Steel Authority of India Limited - BSL, BOKARO

Project Training Report on

"LATEST TECHNOLOGIES IN COKE MAKING"

(30.06.2025 – 26.07.2025)

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I would like to express my heartfelt gratitude and special thanks to my mentor, **Mr. K. N. Jha**, **General Manager (CO & CC)** at **SAIL – BSL, Bokaro**, who, despite his demanding schedule, took the time to guide, support, and keep me on track. His valuable insights, constant encouragement, and generous support were instrumental in the successful completion of my industrial project.

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This training has been an invaluable part of my academic and professional development, and I deeply appreciate the opportunity provided to me.

DATE: ____________

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1. INTRODUCTION

Role of Coke in Steelmaking

Coke is an essential raw material in the steel manufacturing process, especially in the operation of blast furnaces. It serves three primary functions: it acts as a fuel, a reducing agent, and a structural support in the blast furnace. Metallurgical coke, derived from coking coal, provides the necessary thermal energy to melt the iron ore and other charge materials, enabling the reduction of iron oxide to metallic iron. Additionally, the porous structure of coke allows for the efficient passage of gases in the furnace, ensuring proper heat distribution and reaction kinetics.

In the context of integrated steel plants like SAIL – Bokaro Steel Plant (BSL), coke is not merely a fuel but a critical determinant of overall plant performance, influencing hot metal quality, blast furnace productivity, and even the environmental footprint of the entire steelmaking process. As the demand for high-quality steel increases, the need for high-quality, low-ash coke becomes even more significant.

Importance of Technological Upgrades in Coke Production

Traditional coke making methods, though proven over decades, have several limitations. These include high energy consumption, substantial emissions of pollutants (such as particulate matter, SOx, and NOx), water wastage due to wet quenching, and safety risks due to outdated infrastructure. As global environmental regulations tighten and sustainability becomes a core focus of industrial operations, steel plants must modernize their coke production facilities.

Technological advancements in coke making, such as the adoption of **Coke Dry Quenching (CDQ)**, **automation and process control**, **waste heat recovery systems**, and **advanced emission control units**, not only address environmental concerns but also lead to improved efficiency, lower operational costs, and better quality of coke. These technologies support the transition toward a more sustainable and cost-effective steel production ecosystem.

Objective and Scope of the Report at SAIL – BSL

This report aims to present a comprehensive overview of the latest technologies adopted and proposed at **SAIL – Bokaro Steel Plant** in the domain of coke making. It highlights how the plant is shifting from conventional practices toward modern, energy-efficient, and environmentally responsible methods. The report includes:

- An overview of the conventional coke making process used at BSL
- Key technological upgrades implemented in recent years
- Performance improvements in terms of efficiency, emissions, and cost
- Future scope for innovation and expansion in coke oven operations

By focusing exclusively on the operational practices and technological trajectory of SAIL – BSL, this report provides an in-depth look into how the plant is aligning itself with modern industry standards, national environmental policies, and global best practices.

Traditional Slot Oven Battery Overview

At **SAIL – Bokaro Steel Plant (BSL)**, metallurgical coke is produced using the **conventional slot oven method**. The plant currently operates with **8 coke oven batteries**, each comprising **69 ovens**, totaling **552 ovens** across the plant. These ovens operate at temperatures ranging from **1200°C to 1250°C**, ensuring efficient carbonization of coking coal into high-strength metallurgical coke.

In this process, finely crushed coking coal is charged into the ovens and subjected to carbonization in the absence of air for about 18 to 19 hours. During this time, volatile matter is driven off, and the solid residue, coke, is formed. Once the coking cycle is completed, the incandescent coke is pushed out of the oven and sent for quenching before being transferred to blast furnaces or dispatched.

These slot-type batteries have been the backbone of BSL's coke production, providing a steady and reliable supply of coke essential for ironmaking in the blast furnaces. However, with time, the conventional system has shown limitations in terms of efficiency, environmental compliance, and operational challenges.

3. LATEST TECHNOLOGICAL DEVELOPMENTS AT SAIL – BSL

Transition to Dry Quenching Systems (CDQ)

In an effort to modernize operations and reduce environmental impact, **SAIL – Bokaro Steel Plant (BSL)** is making significant progress toward adopting **Coke Dry Quenching (CDQ)** technology. Unlike conventional wet quenching, CDQ involves cooling hot coke in an inert atmosphere using **circulating nitrogen or inert gas**, which absorbs the heat without allowing combustion. The recovered heat is then used to generate steam or electricity, thereby conserving energy and reducing emissions.

