SUPREME AUDIT INSTITUTION OF INDIA
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Report of the Comptroller and Auditor General of India on Performance of Blast Furnaces in Steel Authority of India Limited

Union Government
Ministry of Steel
No. 38 of 2025
(Performance Audit - Commercial)

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Laid on the table of Lok Sabha and Rajya Sabha on ……………………….

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PREFACE

The Performance Audit Report on Performance of Blast Furnaces in Steel Authority of India Limited has been prepared for submission to the Government of India by the Comptroller and Auditor General of India for laying before the Parliament under the provisions of Section 19(1) and 19-A of the Comptroller and Auditor General's (Duties, Powers and Conditions of Service) Act, 1971. The Audit has been carried out in line with the Regulations on Audit and Accounts, 2007 (amended in 2020) and Performance Audit Guidelines, 2014 of the Comptroller and Auditor General of India.

The Audit covered the period from 2017-18 to 2023-24. The Report is based on the scrutiny of documents pertaining to the Steel Authority of India Limited.

This Report examines the performance of the Blast Furnaces of SAIL considering the inputs for the Blast Furnace, the techno-economic parameters, the output achieved and the adherence to Safety and Environment norms and guidelines.

Executive Summary

EXECUTIVE SUMMARY

Steel Authority of India Limited (SAIL), a Maharatna Company under the Ministry of Steel, is one of the leading steel producing companies in India. It has five integrated Steel Plants at Bhilai, Bokaro, Rourkela, Durgapur, and Burnpur; three special steel plants at Durgapur, Salem and Bhadravati, and a Ferro Alloy Plant at Chandrapur. The Company has captive mines for iron ore, limestone, dolomite and coal. The marketing of SAIL products is administered from the Company's Central Marketing Organisation, Kolkata. SAIL produced 18.73 million tonne, 19.41 million tonne and 20.50 million tonne of hot metal in 2021-22, 2022-23 and 2023-24 respectively.

Justification for taking up this audit

The National Steel Policy, 2017 envisioned raising India's crude steel production capacity to 300 million tonnes and increasing per capita consumption of finished steel from 61 kg to 158 kg by 2030-31. In line with this vision, SAIL aimed production of 35.80 million tonne of crude steel by 2025-26 (Phase I) and 49.6 million tonne by 2030-31 (Phase II) to secure at least 20 *per cent* of the emerging demand. The Phase I expansion target was revised to around 35.6 million tonne by 2030-31 on the advice of a consultant (December 2022). Earlier, under its 2008 Modernization and Expansion Plan (MEP), SAIL had aimed to raise hot metal capacity from 13.83 million tonne per annum to 23.46 million tonne per annum by 2010. The company fell short of this target and could achieve 23.07 million tonne (2024). The audit objectives of this performance audit were to assess whether:

i. Requirement of raw materials was assessed adequately; raw materials were available in desired quantity and used as per desired proportion and whether Coke rate, Coal Dust Injection rate, other operating indices and consumption of services were within the norms/plan;

ii. Blast Furnaces were operated economically, efficiently and effectively as per the Annual Production Plan/Perspective;

iii. Capital repairs, preventive repairs & maintenance of blast furnaces were carried out as per schedule and techno-economic parameters were achieved;

iv. Projects relating to upstream and downstream facilities of blast furnace were planned judiciously and carried out economically and efficiently. Blast Furnaces were operated with adherence to the safety and environmental laws.

Significant Audit Findings & Recommendations

The Blast Furnace is the key unit of a steel plant, producing hot metal, the primary raw material for steel making. It is a vertical shaft furnace, in which solid raw materials like Iron ore, Sinter, Pellet, Linz-Donawitz (LD) slag, Quartzite and fuel like Coke are charged from top of the furnace and hot blast and Coal Dust Injection are blown from the tuyeres. The process also requires oxygen, and water for efficient operation. The hot metal is sent to the Steel Melting Shop for crude steel production, which is cast into billets, blooms, or slabs. These are either sold as semi-finished products or rolled into finished goods. Performance of the Blast Furnace is critical to the entire steelmaking process. A summary of significant audit findings and recommendations is given below:

Assessment, Availability and Consumption of Raw Materials, Fuel & Services

All the five integrated Steel Plants of SAIL had planned their annual requirement of major raw material adequately except Coal Dust Injection (CDI). The availability of iron ore lump ranged between 83 *per cent* to 115 *per cent* while that of sinter ranged between 84 *per cent* to 102 *per cent* of the planned quantity. The coke availability ranged between 90 *per cent* to 132 *per cent* whereas CDI coal ranged from 54 *per cent* to 83 *per cent*.

The consumption of iron ore lump more than the norm was mainly due to variation in the *Fe* content in iron ore. Inconsistent use of pellets also contributed to the excess consumption of iron ore lump. Usage of 10 *per cent* pellets in blast furnace input charge can reduce coke rate by 1.5 to two *per cent*, improve productivity by three to four *per cent*, and save ₹268 crore annually for SAIL. The National Steel Policy (2017) also emphasized on optimal use of low grade iron ore to produce pellets. However, during 2017-2024, SAIL plants often relied on excess sinter due to limited availability of iron ore lump or pellets and with declining ore quality.

Sinter (53-54 *per cent Fe*) enhances blast furnace efficiency by improving furnace permeability, reducibility, hot metal quality, and reducing coke rate. However, during 2017-2024, its consumption in all SAIL plants intermittently exceeded the norms, mainly due to non-availability of iron ore lump/pellets and declining *Fe* content in ore fines, leading to excess reliance on sinter and adversely impacted cost of production.

Except at Bhilai Steel Plant (during 2022-23) and Durgapur Steel Plant (during 2023-24), CDI coal consumption during 2017-2024 was below targets at all the Steel Plants of SAIL. SAIL Plants consumed 2.945 million tonnes more coke and 2.235 million tonnes lesser CDI coal than norms, resulting in potential extra expenditure of ₹6,259.25 crore.

