Use of Alternative Carbon Sources in Blast Furnace at JSW Steel

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About JSW Steel

3 decade of JSW Crude Steel Growth in Million ton

Technology Growth

- Corex
- Medium BF
- Large BF
- Super Large BF

Volume Growth

- 12 MTPA (1st decade)
- 12 MTPA (2nd decade)
- 26 MTPA (3rd decade)

- 27.8 MTPA Domestic crude steel capacity
- >12 MTPA Domestic downstream capacity

BPSL Chandigarh, BPSL Kolkata, BPSL Jharsuguda: 3.5 MTPA, Raigarh: 0.95 MTPA (JISPL), Raipur: 0.25 MTPA (JISPL), Dolvi: 10 MTPA, Vijayanagar: 12 MTPA, Salem: 1 MTPA

Includes joint venture, JSW Ispat Special Products Ltd (JISPIL), announced merger with JISPL in May 2019.
Sustainability at JSW Steel

ESG Focus Areas

**Environment**
- Climate change
- Energy
- Resources
- Water resources
- Waste
- Waste Water
- Air emissions
- Biodiversity
- Sustainable mining
- Supply chain sustainability

**Social**
- Indigenous people
- Cultural heritage
- Employee wellbeing
- Local considerations
- Social sustainability

**Governance**
- Business ethics
- Human rights

Driving Sustainability Initiatives Across Platforms

Aligned to National & International Frameworks

Governance & Oversight By Board-level Business Responsibility And Sustainability Committee
JSW Steel
Decarbonisation
Roadmap

48% of JSW Carbon reduction journey

**A: Achieved**

- CO2 reduction, TCO2/TCS
- 3.39
- -1.03
- -30%
- 2.50
- 2.36

**B: Near Term Plan**

- -0.42
- -18%
- 1.95

Some undertaken initiatives:

1. Solid fuel reduction in BF
2. TRT, Stove waste heat recovery in BF
3. Waste heat recovery in sinter plant
4. Gas flaring reduction
5. Commissioning of Gas-based DRI, BF1 upgradation, EAF Commissioning etc.,
6. Commissioning of gas-based steam boiler

Key Levers of Decarbonization:

1. RE Power
2. Solid Fuel Reduction
3. Gas Injection in BF
4. Pellet Burden in BF
5. Scrap Addition in SMS
6. Waste Heat Recovery

FY05 FY10 FY15 FY19 FY20 FY22 FY23

FY24 FY25 FY26 FY27 FY28 FY29 FY30
Decarbonization Strategy

**FY05 BASEYEAR**
- Fuel Switch/reduction
- Energy recovery
- Energy & Tech transition
- Circularity

**FY23 30% REDUCTION**
- Solid fuel reduction in BF
- Heat recovery systems in Sinter Plant
- Gas based DRI commissioning; BF upgradation; EAF commissioning

**FY30 48% REDUCTION**
- Fuel rate optimization through Burden-mix optimization; Fe improvement through beneficiation
- Gas flaring reduction
- Gas based DRI commissioning; BF upgradation; EAF commissioning
- RE Power (~10 GW)
- Top gas recovery in BF
- Solid slag heat recovery
- Continued BF upgradation

**Path towards Net Zero**
- Fuel rate optimization through Green H2 in BF-BOF; Syngas in BF; Green H2 in DRI
- Heat recovery across all shops
- Solid slag heat recovery
- Top gas recovery in BF
- Solid slag heat recovery
- Technology transition of end campaign BF
- Implementation of CCUS
- Gas flaring reduction
- Scrap addition in SMS
- COG/plastic/biofuel use in BF
- Scrap based EAF
Energy

Deploying efficiency, innovation and energy transition

**Strategy**
- PAT (Perform, Achieve & Trade) compliance and transition to RE

**Key Interventions**
- Usage of Renewable energy in operations
- Extend installation of waste gas recovery and waste gas recirculation system
- Better demand and supply management
- Participation in StepUp Program (World Steel Association)
- Adopted energy-efficient systems and streamlined practices across operations

100% Phase out of thermal coal by 2030

1000 MW Renewable power installation completed within FY25

225 MW Renewable power installation completed
25 MW Electrolyzer, Operates from Green Energy

Green Hydrogen

Phase 1
5,000 Nm3/Hr

Phase 2
20,000 Nm3/Hr

Phase 3
125,000 Nm3/Hr

Green Hydrogen

~3500 TPA Green hydrogen Generation for DRI unit
Exploring and adopting latest technologies for decarbonisation

Collaborating with leaders
- Agreement with Royal Dutch Shell¹ to evaluate and develop options to improve energy efficiencies, optimise carbon products demand, and explore decarbonisation technologies
- Collaborated with Larsen and Toubro to evaluate various CCUS technologies

Front ending the call for India’s hydrogen economy
- JSW Steel is a member of the India H2 Alliance
- Scoping to pilot hydrogen-based pilot project at Vijayanagar

Carbon capture
Implemented carbon capture and utilisation (CCU) technology at JSW Salav Works.