The adoption of CDQ at BSL addresses several key issues:

- **Drastic reduction in air pollution** caused by water vapor and dust emissions during wet quenching.
- **Recovery of waste heat**, leading to improved energy efficiency and lower operating costs.
- **Preservation of coke quality**, as the absence of thermal shock maintains its strength and size consistency.

Although full-scale CDQ implementation may still be in progress or planned in phases, SAIL's direction toward this environmentally sound technology reflects its commitment to sustainable coke production practices.

Installation of Modern Coke Oven Batteries with Improved Lining and Design

Recognizing the aging condition of its older batteries, SAIL – BSL has undertaken **modernization programs** to install **advanced coke oven batteries** with improved brick linings, enhanced insulation, and more robust structural design. These modern batteries are built with:

- **High-alumina or silica refractories** for improved heat resistance.
- **Optimized oven geometry** for uniform heat distribution and reduced heat loss.
- **Better door sealing systems** to minimize gas leakage and ensure safer operation.

These new batteries not only increase the lifespan of coke ovens but also **enhance the overall efficiency and capacity** of coke production. Improved heat retention reduces fuel consumption, while better sealing and charging systems contribute to lower fugitive emissions.

Such structural improvements also ensure smoother operations, lower maintenance frequency, and greater compliance with **pollution control norms** set by regulatory authorities.

Integration of Automation and Process Control Systems (PLC, SCADA)

One of the most transformative developments at SAIL – BSL has been the **integration of automation and digital control technologies** into coke oven operations. Traditional manual systems are increasingly being replaced with advanced tools such as:

- **Programmable Logic Controllers (PLCs)** for precise control of charging, coking time, and pushing schedules.
- **SCADA (Supervisory Control and Data Acquisition)** systems for real-time monitoring and data logging.
- **Temperature and pressure sensors** embedded throughout the battery for optimized heat control.
- **Automated coke pushing and quenching machines** to reduce human intervention and improve safety.

These technologies enable operators to maintain consistent process parameters, reduce human error, and optimize fuel usage. They also facilitate **predictive maintenance**, reducing unplanned breakdowns and extending equipment life.

The shift to automation represents SAIL – BSL's embrace of **Industry 4.0 practices** within the coke making sector, aligning with global trends in intelligent manufacturing and sustainable operations.

4. PRODUCTION EFFICIENCY ENHANCEMENTS

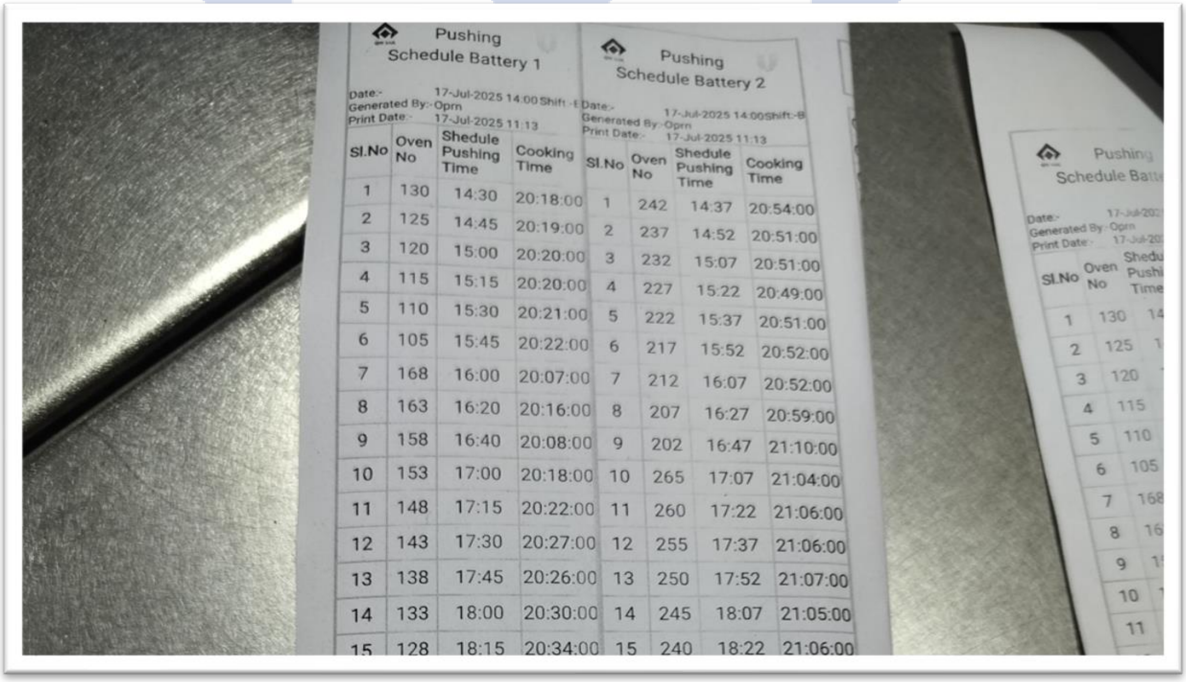
Enhancing production efficiency is one of the key goals of modernization efforts at **SAIL – Bokaro Steel Plant (BSL)**. With the adoption of improved technologies in coke making, the plant has achieved notable gains in output quality, operational stability, and energy optimization. These developments have directly contributed to **cost savings**, **higher productivity**, and **better coke quality**, which are critical to supporting the performance of the blast furnaces.