Power is also an important element of cost in steelmaking, but the specific power consumption could not be achieved by SAIL Plants in most of the years during 2017-24 due to non-achievement of targeted production of hot metal. Excess consumption of power than the norm in the steel plants led to potential avoidable expenditure of ₹310.48 crore during 2017-24.

At Bokaro Steel Plant the actual use of refractories (2-2.34 kg/thm) during 2018-2024 exceeded norms (1.75-1.98 kg/thm). Rourkela Steel Plant met the norms in 2018-2021 but exceeded them in 2017-18 and 2021-24. No norms were set at Bhilai, Durgapur, and IISCO plants.

Recommendation 1: To achieve the norms fixed in the Annual Business Perspective for consumption of raw materials, fuel and services, the Company may expedite the setting up of Beneficiation Plants, Silica Reduction Plants and Pellet Plants and may also adopt better operational practices.

(Para 3.2 to 3.7)

Operational Performance of Blast Furnaces

SAIL's hot metal capacity was 23.07 mtpa (March 2024). Against the planned production of 140.88 million tonne as per Annual Business Perspective and 130.96 million tonne as per MoU (with Ministry of Steel), actual production was only 126.15 million tonne during 2017-2024.

Blast Furnace productivity, measured as hot metal produced per cubic meter of blast furnace working volume per day (tonnes/m^3/day), is fixed annually in the Annual Business Perspective based on operating conditions. During 2017-2024, actual production against Annual Business Perspective targets ranged from 81 *per cent* (Bhilai) to 97 *per cent* (Durgapur). Performance against MoU targets was better, ranging from 89 *per cent* (Bhilai) to 105 *per cent* (Durgapur).

SAIL lacked a structured policy for capital repairs, causing delays and unclear repair criteria. For example, capital repair of BF#4 at Bokaro, due in 2015-16, was deferred to 2019-20 due to delay in BF#1 repairs, resulting in lower productivity.

During 2017-2024, blast furnace capital repairs took 1,72,892 hours, including 76,883 excess hours. Of these, 39,904 hours were for unplanned repairs at Bokaro and Rourkela, while 36,979 hours exceeded planned schedules. Major delays occurred at Bhilai (20,926 hrs), Bokaro (13,965 hrs), and Rourkela (1,152 hrs).

Recommendation 2: The Company may prepare a structured policy for capital repair of blast furnaces and timely completion of capital repairs to ensure synchronized planned shutdowns of blast furnaces to avoid deferment of capital repairs and maximize the efficient operations of blast furnaces.

(Para 4.4.1)

High unplanned shutdown hours were mainly attributable to the shortage of raw materials, poor off take of hot metal by Steel Melting Shops, technical (electrical/mechanical/ operational/ instrumentation failures) and other miscellaneous issues and resulted in lesser hours for hot metal production.

Recommendation 3: The Company may minimise the unplanned shutdown hours by ensuring better availability of blast furnace through periodical repair & maintenance, ensuring availability of raw materials and addressing the off take issues downstream.

(Para 4.4.2)

Non-achievement of techno-economic parameters

Hot Blast Temperature (900-1250°C) is fed into blast furnaces through tuyeres, raising temperatures to about 1650°C. Higher temperatures increases productivity and decreases the consumption of coke, while a 100°C decrease in hot blast temperature increases coke consumption by 2-3 *per cent*, raising hot metal costs. Neither the new blast furnaces at Bhilai (BF#8), Burnpur (BF#5) and Rourkela (BF#5) nor the old blast furnaces of SAIL could completely achieve the desired hot blast temperature during 2017-2024.

All SAIL plants, except Bhilai, had fixed oxygen enrichment norms (2.5-6 *per cent*) based on furnace capacity and age. However, targets were not achieved due to constraints like low oxygen plant capacity (Bokaro), limited enrichment facility (Durgapur), underperformance in production (Rourkela), and design/temperature issues in new furnaces (Bhilai & IISCO). The non-achievement of the desired level of oxygen enrichment during 2017-2024, while the Steel Plants of SAIL could not achieve the envisaged production targets as per Annual Business Perspective, indicates that the hot metal production could have been improved through better oxygen enrichment.

Blast pressure and Blast volume are critical techno-economic parameters of a blast furnace. Low blast pressure between 0.81 and 2.80 Kg/cm^2 was noted against the desired level between 1.65 and 3.00 Kg/cm^2 in old blast furnaces. Audit noted that blast volume was between 71 and 231 (10^3 Nm^3/hr) against the desired level of 120 and 240 (10^3 Nm^3/hr) in old furnaces and between 176 and 356 (10^3 Nm^3/hr) against the desired level of 306 and 330 (10^3 Nm^3/hr) in the new furnaces.

Recommendation 4: The Company may fix norms for all techno-economic parameters for all blast furnaces at the steel plants. Efforts may be made to adhere to the desired parameters to achieve desired level of hot metal production and Blast Furnace productivity.

(Para 4.5)

Capacity imbalance in steel making process

Capacity imbalance in Blast Furnace operations occurs when the installed or upgraded capacity of the Blast furnace is not commensurate with the supporting upstream facilities such as Coke ovens, Sinter plants and Steel Melting Shops in the downstream. The upstream facilities of Raw Material Handling Plant, Coke oven batteries and Sinter Plant were commensurate to meet the requirements of the Blast Furnaces in all the Steel plants. However, in the downstream, capacity of the Steel melting shops could not meet the capacity of the Blast furnace at Bokaro and Rourkela Steel Plants.

The planned upgradation of Casters #1 and #2 at Rourkela (2008) to raise crude steel capacity to 4.2 MTPA was not implemented. Against the recommendation to install a new caster (2012-13) to achieve 3.7 MTPA, Stage-I approval for the 4th Slab Caster came only in 2019. The project was awarded in 2022 at a revised cost of ₹922.31 crore, for completion by July 2025 after a delay of over six years. Meanwhile, a 0.6 MTPA capacity gap persisted, causing potential annual savings loss of ₹633.78 crore.

