Hydrogen Injection at Tata Steel

Dr. Samik Nag
Asia’s first integrated private steel company, established in 1907

**India**
- Mining operations
  - Iron ore
  - Coal
  - Chromite
  - Manganese
  - Dolomite
- Manufacturing works
  - Tata Steel Jamshedpur
  - Tata Steel Kalinganagar
  - Tata Steel BSL, Dhenkanal

**The UK**
- Manufacturing works
  - Port Talbot Steel Works

**Canada**
- Mining operations
  - Iron ore

**Thailand**
- Manufacturing works
  - Tata Steel Thailand
Tata Steel: Business Overview

11th largest steel producer in the world (crude steel capacity) *worldsteel 2019 ranking

34 MnTPA annual crude steel capacity

>77,000 employees

$30.3 billion Turnover

**PRODUCT RANGE**
- Hot Rolled Coil
- Cold Rolled Coil
- Galvanised coil
- Wire Rod
- Coated Coil
- Rebar
- Wires
- Tubes

**KEY MARKET SEGMENTS**
- Construction
- Automotive
- General Engineering
- Industrial Products
- Agriculture

**KEY BRANDS**
India
Target Net-Zero Emission by 2070

Tata Steel
Target Net-Zero Emission by 2045
Target for Tata Steel

Performance Over the Years

Emission Intensity (tCO₂/tcs)

- FY05: 3.12
- FY10: 2.50
- FY16: 2.30
- FY21: 2.52
- FY22: 2.5
- FY23: 2.45

Target

- 2023: CO₂ to be abated @ 40MTPA
- 2045: Much more...

Calculation Standard: World Steel Association

Tata Steel India (TSL Standalone & TSLPL including NINL); GHG Emissions as per WorldSteel Association Methodology
Multitrack decarbonization strategy

**Lever #1**
- **Process Improvement (PI)**
  - Using best available technologies

**Lever #2**
- **Carbon Direct Avoidance (CDA)**
  - Usage of alternative fuels to replace fossil fuels

**Lever #3**
- **Carbon Capture and Utilization (CCU)**
  - Captured CO₂ to be sequestrated and make valuable products

**CCU**
- **MTPA to be abated**
  - 71 MTPA Methanol

**PI/CDA**
- **Captured CO₂**
  - 98 MTPA

**Ref:** Innovation Outlook, Renewable Methanol, IRENA

**Usage of alternative fuels to replace fossil fuels**
- **Green H₂**
  - 13.4 MTPA
  - Global Projection: 385 MTPA by 2050
  - India Projection: 55 MTPA by 2050

**Land**
- **5000 Acre**
  - TSJ: 1750 Acre

**Energyworld.com**

**Ref:** Innovation Outlook, Renewable Methanol, IRENA
Process Improvement || Some shining cases

**A** Reduction of solid fuel consumption in Pellet

Use of waste carbonaceous material for pellet making

![Graph showing reduction in solid fuel consumption](image)

- **CO₂ savings | 20 kg/tcs**

**B** Burden Distribution Simulators for Blast Furnace

- **Continuum Model**
- **Center Coke Optimization: DEM**

![Image of burden distribution with labels](image)

- **CO₂ savings | 26 kg/tcs**

**C** Managing low grade ore

- **CO₂ savings | 17 kg/tcs**

**D**

- Visualisation inside furnace
- Best ever coke rate in F BF

![Image showing visualisation inside furnace](image)

- **CO₂ savings | 50 kg/tcs**
Tata Steel’s efforts

Decarbonization Strategy

Identified Technology routes

Carbon Direct Avoidance

Alternate Iron making route

Coal Gasification

CO\textsubscript{2} \rightarrow \text{Syngas}

H\textsubscript{2} or Syngas

Gas-based DRI

H\textsubscript{2} bearing gases Injection

- Mill off gases COG, LD Gas
- Coal Bed Methane (CBM)

H\textsubscript{2} Generation

Electrolysis

Biomass gasification

Other Technologies
  - Chemical Loopin

Carbon Capture & Utilization

PSA-based separation

CO & N\textsubscript{2} removal

CO\textsubscript{2} Capture, Utilisation and Storage

- Ethanol/Methanol
- Mineral Carbonation
- Polycarbonate
- Carbon Nanotubes
- Sustainable Aviation Fuel
- Storage and sequestration
- Reforming

Scrap Utilization

BOF

EAF ConArc

Partial Replacement of Hot Metal

Steel Mill off gas

Gas Separation

Blast Furnace

Hisarna

CO\textsubscript{2} \rightarrow \text{Syngas}

Electrification: Superheated

Electrification:
- Reforming
- Superheated

H\textsubscript{2} or Syngas

Injection

ConArc

Electrolysis

Biomass gasification

Other Technologies

Chemical Loopin

COG: Coke Oven Gas, DRI: Direct Reduced Iron, BOF: Basic Oxygen Furnace, EAF: Electric Arc Furnace, PSA: Pressure Swing Adsorption
Vision

