<td>4.17</td>
<td>1.8</td>
</tr>
<tr>
<td>Porosity, %</td>
<td>28.26</td>
<td>27.97</td>
<td>25.6</td>
<td>-</td>
<td>36.02</td>
<td>-</td>
<td>RDI 10.3</td>
</tr>
<tr>
<td>Swelling, %</td>
<td>~18*</td>
<td>18.6</td>
<td>16.5</td>
<td>-</td>
<td>14.2</td>
<td>14.8*</td>
<td>14.8</td>
</tr>
<tr>
<td>Softening temp</td>
<td>997</td>
<td>1017</td>
<td>1044</td>
<td>1138</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Melting temp</td>
<td>1453</td>
<td>1439</td>
<td>1415</td>
<td>1417</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max dP, mmWC</td>
<td>543</td>
<td>922</td>
<td>893</td>
<td>727</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S Value</td>
<td>64844</td>
<td>100159</td>
<td>114510</td>
<td>86516</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Assimilation problem in fluxes**

Assimilation of Pyroxenite flux
- Relic Pyroxenite
- Hematite
- MgO-Fe
c- CaO-SiO₂

Local pyroxenite
- Fe-5.4%
- CaO-3.3%
- SiO₂-44%
- LOI-10%

- Forsterite
- Quartz
- Silicate melt
- MgO-47%
- CaO-0.9%
- SiO₂-43%
- Fe-5.7%
- LOI-1.3%

**Assimilation of Olivine flux**
- Reaction front
- Silicate melt
- Hematite
- Forsterite
- Quartz

**Thermodynamic view with FACT-Sage**
- Amount of liquid slag formation in pellets at various CaO & MgO levels
- Graph showing % CaO in pellets vs. amount of liquid slag formation
Critical Size of Fluxes used in pelletization

- Normally the Mean size of fluxes are 200 mesh 80 % passing
- The fluxes mainly Pyroxenite/ olivine have higher melting point
- This fluxes need sufficient energy to get assimilate in the pellet matrix

Based on the study it was found that finer the flux more will the rate of assimilation Results in increased reducibility of pellet

The size of the flux should be lower than 50 µn
Smaller MgO based flux particles results in higher silicate melt formation
Metallurgical Testing and Image Analysis of Fired Pellets

CCS Comparison

Swelling Index

Reducibility Comparison

Phase Comparison
Microstructural Examination of Reduced Pellets Using SEM-EDS

Grains being coated by low melting point slag - Low Reducibility

Coated grains are not visible - High Reducibility
Microstructural Examination of Fired Pellets Using SEM-EDS

- Imported Olivine
- Indian Olivine Coarse
- Indian Olivine Fine

Graph showing magnesium content in slag for different types of olivine:
- Imported Olivine: 3.96%
- Indian Olivine Coarse: 3.25%
- Indian Olivine Fine: 5.33%
Enhancement of metallization in DRI
Key criteria affecting metallization of DRI

- CCS of pellets ~ 260-270 and uniform shape factor for better DRI shaft bed permeability and reduction gas Distribution.
- Uniform distribution of slag phase and porosity till the core inside the pellets
- A porous slag phase to enhance gas penetration through micro pores.
- Low slag volume and higher iron component in pellets.

Kinetic steps in Reduction of iron oxide
**Effect of Higher silica and alumina on pellet Reducbility**

<table>
<thead>
<tr>
<th>Sample</th>
<th>PP2 pellet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degree of reduction, %</td>
<td>95.45</td>
</tr>
<tr>
<td>Reducibility(dR/dT), %O2/min</td>
<td><strong>0.54</strong></td>
</tr>
<tr>
<td>Degree of metallization, %</td>
<td>92.8</td>
</tr>
<tr>
<td>FeO in DRI</td>
<td>8.23</td>
</tr>
</tbody>
</table>

1. Due to high silica and alumina in the ore, the slag volume is high.
2. The slag boundary is larger between the iron particles and porosity is not uniformly distributed.
3. Higher silica results in formation of Fayalite (Fe2sio4), which is sluggish and hinders reduction of iron oxide due to higher local oxygen potential particularly at the core.
4. Due to high temperatures and low slag conditions at the core, the re-crystalized hematite forms an impervious bridge retarding the gas penetration.
Ternary Plot of oxide system

As per slag system the melting point of slag matrix increased and shifted to higher temperature zone.