To achieve 5.77 MTPA hot metal, Bokaro needed a new 360 m² sinter plant (3.7 MTPA), approved in 2011 awarded at a cost of ₹653.85 crore for completion by 2017. The project could not progress due to failure of contractor, weak follow-up, and litigation. The progress was minimal despite ₹361.79 crore been spent. Costs later escalated to ₹2,224.18 crore, and no order was placed (January 2025) for balance work, delaying envisaged annual savings of ₹248.16 crore.

To replace obsolete ingot casting, SAIL approved (2013) modernization of Steel Melting Shop-I, Bokaro to produce 1.305 mtpa continuous casting slabs, with expected annual gross margin of ₹291 crore. The project, due in November 2017, was delayed by 40 months in contract finalization and further by lapses in environmental clearance. In the absence of slab caster, liquid steel continued through ingot route from May 2019 to April 2021, resulting in avoidable extra expenditure of ₹418.18 crore.

Recommendation 5: The Company may assess the imbalance in upstream facilities like sinter plant and downstream facilities like Steel Melting Shop and ensure timely completion of its capital projects to achieve optimum utilisation of its steel making capacity.

(Para 5.2.1)

Production of pig iron

The average yield percentage of pig iron in the Steel Plants of SAIL ranged between 86 to 92 *per cent* during the period 2017-2024. Bhilai, Durgapur and Bokaro had fixed the yield percentages for the Pig casting machine. In the absence of assessment of the actual pig iron generated, the operational efficiency of the pig casting machines could not be assessed by Audit.

Dumping of hot metal at sand pit in Bhilai and IISCO Steel Plant

Between 2017-2024, Bhilai and IISCO Steel Plants dumped 0.039 million tonne and 0.111 million tonne of hot metal, respectively, into sand pits due to lack of storage facility and limitations of pig casting machines. The metal was recovered only as scrap, causing a loss of ₹51.29 crore (Bhilai Steel Plant ₹35.90 crore; IISCO Steel Plant ₹15.39 crore).

Generation of Blast Furnace Slag and its disposal

From 2017-18 to 2023-24, SAIL's five integrated plants generated 51.33 million tonne of slag, of which 44.15 million tonne was granulated, 1.37 million tonne was sold, and 5.81 million tonne was dumped in dry pits.

Recommendation 6: The Company may ensure that 100 per cent granulation of slag as mandated by the CPCB guidelines is achieved by installation and modernization of slag granulation facilities. The diversion of slag to dry pits may be minimized to achieve the gainful utilization of blast furnace slag to safeguard the environment and also optimize revenue potential.

(Para 5.2.2 and 5.3)

Safety and Environment Issues

Corporate Safety Policy of SAIL stipulates safety audit to assess compliance to safety standards, mitigating plans, develop improvement plan and accountabilities for completion and follow up on timeline and recommendations. Bhilai, Rourkela, and Durgapur plants had implemented all the recommendations while Bokaro complied with 30 out of 40 recommendations and IISCO complied with 83 out of 84 recommendations, leaving key issues like conducting test of Pressure Relieve Valves of pressure vessels, fluorescent signs in cable galleries, non-working of Fire detection alarm etc. non-complied.

Recommendation 7: Management may ensure periodical conduct of Safety Audits and continuous monitoring and follow up of the compliance to the recommendations of such audits. Effective implementation of Standard Operating Procedures in line with the Statutory provisions would ensure a safe working environment.

(Para 6.1)

At IISCO Steel Plant, effluent levels from the Blast Furnace cast house de-fuming system exceeded norms during 2017-21 but met limits in 2021-24. However, stack discharges remained above limits during 2017-2024 and West Bengal Pollution Control Board (WBPCB) also reporting high emissions at tapping and ladle loading points and fugitive emissions from BF#5. For these violations, WBPCB imposed a ₹3.85 lakh penalty and required a ₹20 lakh bank guarantee. WBPCB again noted very high fugitive emission from the stacks attached to blast furnace Cast House I & II during inspection made in February 2023.

Coal consumption exceeded norms in all SAIL plants (except Bokaro in 2021-22 and Durgapur in 2021-22 & 2023-24), increasing the costs as well as emissions. Bhilai, Bokaro, Rourkela and IISCO Steel used or sold the entire solid waste. However, Durgapur Steel Plant could use only 45 *per cent* of BF sludge during 2017-24.

Recommendation 8: The Company may put efforts to reduce the coke consumption through better operational and project management measures and thereby maintain the CO_2 emissions within the norms. Management may also ensure that the solid waste generated in the Blast Furnace are disposed as per the terms of the consent to operate.

(Para 6.2)

Chapter I

Introduction

CHAPTER I

Introduction

1.1 Introduction

Steel Authority of India Limited (SAIL or Company), a Maharatna Company under Ministry of Steel, is one of the leading steel-producing companies in India. SAIL has five integrated steel plants[1] at Bhilai, Bokaro, Rourkela, Durgapur and Burnpur; three Special Steel Plants[2] at Durgapur, Salem and Bhadravati and a Ferro Alloy Plant at Chandrapur. The company has Captive mines for Iron ore, Limestone, Dolomite and Coal. Marketing of SAIL products is administered from the company's Central Marketing Organisation, Kolkata. SAIL produced 18.73 million tonne, 19.41 million tonne and 20.50 million tonne of hot metal[3] in 2021-22, 2022-23 and 2023-24 respectively.

1.2 Vision of the company:

National Steel Policy 2017 envisaged enhancing crude steel production capacity in India to 300 million tonne and to increase per capita consumption of finished steel from 61 kg to 158 kg by 2030-31. SAIL aimed to produce 35.80 million tonne crude steel by 2025-26 in Phase-I expansion and 49.6 million tonne crude steel by 2030-31 in Phase-II expansion to capture at least 20 *per cent* of the emerging demand. However, the expansion plan was revised to around 35.6 million tonne per annum (mtpa) of crude steel capacity in phase-I by 2030-31 based on the recommendation (December 2022) of a consultant engaged by SAIL. To achieve this goal, SAIL planned to increase the useful volume of blast furnace to 5580 m^3, coke oven batteries was to be stamp charged of 1.2 million tonne per annum and size of Sinter plants was to be increased to 310 m^2.