Key benefits
- CO2 purity level of up to 99.5%.
- Scalable across the energy system and enables emission reduction

The CCU process
JSW Steel Salav DRI

Waste gas recovery
Carbon-rich waste gas is recovered and sent to absorber which treats it counter current with g.v. solution forming rich solution.

HP & LP regenerators
Rich Solution is treated in the Regenerators separating G.V. Solution and Carbon Dioxide which is then passed on for further processing

99.5%
Purity of CO₂

100 TPD
Production capacity
Driving decarbonization agenda at Vijayanagar and Dolvi Plants with SEED

400+ participants involved in driving execution

200+ initiatives identified with granular shop level climate action plans

15 climate action centers set up for agile implementation

40 initiatives implemented in the program so far

SEED EM

Launched customized digital tool to monitor CO2 emissions

35+ champions being trained on through EdTech programs

>18Mn T CO2 reduction potential

Note: CO2 reduction potential calculated on current production levels

Achieving global best-in-class emissions within BF-BOF steel making
200+ initiatives being actively driven across multiple themes

Select initiatives showcased

Fuel consumption reduction
- Oxyfuel burner, burner fuel-flow throttling
- Furnace coating in RHFs at HSM, LP Mills
- Increased % hot charging in HSM and LP Mills

Power consumption reduction
- Installation of VFDs
- Optimizing compressor operations and arresting leakages

Waste Heat recovery
- Multiple Waste Heat Recovery System projects being explored across the plant

Circularity
- Establish waste plastic injection in BF
- Use alternate fluxes, KR slag, LD slag in ag glo. and iron making

Alternate fuels
- Establish green H2 injection in DRI through pilots
- Establish COG injection in BF s
- Establish Super Sinter trials in SP with COG/NG/H2
- Charcoal Trial in Sinter Plant

Digital & Analytics
- Optimized hot stove operations in BF
- Improve HMSi prediction accuracy for reducing fuel rate

Renewable energy
- Deploy renewable energy

Scrap charging
- Exploring avenues to increase scrap charging in SMS

For discussion today
Background of Waste Plastic in India

9.4 Million Ton (MT) of waste plastic generated every year in India\(^1\)

- ~60% of this waste is recycled
- ~40% (3.8 MT) causes water/land pollution wherever it is dumped

Indian steel production is ~ 120 MTPA; expected to increase by 4X by 2050

Potential to inject waste plastic in BF to tackle the challenge of plastic disposal while promoting the principles of a circular economy

1. Source: UNIDO Report- Recycling of Plastics in Indian perspective by Dr. Smita Mohanty, Central Pollution Control Board (CPCB)
Waste plastic injection in BF can lead to reduction in CO₂ emissions

Waste plastic has higher H₂ content and can replace coke in the blast furnace leading to CO₂ reduction

Methodology

- Waste plastic injected in BF via tuyeres
- Higher H₂% and CV in plastic reduces CO₂ emissions by replacing coke in BF
- Consistent size, quality and availability are a challenge

Working principle

- Objectives of the trials was to demonstrate successful plastic injection by conducting multiple trials by injecting plastic:
  - In various form factors (plastic chips, granules)
  - Via multiple injection setups (conventional lance, coaxial lance, with or without PCI, etc.)

Challenges

- 14.5 Kg/thm savings in CO₂ emissions @ 50 kg/thm plastic injection in BF

Waste plastic injection in BF is a one of the initiatives being pursued as part of SEED, JSW Steel’s flagship decarbonization program

Objective of the trials was to demonstrate successful plastic injection by conducting multiple trials by injecting plastic:

- In various form factors (plastic chips, granules)
- Via multiple injection setups (conventional lance, coaxial lance, with or without PCI, etc.)

1. Assumptions: Waste plastic composition taken as 78% C, 12% H₂, subject to change based on plastic availability, Replacement ratio of 0.95 for waste plastic and coke
Multiple trials conducted over the past year leveraging key learnings to make adjustments to plastic form factor and injection mechanism

**Fibrous plastic chips**

1st Set of trials
Sep 2022

- 20kg fibrous plastic chips made from PP1 (<5mm) collected from Municipal Solid waste plant
- Hopper choking observed when using fibrous chips which hampered plastic injection

**Plastic granules**

2nd set of trials
Nov 2022 - Apr 2023

- Type of plastic changed from PP fibrous chips to PE granules (3mm) to facilitate smooth discharge
- 1 kg trial injection done successfully with existing injection system in BF2
- However, injection of 30kg via conventional lance led to melting of plastic in lance leading to choking