Reduction in Downtime and Delays Due to Automation

One of the significant improvements in recent years has been the **reduction in unplanned downtime** and process delays. This has been largely achieved through the **implementation of automation and process control systems** such as **PLC and SCADA**.

With automated control of operations like:

- **Coal charging**
- **Coke pushing**
- **Heating regulation**
- **Quenching cycles**



Pushing Schedule Battery 1

Date:- 17-Jul-2025 14:00 Shift -E
Generated By:-Oprn
Print Date:- 17-Jul-2025 11:13

Sl.No	Oven No	Shedule Pushing Time	Cooking Time
1	130	14:30	20:18:00
2	125	14:45	20:19:00
3	120	15:00	20:20:00
4	115	15:15	20:20:00
5	110	15:30	20:21:00
6	105	15:45	20:22:00
7	168	16:00	20:07:00
8	163	16:20	20:16:00
9	158	16:40	20:08:00
10	153	17:00	20:18:00
11	148	17:15	20:22:00
12	143	17:30	20:27:00
13	138	17:45	20:26:00
14	133	18:00	20:30:00
15	128	18:15	20:34:00

Pushing Schedule Battery 2

Date:- 17-Jul-2025 14:00 Shift:-B
Generated By:-Oprn
Print Date:- 17-Jul-2025 11:13

Sl.No	Oven No	Shedule Pushing Time	Cooking Time
1	242	14:37	20:54:00
2	237	14:52	20:51:00
3	232	15:07	20:51:00
4	227	15:22	20:49:00
5	222	15:37	20:51:00
6	217	15:52	20:52:00
7	212	16:07	20:52:00
8	207	16:27	20:59:00
9	202	16:47	21:10:00
10	265	17:07	21:04:00
11	260	17:22	21:06:00
12	255	17:37	21:06:00
13	250	17:52	21:07:00
14	245	18:07	21:05:00
15	240	18:22	21:06:00

...the plant is now capable of maintaining consistent coking schedules with **minimal manual intervention**. This reduces the risk of human error and eliminates time lost in manual coordination, mechanical jamming, and unsafe handling practices.

Additionally, **real-time monitoring** of oven temperatures, pressure, and gas compositions helps identify operational anomalies early, allowing for **predictive maintenance** and preventing major breakdowns. As a result, equipment availability and process reliability have significantly improved, which translates to **higher throughput and reduced production costs**.

Increased Coke Yield from Same Coal Quality

Another major efficiency gain has been the **improvement in coke yield**, even when using the **same grade and blend of coking coal**. The following factors have contributed to this:

- **Optimized carbonization cycles** using advanced control systems.
- **Uniform heat distribution** due to better oven lining and design.
- **Reduction in handling losses** through automation.

By fine-tuning the coking parameters and minimizing losses during charging, pushing, and quenching, BSL has been able to extract **more coke per tonne of coal charged**, thereby increasing material efficiency.

This improved yield not only enhances the plant's productivity but also has a **direct economic impact**, as imported coking coal is expensive and constitutes a significant portion of input cost in steelmaking.