Accordingly, Stage-1 approval was accorded (January 2024) by SAIL Board for expansion for 4.08 million tonne per annum Crude Steel of IISCO Steel Plant[4]. Detailed Project Report was submitted (May 2024) for expansion of 2.43 mtpa crude steel at Bokaro Steel Plant. Pre-Feasibility/Draft Pre-Feasibility Report at Durgapur Steel Plant for brownfield expansion (0.89 mtpa crude steel) and for greenfield expansion respectively was submitted (October 2023 and May 2024). The projects associated with Vision 2030 are either not earmarked or are in the initial phase of implementation.

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[1] ***Bhilai Steel Plant, Bokaro Steel Plant, Rourkela Steel Plant, Durgapur Steel Plant and IISCO Steel Plant.***

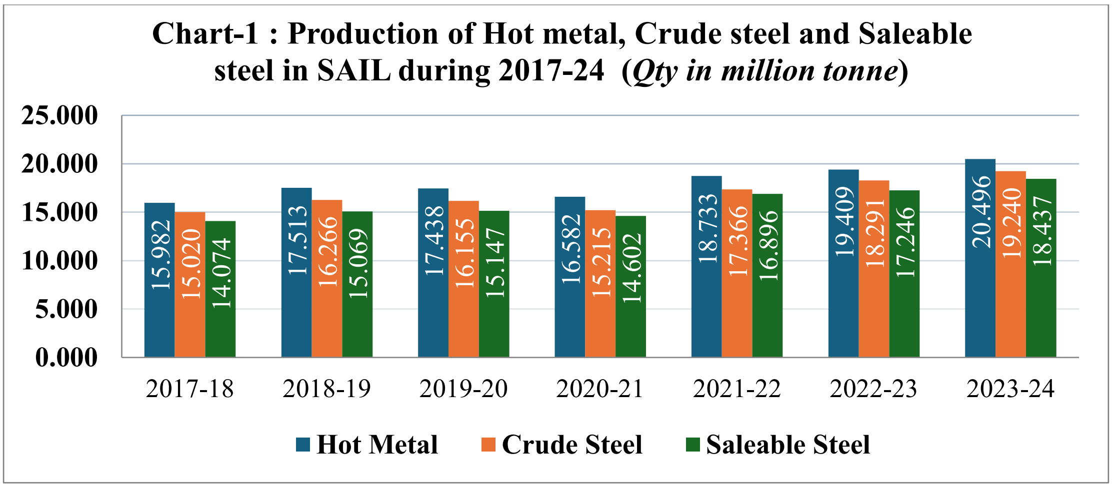
[2] ***Alloy Steels Plant, Durgapur, Salem Steel Plant, Salem and Visvesvaraya Iron & Steel Plant, Bhadravati.***

[3] ***Hot metal refers to liquid iron produced in blast furnace which is the primary raw material for steelmaking.***

[4] ***Established in the year 1918 as the Indian Iron & Steel Company (IISCO), was amalgamated with SAIL in the year 2006.***

1.3 Production Performance

Production of Hot metal, Crude Steel and Saleable Steel in SAIL during 2017-18 to 2023-24 is as below:



Source: Data furnished by Management.

Production of hot metal in SAIL was 15.98 million tonne in 2017-18 which increased gradually to 20.50 million tonne in 2023-24 (except in 2019-20 and 2020-21 when the production was lower than the preceding year).

1.4 Financial Performance

The financial performance of SAIL from 2017-18 to 2023-24 is as below.

Table 1: Financial Performance of SAIL

(Amount: ₹ in crore)

Year	Turnover	Total Expense	Profit Before Tax	Net worth
2017-18	58,297	60,232	(-)759	35,714
2018-19	66,267	63,773	3,338	38,152
2019-20	61,025	58,703	3,171	39,777
2020-21	68,452	63,301	6,879	43,495
2021-22	1,02,805	88,123	16,039	52,017
2022-23	1,03,729	1,03,423	2,637	52,139
2023-24	1,04,545	1,01,994	3,688	54,131

Source: Data furnished by Management.

SAIL was in loss in 2017-18 but became profitable from 2018-19 onwards. There was an increase of around 50 *per cent* in the turnover in 2021-22 over 2020-21 on account of increase in net sales realization of saleable steel, increase in sales, better technical parameters etc. Profit of SAIL came down drastically in 2022-23 in comparison to 2021-22 due to higher input cost, increase in stores & spares consumption, repairs & maintenance expenses, increased purchased power rates, higher usage of raw materials, higher interest, and depreciation etc. There was a marginal increase in profit in 2023-24.

1.5 Organizational Structure

Director (Technical, Projects and Raw Materials), SAIL who reports to Chairman, SAIL is responsible to monitor the production activities in the steel plants of the Company with responsibility of ensuring effective adoption of operational strategies to achieve the production target using the latest technologies, project management capabilities for efficient, optimum and smooth implementation of the projects. Operation Directorate headed by Executive Director (Operations) at corporate office monitors the plant level production and flags the issues to the top management for corrective action. They also facilitate coordination between plants and Logistics & Infrastructure for timely movement of supply and inputs/services so as to avoid deviation from the Annual Business Plan/Perspective (ABP).

Executive Director (Works) is the head of the entire operation of respective steel plant who reports to the respective Director In-charge/Head of the Plant. The Blast Furnace department headed by a Chief General Manager/General Manager of the respective plants is responsible for production of hot metal and repair & maintenance of blast furnaces.

The Company has an Internal Audit Department which conducts Compliance Audit and reviews operations. Internal Auditors advise Management and the Board of Directors how to better execute their responsibilities. The significant findings of internal audit are discussed by the Audit Committee. During last seven years, internal audit of Blast Furnace department was conducted nine times in Bhilai Steel Plant, five times in IISCO Steel Plant, four times each in Bokaro and Durgapur Steel Plant, and twice in Rourkela Steel Plant.