**Coaxial injection**

3rd set of trials
May 2023 - Jul 2023

- Type of injection mechanism changed to a coaxial lance to regulate temperature inside the lance
- 300 kg plastic granules (3-5 mm) successfully injected via a coaxial lance in BF3
- In later trials, plastic was injected with PCI using a similar injection mechanism

1. PP Composition by weight: 85.75% Carbon, 14.15% Hydrogen, 0.1% Ash
2. PE Composition by weight: 85.60% Carbon, 14.21% Hydrogen and 0.19% Ash
1st set of trials | ~20kgs Fibrous type plastic chips <5mm collected from Municipal Solid Waste Plant

Hopper pressurized & trial taken in open atmosphere; Hopper choking observed
2nd set of trials | 1kg trial injection done successfully in BF2 with plastic granules
2nd set of trials | 30kg trial injection attempted but melting of plastic in lance led to fusing & hosepipe choking observed
3rd set of trials | Successfully demonstrated injection of waste plastic in large quantities

Trial successfully conducted in BF3 at JSW Vijayanagar plant

- 300 kg plastic injected
- 3-5mm plastic granules injected with in-house modified lance

Way forward: We are in discussion with the Municipal Corporation of Bellary to source waste plastic which will then be segregated and granulated such that it satisfies our required quality, form factor and replacement ratio requirements for injection.
COG Injection in Blast Furnace

Objective

Through COG injection, we aim to reduce consumption of coke, which will effectively decrease both emissions and costs at Blast Furnace.

1. Source: UNIDO Report- Recycling of Plastics in Indian perspective by Dr. Smita Mohanty, Central Pollution Control Board (CPCB)
# COG Injection | COG chemistry analysis for injection

**COG Chemistry for injection**

**Coke oven gas composition**

<table>
<thead>
<tr>
<th></th>
<th>Carbon Dioxide (Vol %)</th>
<th>Oxygen (Vol %)</th>
<th>Hydrocarbons (ethane etc.) (Vol %)</th>
<th>Carbon Monoxide (Vol %)</th>
<th>Hydrogen (Vol %)</th>
<th>Methane (Vol %)</th>
<th>Nitrogen (Vol %)</th>
<th>Calorific value (Kcal/Nm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CO3</strong></td>
<td>2.37</td>
<td>0.98</td>
<td>3.74</td>
<td>7.27</td>
<td>55.56</td>
<td>25.22</td>
<td>4.87</td>
<td>4,454.42</td>
</tr>
<tr>
<td><strong>CO4</strong></td>
<td>2.31</td>
<td>1.29</td>
<td>3.38</td>
<td>7.04</td>
<td>56.15</td>
<td>25.24</td>
<td>4.59</td>
<td>4,404.33</td>
</tr>
</tbody>
</table>

**Summary of other chemical constituents in COG**

<table>
<thead>
<tr>
<th></th>
<th>Ammonia (g/Nm³)</th>
<th>Hydrogen sulfide (g/Nm³)</th>
<th>Naphthalene g/NM³</th>
<th>Tar &amp; dust, g/NM³</th>
<th>Tar fog, g/NM³</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CO3</strong></td>
<td>0.11</td>
<td>0.25</td>
<td>0.30</td>
<td>Traces</td>
<td>Traces</td>
</tr>
<tr>
<td><strong>CO4</strong></td>
<td>0.12</td>
<td>0.17</td>
<td>0.27</td>
<td>Traces</td>
<td>Traces</td>
</tr>
</tbody>
</table>

### Highlights

- For COG injection in BF, target COG chemistry required is:
  - H₂S < 0.3 g/Nm³
  - Naphthalene < 0.5 g/Nm³
  - BTX < 10 g/Nm³
COG & Syngas | CO2 impact varies from -17 to -99 Kg/thm depending on furnace and type of gas being injected

<table>
<thead>
<tr>
<th>CO2 emissions impact (Kg/thm)</th>
<th>Split of CO2 emissions (Kg/thm)</th>
<th>Cost impact (Rs/thm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 50 Nm3/thm COG: BF5</td>
<td>-17 -17 -57 43</td>
<td>-194</td>
</tr>
<tr>
<td>2 250 Nm3/thm Syngas: BF5</td>
<td>-66 -66 -108 47</td>
<td>-786</td>
</tr>
<tr>
<td>3 50 Nm3/thm COG: BF2</td>
<td>-6 -6 -38 34</td>
<td>+7</td>
</tr>
<tr>
<td>4 400 Nm3/thm Syngas: BF2</td>
<td>-99 -99 -156 64</td>
<td>-1133</td>
</tr>
</tbody>
</table>