Gangue content in Pellet
SiO$_2$=5-6 %, Al$_2$O$_3$= 3.5 - 4 %
CaO= 1.6 - 1.8 %

Present operating range
Effect of slag bonding on Reduction kinetics of pellets

- Pellets usually reduce at a slower rate at core than that at surface (where the bonding is predominantly due to grain growth bridging).
- Excessive slag bonding in pellets tends to cause shrinkage and reduces the porosity which, in turn, increases the time required for reduction.

Higher FeO in slag causes steep reduction in reducibility by decreasing the pellet porosity.

Reducibility of Cao-SiO\textsubscript{2}-FeO slag

<table>
<thead>
<tr>
<th>C.C.S, kg/pellet</th>
<th>R.D.I (-6.3mm)</th>
<th>R.D.I (-3.15mm)</th>
<th>R.D.I (-0.5mm)</th>
<th>Porosity</th>
</tr>
</thead>
<tbody>
<tr>
<td>256</td>
<td>8.6</td>
<td>7.34</td>
<td>6.90</td>
<td>28.00</td>
</tr>
</tbody>
</table>

Analysis of CDRI and HDRI, %

<table>
<thead>
<tr>
<th></th>
<th>T(Fe)</th>
<th>Fe(Met)</th>
<th>metallization</th>
<th>FeO</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDR</td>
<td>83.23</td>
<td>76</td>
<td>92.33</td>
<td>9.2544</td>
<td>1.63</td>
</tr>
<tr>
<td>HDR</td>
<td>84.55</td>
<td>77</td>
<td>92.24</td>
<td>9.664</td>
<td>1.05</td>
</tr>
</tbody>
</table>
Formation of FeO in DRI making

<table>
<thead>
<tr>
<th>Oxide</th>
<th>Ratio of oxygen to iron atoms</th>
<th>Weight ratio of oxygen to iron</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hematite</td>
<td>1.5</td>
<td>0.428</td>
</tr>
<tr>
<td>Magnetite</td>
<td>1.33</td>
<td>0.3809</td>
</tr>
<tr>
<td>Wustite</td>
<td>1.05</td>
<td>0.3</td>
</tr>
</tbody>
</table>

- Lower reduction potential of CO or H2 at the core results in higher FeO in the pellet.
- Presence of FeO rich slag hinders the supply of gases to the iron grain.
Targets for improving the metallization in DRI

- To improve slag characteristics and porosity distribution under the high silica and alumina conditions.
- Create emulsified slag phases (combination of liquid and solid phases) for better slag penetration in the core and thinner slag wall.
- Enhancement of micro pore distribution for improved reduction gas transfer to iron particle and improved reduction kinetics by reduction in local oxygen potential resulting in lower fayalite formation.
- Formation of low melting slag phases by chemical doping without effecting the pellet chemistry.
- Nucleating larger number of active sites for reduction gas transfer for increasing the reduction kinetics.
1. Alkalies (Na, K) are known to enhance melting of slag by lowering the M.Point.

2. Boron oxide also lowers the M.P but helps in formation of multiphase complex slag which are porous.

Identification of Chemical agents for slag modification.

1. Easy melting of slag, forms highly fluid slag resulting in blocking of micro pores.
2. Increases alkali load

1. Boron oxide helps formation of emulsified slag at temp of 850-900°C and forms thin slag boundary with larger micro pores.
2. The boron oxide forms complex compounds and resides in the slag and does not effect the iron grain.
Effect of chemical dosing on slag phase system

- The dosage of doping chemical is to be optimized to operate in the boundary condition for emulsified porous slag phase.
- Shifting of the operating range towards right will result in excess amounts of fluid slag which will block the micro pores.
- Similarly shifting towards the left will result in formation of hard non porous slag resulting in thicker slag wall and blocked micro pores.