1.6 Process of running of Blast Furnace

Blast Furnace is a key unit in the production process of a steel plant which produces hot metal, the primary raw material for steel making. It is a vertical shaft furnace, in which solid raw materials like Iron ore, Sinter[5], Pellet[6], Linz-Donawitz (LD) slag[7], Quartzite and fuel like Coke[8] are charged from top of the furnace and hot blast[9] and Coal Dust

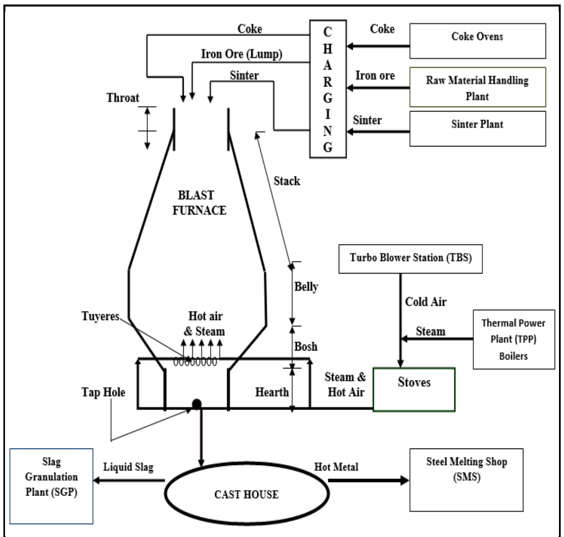


Figure 1: Blast Furnace Process Layout

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[5] *Sinter is an agglomeration of iron ore fines, flux materials (Limestone and Dolomite) and coke breeze prepared in a Sintering Plant.*

[6] *Thermally agglomerated substance formed by heating a variable mixture of iron ore, limestone, dolomite, binder and miscellaneous iron bearing materials.*

[7] *It is a by-product generated during the steelmaking process due to oxidation of impurities in molten iron.*

[8] *A fuel used in the iron making process that is created by heating coal in the absence of air.*

[9] *The air which is heated in the hot blast stoves and fed into the blast furnace through the tuyeres for combustion of fuel.*

Injection[10] are blown from the tuyeres[11] as shown in Figure 1. Apart from these solid raw materials, Blast furnace also requires oxygen for enrichment to increase thermal efficiency by burning of coke, water for cooling the refractory lining. Blast Furnace receives Iron ore from Raw Material Handling Plant, Sinter from Sinter Plant and Coke from Coke Ovens.

Hot metal is sent to the Steel Melting Shop for production of Steel and sent to the Continuous Casting Shop where Crude Steel[12] is produced in the form of billet/bloom/slab and only a limited quantity of steel is sent to Ingot Casting Shop at Durgapur Steel Plant for making ingots. The billets/slabs formed are cut to proper lengths and are either sold as semi-finished products or converted at different rolling mills into finished products for sale. The steel at this phase is called saleable steel[13]. Therefore, the production performance of Blast Furnace has a very significant role in the entire steel making process.

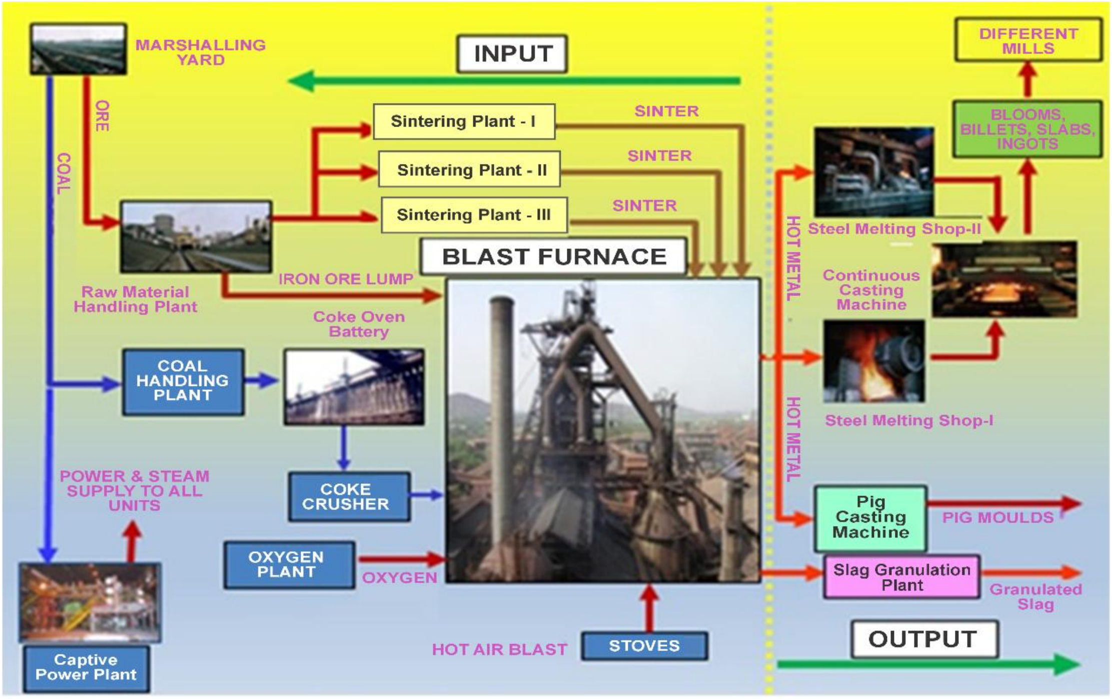

Figure 2: Steelmaking Process

1.7 Status of Blast Furnace

SAIL had 28 blast furnaces with installed capacity of 23.07 million tonne per annum as on 31 March 2024. Twenty-seven blast furnaces were in five integrated steel plants and