BEGINNER

115 Years of Blast Furnace operation
No Gas Injection

COMPETENT
Learn with Hydrogen bearing gas

PROFICIENT
Design system for pure $H_2$ injection

EXPERT
Plan for continuous use
Carbon Direct Avoidance journey at a glance

- **Jan’ 22**: CBM injection - One-month long trial
- **Dec’ 22**: Bio-char injection - Replacing 10% PC
- **Apr’ 23**: H₂ injection - Record injection volume
- **July’ 25**: COG injection - Continuous injection with PC

**Abbreviations**
- CBM: Coal Bed Methane
- PC: Pulverized Coal
CBM Injection

Tata Steel initiates a ‘first-of-its-kind in the world’ trial for continuous injection of Coal Bed Methane (CBM) in Blast Furnace to reduce emissions.

- Onsite pressure reducing station & heating arrangement
- Successfully co-injected with tar
- Replacement ratio: ~ 1.2-1.4 kg coke / kg of injectant
- Potential carbon footprint reduction: ~ 10 %
H₂ injection challenges

Process Stability
- Selection of Tuyeres & flow rate
- Control Strategy
- Risk mitigation plan

Injection System

Material Selection
- Due diligence: PFD, P&ID
- Detailed HAZOP
- CFD analysis of Raceway

Interlock designs

Sourcing & Logistics
Lab scale analysis

A. Gas-Temperature profile from 2-D model

B. Degradation studies

Tweaking process to keep degradation under control

C. Simulation of Cohesive zone

D. Designing lance

- Optimize flow to maintain lance temperature under control
Site activities

A Cold simulation of Injection system

- Design Interlocks
- Process Interlocks

B Access control

- SOP training to all shift employees, Detailed trial plan
- Barricading, Do’s & Don’ts
- Remote monitoring of BF sites
- Installation of detectors, thermography at each shift

C Domestic Sourcing from ~1400km dist.

- Tankers’ parking area barricaded; security force deployed with fire hydrant is in position for round the clock
- Special Permission was sought from local administration
- Dedicated work force involved to track movement and ensuring vehicles reach safely at site
Realization

1. Valve station-1
   - Reduction of pressure: 200-5 bar(g)
2. Valve station-2
   - To isolate BF from H₂ source
3. Valve station-3
   - To distribute H₂ across tuyeres

In-house Engineering

> 100 interlocks

Special Material
Trial Findings

Highlights

✓ 4 days of continuous trial
✓ Trial performed in 2 phases – 1100 Nm³/h and 1800 Nm³/h
✓ Injection with 40% tuyeres
✓ Highest volume injected | 6kg/thm
✓ Drop in resistance | 5%
✓ Drop in RAFT | 5%
Beyond Injection: Disruptive Technologies

**A** Top gas Recycling: CO₂ regeneration

- Co2 | ~ 50%
- BF Gas Recirculation
- SynGas

**B** Hlsarna

- Co2 | ~ 80% (CCU/S)

- Benefits:
  - Usage of 100% non coking coal
  - Usage of low-grade iron ore
  - No coke, sinter and pellet plant needed
  - Use of LD slag to replace imported limestone
H₂ production

A Global Research

Unique Proposition of Hydrogen Production

Electrolyzer & Biomass gasification

BF Gas

Chemical Looping Technology
- Economical

Integration of Chemical Looping with Steel Plant

Potential to meet 10% H₂ demand

Lab Scale (0.1 H₂ kg/h) → Pilot Plant 5 kg/h → Demo Plant 1 TPD → Industrial Plant >5 TPD

Completed
Carbon Capture and Utilization

A 5 TPD CO₂ capture plant

- Novelty
  - 1st time by any steel plant in India
  - Recovery of CO₂ from blast furnace gas
  - Scalable up to 2500 – 3000 TPD
  - Low emission loss and non-flammable solvent

B 10 TPD Methanol generation

Tata Steel to set up a pilot plant for methanol

Tata Steel is putting up a 10 tonnes-per-day pilot plant at its Kalinganagar plant in Odisha to produce methanol from blast furnace flue gases. If successful, this has the potential to open an avenue for substantial production of methanol in India.
Summarized Plan to Achieve Net Zero

**PI**
- Use of energy savings technologies, increased efficiency (Waste heat utilization, dehumidifier etc.)
- Tackling low grade raw materials & utilize efficiently
- Adaptation of the best technologies at design stage (Shaft Injection, enhanced process control through digitalization)

**CDA**
- Increased scrap use in BF-BOF
- Use of Coke oven Gas, Bio-Char
- HIsarna
- EASyMelt
- Green hydrogen Iron making

**CCU**
- CO₂ to value added products (Methanol, SAF)
- CO₂ mineralization (Carbicrete, carbonates)
- CO₂ electrolysis
- CO₂ sequestration

**CO₂ emission intensity**
- 2020
- 2025
- 2030
- 2035
- 2040
- 2045

- Process efficiency, use of scrap, in-house gas
- Intervention of breakthrough technologies
- Large scale solution for H₂ CCU
And miles to go

Making Greener Tomorrow |