Boron oxide and Colemanite (Ca-boron oxide compound) are selected for doping to manipulate the slag phases.
Test conditions for Lab studies

Chemical analysis of Doping agents

**Colemanite**

<table>
<thead>
<tr>
<th>Chemical composition</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boron oxide (as $B_2O_3$)</td>
<td>30.00%</td>
</tr>
<tr>
<td>CaO</td>
<td>30.00 – 35.00 %</td>
</tr>
<tr>
<td>SiO$_2$</td>
<td>6.00 % max.</td>
</tr>
<tr>
<td>MgO</td>
<td>3.00% max.</td>
</tr>
<tr>
<td>Fe$_2$O$_3$</td>
<td>0.6% max.</td>
</tr>
<tr>
<td>Al$_2$O$_3$</td>
<td>1.00% max.</td>
</tr>
</tbody>
</table>

Chemical formula: $2CaCO_3 \cdot B_2O_3 \cdot 5H_2O$

**Boron Oxide (Boric acid)**

Chemical Formula: $H_3BO_3$

Contains ~ 65 % $BO_3$

---

**Reduction gas composition**

<table>
<thead>
<tr>
<th>Gas</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO</td>
<td>54%</td>
</tr>
<tr>
<td>H$_2$</td>
<td>30%</td>
</tr>
<tr>
<td>N$_2$</td>
<td>16%</td>
</tr>
</tbody>
</table>

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**Pellet chemistry**

<table>
<thead>
<tr>
<th>Pellet blend chemistry</th>
<th>Basicity</th>
<th>Chemical Doping dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fe- 62.18</td>
<td>0.3-0.0.35</td>
<td>0.5</td>
</tr>
<tr>
<td>SiO2- 5.34</td>
<td>0.7</td>
<td>0.7</td>
</tr>
<tr>
<td>Al2O3- 3.68</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>Mgo – 1.2</td>
<td>1.2</td>
<td>1.2</td>
</tr>
</tbody>
</table>

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Tata Steel
**Results - Properties of Fired pellets**

- **Addition of boric oxide** melts the slag at lower temp and distributed uniformly with uniform porosity distribution till the core.
- **Bonding mechanism** showed improved CCS strength due to physical melting of boron oxide at the contact points of ore grains during thermal treatment.
- **Addition of Colemanite** resulted in increased basicity (by 0.08) due to presence of Cao; increased slag volume resulting in lowering of CCS marginally.
Micro graphs of fired pellets at 0.5 % Boron oxide

- Boron saturated silicate slag forms thin slag boundaries with uniform slag distribution and higher micro pores
- Pores density is higher at the center results in better gas diffusion to core giving lower FeO.
Results – Optical micro graphs of DRI with Boron oxide doping

<table>
<thead>
<tr>
<th>Boric oxide %</th>
<th>0.5</th>
<th>0.7</th>
<th>0.9</th>
<th>1.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degree of reduction, %</td>
<td>96.25</td>
<td>96.71</td>
<td>94.84</td>
<td>93</td>
</tr>
<tr>
<td>Reducibility(dR/dT) %O2/min</td>
<td>0.65</td>
<td>0.66</td>
<td>0.56</td>
<td>0.45</td>
</tr>
<tr>
<td>Degree of metallization, %</td>
<td>94.21</td>
<td>94.67</td>
<td>92.52</td>
<td>91.2</td>
</tr>
<tr>
<td>FeO in DRI</td>
<td>6.54</td>
<td>6.23</td>
<td>9.1</td>
<td>10.2</td>
</tr>
</tbody>
</table>

Kinetic of iron whiskers formation from surface to center of DRI pellet
Dosage of colemanite @ 0.9% and 0.5% of boron oxide are comparable.