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[10] *Coal Dust Injection is a process that involves blowing large volumes of fine coal dust into the Blast Furnace. It provides a supplemental carbon source to speed up the production of metallic iron, reducing the need for coke production. This helps in substantial reduction of coke consumption in the Blast Furnace.*

[11] *Tuyeres are nozzles located just above the hearth through which hot air blast and CDI (with Nitrogen as carrier) are blown into the Furnace.*

[12] *Steel product from Steel Melting Shop upon solidification of liquid steel. It includes ingots, slab, blooms and billets.*

[13] *Various steel products which are sold to the customers for further processing or for direct use/consumption.*

one was at Visvesvaraya Iron and Steel Plant (VISP), Bhadravati. Status of working Blast Furnaces in SAIL was as given in table:

Table-2: Status of Blast Furnaces (BF) of SAIL as of March 2024

Plant	No. of BF	No. of Blast Furnace in operation	Useful Volume[14] (in m^3)	Working volume[15] (in m^3)	Year of Commissioning							
					Re-commissioning							
					BF#1	BF#2	BF#3	BF#4	BF#5	BF#6	BF#7	BF#8
Bokaro *	**5**	**BF#1, 2, 4 & 5**	10,500	9,282	1972	1976	1978	1981	1985	--	--	--
					--	2010	--	--	--	--	--	--
Bhilai *	**8**	**BF#1, 4, 5, 7 & 8**	12,605	10,909	1959	1959	1960	1964	1966	1971	1987	2018
					1988	-	1998	1989	1992	1998	2007	-
Durgapur*	**4**	**BF#2, 3 & 4**	4,600	3,947	1959	1961	1962	1967	--	--	--	--
					-	1993	2002	1996	-	-	-	-
Rourkela*	**5**	**BF#1, 4 & 5**	7,428	6,409	1959	1960	1962	1967	2013	--	--	--
					2018	--	--	--	--	--	--	--
Burnpur*	**5**	**BF#5**	4,161	3,551	1922	1924	1958	1958	2015	--	--	--
Bhadravati	**1**		530	450	1995	-	-	-	-	-	-	-
Total	**28**		**39,824**	**34,548**								

Source: Data furnished by Management.

*** BF#3 of Bokaro Steel Plant (30 September 2022) and BF#6 of Bhilai Steel Plant (20 August 2023) were under capital repair, BF#1, BF#2, BF#3 & BF#4 of IISCO Steel Plant, BF#2 & BF#3 each of Bhilai and Rourkela Steel Plant and BF#1 of Durgapur Steel Plant have been phased out.***

Out of the above, one blast furnace each at Rourkela, IISCO and Bhilai Steel Plant were installed in August 2013, April 2015 and February 2018 respectively under modernization and expansion plan of SAIL. As of March 2024, 16 blast furnaces were in operation, two were under capital repair and nine were phased out due to ageing, beyond economic repair/ up-gradation and enhancement of production capacity with installation of new high capacity blast furnaces. Production from the blast furnace at VISP has been suspended since January 2017 due to difficulty in getting steady supply of Coke and Iron ore at optimum price and shortage of orders due to subdued market condition.

1.8 Structure of the Report

Chapter I: Introduction

Chapter II: Audit Approach

Chapter III: Assessment, Availability and Consumption of Raw Materials, Fuel & Services

Chapter IV: Operational Performance of Blast Furnaces

Chapter V: Blast Furnace Output

Chapter VI: Safety and Environment Issues

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[14] ***Inner volume of blast furnace between a horizontal plane through the centre-line of the tap hole and stockline level.***

[15] ***Inner volume of blast furnace between a horizontal plane through the centre-line of the tuyeres and stockline level.***

1.9 Significant Achievements

- All the integrated Steel Plants had planned the Annual requirement of major raw materials adequately (*except for CDI coal*).
- Bokaro Steel Plant, Durgapur Steel Plant and IISCO Steel Plant achieved the target for consumption of power during the period 2021-2024, 2017-18 & 2020-2024 and 2023-24 respectively.
- The Planned and Actual production of Hot metal had shown a marginal increase consistently over the last four years during 2020-21 to 2023-24.
- Productivity of the Blast Furnaces in SAIL had also consistently improved over the last three years.
- The off blast/idle hours of the Blast Furnace consistently reduced over the last three years from 9,952 hours in 2021-22 to 6,185 hours in 2023-24.
- The new Blast Furnace at Rourkela Steel Plant achieved the desired level of oxygen enrichment during 2017-2024.
- Safety audit of Blast Furnaces of SAIL was being conducted periodically by SAIL Safety Organisation during 2017-2024.

Chapter II

Audit Approach

CHAPTER II Audit Approach

2.1 Audit Objectives

The audit objectives were to assess whether:

- Requirement of raw materials was assessed adequately; raw materials were available in desired quantity and used as per desired proportion and whether Coke rate[16], Coal Dust Injection rate[17], other operating indices and consumption of services were within the norms/plan;
- Blast Furnaces were operated economically, efficiently and effectively as per the Annual Production Plan/Perspective;
- Capital repairs, preventive repairs & maintenance of blast furnaces were carried out as per schedule and techno-economic parameters were achieved;
- Projects relating to upstream and downstream facilities of blast furnace were planned judiciously and carried out economically and efficiently. Blast Furnaces were operated with adherence to the safety and environmental laws.