Improved Consistency and Quality of Coke

With the help of **digitalization, structured coal blending**, and **controlled heating profiles**, the plant has successfully improved the **uniformity and quality of the coke produced**. Key quality parameters such as:

- **Coke Strength after Reaction (CSR)**
- **Coke Reactivity Index (CRI)**
- **Ash content**
- **Moisture level and volatile matter**

...are now maintained within tighter limits. This results in coke that meets the exacting requirements of modern blast furnaces, enabling **better furnace permeability, reduced fuel consumption**, and **more stable iron production**.

Moreover, the introduction of **dry quenching systems** (CDQ) in some units helps preserve coke structure, as the material is no longer subjected to sudden thermal shock from wet quenching, which previously caused surface cracks and friability.

5. ENVIRONMENTAL NORMS COMPLIANCE

As part of its commitment to sustainable steelmaking, **SAIL – Bokaro Steel Plant (BSL)** has taken several proactive measures to comply with stringent **environmental regulations** laid out by the **Ministry of Environment, Forest and Climate Change (MoEFCC)** and the **Central Pollution Control Board (CPCB)**. The focus is on minimizing the environmental impact of coke production while ensuring safe and efficient plant operations.

To reduce **gaseous emissions**, SAIL – BSL has installed **advanced gas cleaning systems** that treat coke oven gas before release. These include **desulfurization units, tar separators, ammonia scrubbers**, and **electrostatic precipitators (ESPs)**, which collectively reduce pollutants such as **SO_2, NOx, VOCs, and particulate matter**. These systems help maintain emission levels well within the prescribed norms.

In addressing **water pollution**, **Effluent Treatment Plants (ETPs)** have been deployed to treat wastewater generated during quenching and coke oven gas cleaning processes. The treated water is often reused within the plant for cooling and gardening purposes, significantly reducing fresh water demand and preventing contamination of local water bodies.

By upgrading its infrastructure, monitoring systems, and waste management practices, SAIL – BSL ensures full **compliance with environmental standards**, reflecting its dedication to cleaner production and responsible industrial development.

6. ENERGY EFFICIENCY MEASURES

Energy efficiency is a core performance parameter in modern steel plants, and **SAIL – BSL** has implemented several measures to reduce its **Specific Energy Consumption (SEC)** in coke making operations. By optimizing heating cycles and upgrading process equipment, the plant has achieved notable reductions in energy usage per ton of coke produced.

A major advancement is the implementation of **waste heat recovery systems**, especially in conjunction with **Coke Dry Quenching (CDQ)** units. These systems capture thermal energy from red-hot coke and flue gases and use it to generate steam or electricity, effectively converting waste heat into usable power. This not only reduces dependency on external energy sources but also lowers the plant's carbon footprint.

Another significant improvement is the **adoption of regenerative burners** in heating systems. These burners utilize the heat from exhaust gases to preheat combustion air, thereby improving thermal efficiency and reducing fuel consumption. When installed across coke oven batteries, these systems contribute to substantial energy savings and improved temperature control within ovens.

Together, these initiatives have helped SAIL – BSL move toward **greener, more economical operations** while meeting the energy demands of large-scale coke production.

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7. FLUE GAS EMISSION CONTROL

Flue gas emissions from coke ovens contain pollutants such as **particulate matter (PM), SO_2, NOx**, and volatile organic compounds. To minimize these emissions, **SAIL – BSL** has installed **advanced Electrostatic Precipitators (ESPs)** and other filtration units at various stages of the coke making process. These ESPs are designed to capture fine particulates before they are released into the atmosphere, significantly improving air quality in and around the plant.

In addition, the plant uses **real-time stack monitoring systems** to continuously track emission levels. These systems provide critical data on pollutants and ensure that discharge values remain within regulatory limits as set by **CPCB and MoEF**. Any deviation triggers immediate alerts for corrective action, ensuring compliance and operational transparency.

While current systems are effective, there remains **scope for further improvement**. Future upgrades may include the integration of **desulfurization units** for SO_2 removal and **low-NOx burners** or selective catalytic reduction (SCR) technologies for nitrogen oxide control. Implementing these will bring SAIL – BSL closer to achieving **global best practices** in environmental performance.

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8. COST OPTIMIZATION INITIATIVES

Cost efficiency is vital for the long-term sustainability of any large industrial operation. At **SAIL – BSL**, coke making cost optimization has been achieved through both **technological upgrades and process streamlining**.

One key contributor is the **reduction in fuel consumption** per ton of coke produced. By improving heat retention within ovens, optimizing coking cycles, and using regenerative burners, the plant has reduced its dependence on supplementary fuels. Automation has further enhanced this by ensuring precise control over fuel and air flow rates.