<table>
<thead>
<tr>
<th>Colemanite %</th>
<th>0.5</th>
<th>0.7</th>
<th>0.9</th>
<th>1.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degree of reduction, %</td>
<td>96.66</td>
<td>95.42</td>
<td>96.42</td>
<td>95.42</td>
</tr>
<tr>
<td>Reducibility(\frac{dR}{dT}) %O2/min</td>
<td>0.51</td>
<td>0.56</td>
<td>0.62</td>
<td>0.56</td>
</tr>
<tr>
<td>Degree of metallization, %</td>
<td>91.45</td>
<td>92.46</td>
<td>94.52</td>
<td>94.32</td>
</tr>
<tr>
<td>FeO in DRI</td>
<td>9.45</td>
<td>8.23</td>
<td>7.9</td>
<td>7.5</td>
</tr>
</tbody>
</table>

Wustite and Iron at centre

Iron whiskers at the surface

*Excess of Colemanite melts larger proportion of slag making the pellet more dense and hence lowers the reducibility*
Unit wise Expected Benefits -

PELLETIZATION

1. Due to the formation of low melting slag, the firing temperature can be reduced 1270-1280 C – Fuel saving

2. The pellet quality parameters will be better due to more uniform slag porosity distribution - CCS increase by ~ 10 points.

DRI

1. Better gas diffusion through higher volume of micro pores resulting in enhancement of metallization by 1-1.5%.

2. Increase in productivity by 2% in DRI plant.

3. Reduction in DRI fines generation due to lower high temperature degradation

*The addition of boron retards the formation of Di-calcium silicate and stabilizes the slag in terms of volume expansion in EAF slag.*
INNOVATIONS in area of Pelletization

NEW MINDSET
NEW RESULTS
REDUCTION ROASTING

- In reduction roasting process, iron phase minerals i.e., goethite and hematite converts to magnetite and simultaneously remove the swelling properties associated clay minerals.
- After reduction roasting, the ore is ground to its liberation size of iron phase minerals and concentrate the magnetite using low intensity magnetic separator.

- The magnetite concentrate helps in reducing energy consumption during pelletization
- The magnetite bond during Induration provide excellent pellet strength
- The firing temp required for magnetite conc in range of 1240-1250 °C against 1300-1320 °C for hematite pellets
COLD BONDED PELLETIZATION

- Iron ore concentrate pellets are traditionally hardened (indurate) at high temperatures in horizontal grates and grate-kiln furnaces.
- Cold bonding is a low-temperature alternative to heat Induration. Cold bonded pellets are usually hardened at temperatures lower than 300 °C.
- Strength achieved by chemical reactions that form new phases among the iron bearing grains in the pellet

- Cement Bonding
  - Slaked lime/Portland cement
  - Fine silica
  - Slaked lime
  - Fine silica
  - Starch
  - Dextrin
  - Lignosulfonate
  - Funa

- Hydrothermal bonding
  - Slaked lime
  - Burnt lime
  - Silica flour

- Typical dry pellet content (wt %), excluding reductant
  - Mixed Fe-oxide
  - Burnt Lime, CaO
  - Silica flour, SiO₂
  - Also add H₂O + reductant

- Example cold-bonded pellet properties
  - Crushing strength: 400 lbs
  - Various C-S-H phases precipitate & bond pellet
  - Minerals dissolve and diffuse in steam phase

- Cold bonding capital and operating costs to be 2/3rd that of heat Induration.
- High potential of iron and coal bearing generation in future, CBP proven to be the promising as future pelletization
It helps in conservation of natural resources and pollution control.

Recovery and recirculation of useful minerals from process waste help in cost reduction.

Fe upgrading from 35 to 63% with 40-50% yield.

Concentrate (63% Fe) used in Pellet making

Presently TATA steel JSR utilize GCP sludge in pellet making to gain advantage in carbon consumption.
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Results - XRD analysis of DRI

XRD analysis reveals that the iron formed is ferritic (α-iron) and the wustite is alloyed with silica & alumina and hence remains unreduced during the DRI process.
Unit wise Expected Benefits -

**SMS-3 (For every 1 % increase in metallization)**

1. Yield improvement by 1 %.
2. Decrease in charge by 3 T (207-204)
3. Reduction in power consumption by 1500 Kwh.
4. Reduction in electrode consumption by 0.07 kg/TLS.
5. The addition of boron retards the formation of Di-calcium silicate and stabilizes the slag in terms of volume expansion.