2.2 Audit criteria

The audit criteria were derived from:

- Annual Business Plan/Perspective,
- Production reports, MIS data and Operational Statistics
- Agenda and minutes of the SAIL Board meetings, Annual Reports of SAIL and Ministry of Steel
- Environmental laws/ Pollution control norms relating to iron making,
- Quality report of input raw material (Coke, Iron Ore, etc.)
- Norms and actuals for techno-economic parameters, consumption of raw materials and services in blast furnace
- Schedule of capital repair, preventive repair & maintenance and Contract for up-gradation and Capital repairs of blast furnace and
- Safety Audit reports on blast furnace operations

2.3 Scope of Audit

Audit analysed the performance of all the working Blast Furnaces (18 Blast Furnaces) during the period from 2017-18 to 2023-24 including Blast Furnace 3 of Bokaro Steel Plant and Blast Furnace 6 of Bhilai Steel Plant till those were put under capital repair from 30 September 2022 and 20 August 2023 respectively. Audit examined records

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[16] ***Quantity of coke consumed to produce one tonne of hot metal. Coke rate is measured in Kg/thm.***

[17] ***Coal Dust Injection rate is the quantity of Coal Dust injected to produce one tonne of hot metal. It is measured in Kg/thm.***

relating to assessment of requirement, availability and consumption of raw material, production performance, up-gradation, capital repairs and preventive repair & maintenance of blast furnaces, operating indices, adherence to the safety & environmental laws. Audit examined electronic and paper records pertaining to all the integrated Steel plants and VISP, Bhadravati for a period from 2017-18 to 2023-24.

2.4 Audit Methodology

An entry conference was held with the Management and Ministry of Steel on 5 November 2022. Draft Performance Audit report was issued to SAIL Management on 15 September 2023. Exit meeting was held on 4 October 2023 with the Management. Draft Performance Audit report was issued to the Ministry of Steel on 26 April 2024. Replies of Management (November 2023) and Ministry (July 2024) have been duly incorporated in the report. The report was updated till March 2024 and issued to the Ministry of Steel on 22 November 2024. Exit conference with the Ministry was held on 13 February 2025. Response of Ministry after exit conference was received on 17 February 2025 and 7 April 2025, which has been duly incorporated in the report.

2.5 Acknowledgement

Audit acknowledges the co-operation extended by the Management of the Company and the officials of Ministry of Steel in facilitating the conduct of this Performance Audit.

Chapter III

Assessment, Availability and Consumption of Raw Materials, Fuel & Services

CHAPTER III

Assessment, Availability and Consumption of Raw Materials, Fuel & Services

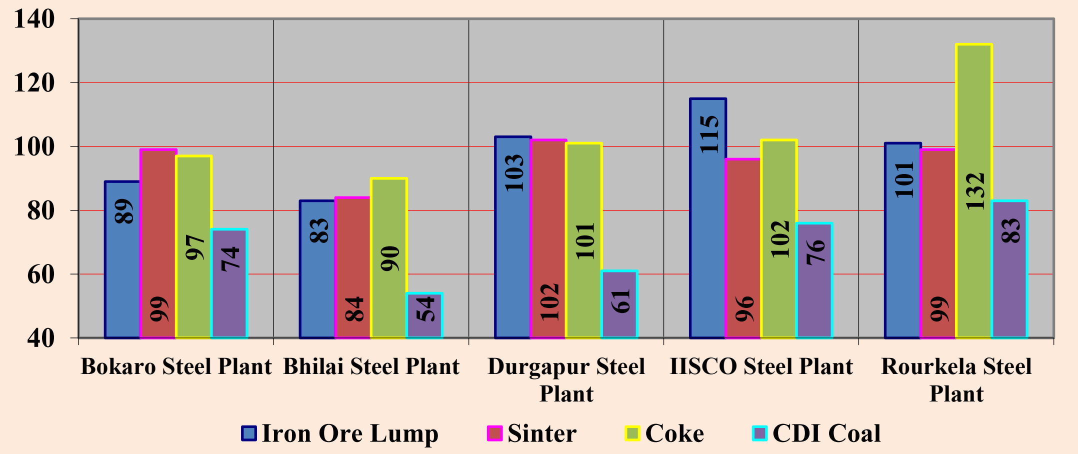
3.1 Raw Materials (Iron ore, Sinter, Limestone, Dolomite & Pellets), Fuel (Coke & Coal Dust Injection coal) and Services (power and refractories) are required for steel making. A significant quantity of raw materials which constitute around 48 *per cent* of expenditure of the company are consumed in the blast furnace. Audit was conducted with an objective to assess whether requirement of raw materials was assessed adequately, raw materials were available in desired quantity and used as per desired proportion and whether Coke rate, Coal Dust Injection rate, other operating indices and consumption of services were within the norms.

3.2 Planning and Availability of Raw Material

Annual requirement of raw materials and norms for consumption of coke are decided in the Annual Business Perspective for respective years. The required quantity of raw materials are arranged/made available either from captive mines, in house production or purchase. Shortage/non-availability of adequate quantity of raw material affects continuous operation of blast furnace which ultimately affects the production of targeted quantity of hot metal adversely.

The percentage of availability of iron ore lump, sinter, coke, and Coal Dust Injection (CDI) coal at plants with respect to the plan during the period 2017-24 is depicted in the chart below.

Chart-2: Percentage of Availability of Raw Material at Steel Plants during 2017-24



Source: Data furnished by the Management.

It was seen that all the five integrated Steel Plants had planned their annual requirement of major raw material adequately except for Coal Dust Injection. The availability of iron ore lump ranged between 83 *per cent* to 115 *per cent* while that of sinter ranged between 84 *per cent* to 102 *per cent* of the planned quantity. The coke availability ranged between 90 *per cent* to 132 *per cent* whereas CDI coal ranged from 54 *per cent* to 83 *per cent.*

Audit noted cases of excess consumption of iron ore, sinter, coke, power and refractories as well as cases of inconsistent use of pellets which impacted the cost of production of hot metal adversely. These issues have been discussed in the succeeding paragraphs.

3.3 Consumption of Iron Ore

Iron ore is the basic raw material in production of hot metal. SAIL sources iron ore from its captive mines. Audit noted that consumption of Iron ore lump in blast furnaces of SAIL was intermittently more or less than the Annual Business Perspective norm in all the steel plants during 2017-24 as shown in the table below.