The shift toward **automated systems** has also resulted in **lower maintenance costs**. Predictive maintenance enabled by SCADA and PLCs helps detect wear and tear before breakdowns occur, minimizing downtime and repair expenses.

In the long run, the introduction of **Coke Dry Quenching (CDQ)**—though capital intensive—offers significant savings through heat recovery, reduced water use, and emission control. This combination of **short-term gains and long-term strategic investments** places SAIL – BSL in a strong position for sustainable growth.

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9. SUPPORT FROM LEADERSHIP AND TEAMS

The successful implementation of modern technologies at SAIL – BSL has been made possible by the **strong leadership and collaborative spirit** among departments. Under the guidance of experienced professionals and mentors, employees have been trained and empowered to adapt to new systems and practices.

Special acknowledgment goes to the leadership of the **Coke Ovens Department**, with support from **Environment** and **Energy Management divisions**, who work in coordination to implement and monitor improvements. This interdepartmental cooperation ensures that every upgrade is not only technically sound but also environmentally and economically viable.

Their commitment to innovation, training, and teamwork forms the backbone of SAIL – BSL's progress in coke making.

10. CONCLUSION AND FUTURE SCOPE

Conclusion

The process of coke making is a cornerstone of integrated steel production, and its efficiency, sustainability, and reliability have a direct impact on the overall performance of the steel plant. At **SAIL – Bokaro Steel Plant (BSL)**, substantial efforts have been made to modernize this crucial process by integrating advanced technologies and aligning operations with the latest environmental and industrial standards.

This report has reviewed various aspects of technological advancement in coke making at SAIL – BSL. The plant has moved beyond conventional practices by implementing **modern coke oven batteries**, **advanced lining materials**, and **automation systems (PLC and SCADA)** to enhance process control, reduce manual intervention, and improve safety. These measures have resulted in:

- Increased coke yield
- Improved product consistency
- Reduced unplanned downtime
- Enhanced equipment life

The transition from **wet quenching to Coke Dry Quenching (CDQ)** marks a significant leap forward. CDQ not only preserves the structural integrity of coke but also facilitates **waste heat recovery**, which contributes to the plant's energy generation capacity. Additionally, the shift significantly reduces visible emissions and water usage, addressing two of the most critical environmental concerns in conventional coke making.

SAIL – BSL has also installed a range of **gas cleaning units, ESPs, ETPs**, and **real-time emission monitoring systems**, ensuring compliance with the **CPCB and MoEF guidelines**. These upgrades confirm the plant's strong focus on environmental stewardship and sustainable manufacturing practices.

The efforts toward **energy efficiency**—including regenerative burners, automated control systems, and thermal optimization—have translated into tangible cost savings, reduced Specific Energy Consumption (SEC), and lower carbon emissions per ton of coke produced.

Future Scope

While SAIL – BSL has made commendable progress, the scope for future improvements remains vast, especially in the context of India's commitment to reducing industrial emissions and adopting sustainable technologies.

Some forward-looking areas that hold potential for BSL's coke making operations include:

- **Full-scale expansion of CDQ units** across all batteries to eliminate wet quenching altogether and maximize heat recovery.
- **Integration of AI and machine learning** for real-time predictive control of coking cycles, fault detection, and quality optimization.
- **Use of bio-coke or biomass-blended coke** to reduce reliance on fossil fuels and contribute to carbon neutrality.
- **Further reduction in SOx and NOx emissions** through desulfurization units, SCR technology, or low-NOx burners.
- **Digital twin technology** to simulate coke oven performance, optimize maintenance, and improve energy planning.

In alignment with SAIL's corporate sustainability goals, future investments should also focus on **water recycling**, **green certification**, and **energy self-sufficiency**. Cross-functional collaboration between R&D, operations, and environmental departments will be crucial in realizing these goals.

Final Remarks

The advancements in coke making at SAIL – BSL reflect not only a response to industrial challenges but also a strategic shift toward long-term sustainability and competitiveness. By embracing innovation, reducing environmental impact, and optimizing resources, BSL is setting a benchmark for other public sector steel units in India.

With continued support from leadership, skilled workforce involvement, and adoption of cutting-edge technologies, **SAIL – BSL is well-equipped to evolve into a model plant for clean, efficient, and future-ready coke production**.