Key drivers of CO2 emissions

Scope 1:
- Lower coke rate

Scope 2:
- Increased energy input in the form of COG/Syngas
- Reduced steam consumption
- Lower net electricity consumption
- Export of high CV BF gas

COG volume requirement of ~28,000 Nm3/hr in line with excess COG capacity available
Syngas injection not yet implemented on large scale in any steel plant globally
Replacement ratio for Syngas better than COG in BF2; At par in BF5

- Case 1: 50 Nm3/thm COG in BF5
- Case 2: 250 Nm3/thm Syngas in BF5
- Case 3: 50 Nm3/thm COG in BF2
- Case 4: 400 Nm3/thm Syngas in BF2

Replacement ratio

- Case 1: 0.8
- Case 2: 0.8
- Case 3: 0.5
- Case 4: 0.7

Coke rate benefit (Kg/thm)

- Case 1: 18
- Case 2: 34
- Case 3: 12
- Case 4: 49
Scope 2 | Exporting COG as source of energy vs consuming as feedstock more beneficial due to higher grid emissions intensity in India

Illustrative example of emissions tradeoff between Coke reduction and COG injection (case 1)

- Scope 1 emissions not dependent on grid emission intensity
- Scope 2 emissions reduce as grid becomes cleaner
- Grid emission intensity of EU: ~0.5 tCO2/MWH vs 0.79 tCO2/MWH for India
- As grid becomes cleaner, CO2 reduction potential of COG injection increases
Charcoal & COG usage in Sinter Plant

Objective

To improve the Sinter Properties and development of alternate Fuel for Sinter plant

1. Source: UNIDO Report- Recycling of Plastics in Indian perspective by Dr. Smita Mohanty, Central Pollution Control Board (CPCB)
Charcoal | Use of charcoal in solid fuel mixture helps improve productivity and tumbler index

### Improvement in Productivity

<table>
<thead>
<tr>
<th>Charcoal content in solid fuel (%)</th>
<th>0%</th>
<th>22%</th>
<th>45%</th>
<th>64%</th>
<th>84%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sintering time (BTT achieved) (mins)</td>
<td>23.1</td>
<td>21.6</td>
<td>23.7</td>
<td>25.2</td>
<td>27.4</td>
</tr>
</tbody>
</table>

### Improvement in Tumbler Index

<table>
<thead>
<tr>
<th>Charcoal content in solid fuel (%)</th>
<th>0%</th>
<th>22%</th>
<th>45%</th>
<th>64%</th>
<th>84%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sintering time (BTT achieved) (mins)</td>
<td>64.0</td>
<td>64.9</td>
<td>63.9</td>
<td>62.1</td>
<td>61.1</td>
</tr>
</tbody>
</table>

Charcoal can make up to 20-25% of total solid fuel mixture

**Benefits**

- ~8% improvement in productivity
- ~1.4% improvement in tumbler index
- ~15 kg CO2/ts reduction in CO2 emissions
- Reduced CO, SO2, NOx emissions

**Note:**
1. Charcoal with low VM must be used
2. Increased use of charcoal results in higher requirement of water in green mix
COG Injection | Use of hydrogen bearing gas fuel to reduce the coke consumption by ~2.5kg/t of sinter and improve sinter quality

Super-sinter involves blowing of hydrogen bearing fuel in sintering process as partial replacement for coke breeze

Diff. in combustion temperature of fuel gas and coke breeze enables sustaining favorable temp (1200-1400 deg. C) for longer duration

The technology has potential to:
- Decrease coke consumption by ~2.5kg/ts
- Improve TI by 1%<sup>1</sup>
- Improve RI by 4%<sup>1</sup>

Impact on carbon emissions

- Reduction in coke cons. 2.5 kg/ts
- Reduction in CO2 per ton of sinter; accounts to 6-7 kg CO2 per tcs

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1. Impact estimated basis implementation in JFE Steel (Japan)
## Summary of JSW De-carbonisation Initiative

### 2030

**Emissions reduction**
- Demand reduction through material efficiency
- Technology performance improvement with conventional routes
- Internal monitoring & planning by CAG¹
- Risk assessment and mitigation via TCFD² alignment

**Other enablers**
- Adoption of BAT
- Iron ore beneficiation for efficiency
- Reduction in coke rate
- Reducing coke utilisation and increasing PCI³ and NG⁴ in BFs⁵
- Increased usage of RE
- Exploring technology such as CCUS⁶
- Increased usage of scrap
- Creation of carbon sinks
- Efficient logistics through pipe conveyor

### 2030-2050

**Deep decarbonisation**
- Scaled deployment of CCUS
- Carbon Avoidance - Use of hydrogen for reduction of iron

*(to continue post 2050)*

### 2050-2070

**Offsetting and other interventions**
- Direct electrolysis of iron ore
- Development of green cover to act as carbon sink
THANK YOU