Table 3: Norm and consumption of iron ore lump in blast furnaces of SAIL during 2017-24

(unit: kg/tonne of hot metal)

Year / Steel Plants	2017-18		2018-19		2019-20		2020-21		2021-22		2022-23		2023-24	
	Norm	Actual	Norm	Actual	Norm	Actual	Norm	Actual	Norm	Actual	Norm	Actual	Norm	Actual
Bokaro Steel Plant	580	516	577	537	603	553	612	574	**551**	**592**	580	560	**579**	**619**
Bhilai Steel Plant	553	530	**503**	**539**	**509**	**556**	**559**	**588**	630	608	655	571	531	497
Durgapur Steel Plant	**460**	**509**	557	518	550	504	**480**	**512**	**508**	**551**	530	516	515	493
ISP, Burnpur	**325**	**328**	**325**	**384**	406	363	**373**	**376**	**366**	**412**	369	328	**170**	**270**
Rourkela Steel Plant	**327**	**442**	**415**	**434**	**376**	**464**	**414**	**415**	**454**	**478**	487	437	**386**	**415**

Source: Data furnished by the Management

Consumption of iron ore lump was more than the Annual Business Perspective in Bokaro Steel plant in 2021-22 & 2023-24, Bhilai Steel Plant during 2018-21, Durgapur Steel Plant in 2017-18, 2020-21 and 2021-22, Rourkela Steel Plant in 2017-22 & 2023-24 and IISCO Steel Plant in 2017-19, 2020-22 and 2023-24. It was noticed that during 2022-23 consumption of iron ore lump was less than the norm in all the steel plants due to use of pellet in burden though not planned in Annual Business Perspective. In contrast, it was noticed that in 2023-24 although SAIL planned to use pellet in the burden, due to less use of pellet than the plan, excess consumption of iron ore lump was noted in Bokaro, Rourkela and IISCO Steel Plant. Overall there was excess consumption of 0.823 million tonne[18] of Iron ore lump during 2017-22 which valued ₹186.26 crore.

Audit observed that the consumption of iron ore lump more than the norm was mainly due to variation in the *Fe* content in iron ore. The norm for *Fe* content in iron ore lump ranged between 62.50 *per cent* to 64.00 *per cent* while the actual *Fe* content ranged between 60.80 *per cent* to 64.17 *per cent* during 2017-2024. SAIL had never achieved

[18] ***Total excess consumption of 2.130 million tonne minus consumption of iron ore less than norm of 1.307 million tonne.***

the *Fe* parameters in iron ore lump during 2017-24 except by Bhilai Steel Plant in 2017-18 and Durgapur Steel Plant in 2017-19. Depletion of iron ore mines of Dalli and Rajhara had resulted in decrease in the *Fe* percentage in iron ore fines and lumps. To increase the *Fe* percentage in iron ore, iron ore crushing unit was started (December 2023) in Ore handling plant, Silica Reduction Plant (March 2024) and pellet plant was expected to be commissioned by November 2024 at Bhilai. SAIL had planned for setting up of Beneficiation plant along with Pellet Plants at Gua mines (Bokaro Steel Plant), Dalli mines (Bhilai Steel Plant) and at Rourkela Steel Plant. Inconsistent use of pellets also contributed to the excess consumption of iron ore lump (*as discussed in para 3.4 below*).

Management replied (November 2023) that it was closely monitoring process optimization, quality control and efficient logistics to identify and rectify the underlying causes of excess consumption. Ministry added (July 2024/February 2025) that non-availability of pellets and sinter as per plan had led to higher consumption of iron ore against the norm.

Replies of the Management/Ministry may be viewed in the light of the fact that iron ore being the most critical raw material in steel making process, efforts should have been made towards improvement in *Fe* percentage by setting up beneficiation plants, silica reduction plant etc.

3.4 Consumption of Pellet

Pellets are thermally agglomerated substance formed by heating a variable mixture of iron ore, limestone, dolomite and miscellaneous iron bearing materials and are used as a substitute of iron ore lump in production of hot metal. As per study conducted (2012/2017) by Research & Development Centre for Iron & Steel/SAIL, if the pellets are used to the tune of around 10 *per cent* in the input charge/burden of blast furnaces, the expected improvement in reduction of coke rate would be around 1.5 to two *per cent* and productivity could increase by around three to four *per cent*, thus leading to cost reduction.

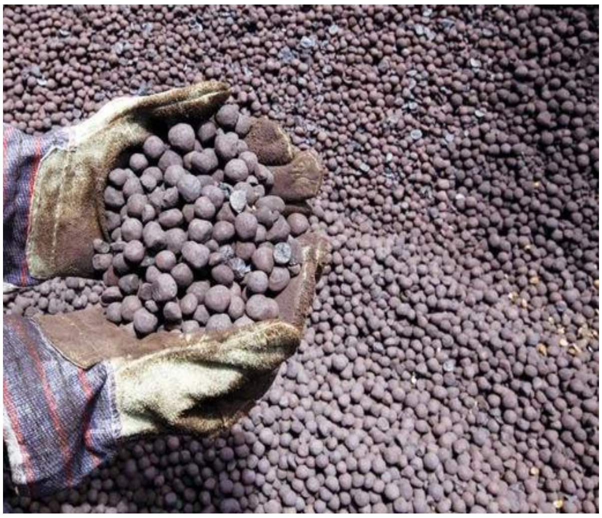


Figure 3: Pellets

Further, Boston Consulting Group (a consultant appointed by SAIL) in its report on Comprehensive Turnaround Roadmap for SAIL opined (October 2017) that by the replacement of 10 *per cent* iron ore lump with pellets, SAIL would additionally be benefitted by ₹268 crore annually if slime and iron ore fines were utilized in pelletization. The National Steel Policy also emphasized (May 2017) for optimal use of existing low grade iron ore resources with special emphasis on conservation of high-grade ores.

Audit noted that despite the above envisaged benefits, Pellets were not used in the blast furnaces of SAIL steel plants during 2017-21 except in Rourkela Steel Plant where minimal use of pellet in the burden was noted during 2017-18 (0.03 *per cent*) and 2020-21 (1.10 *per cent*). Use of pellets in SAIL steel plants was between 0.10 and 9.54 *per cent* during 2021-24 against the desired level of 10 *per cent*.

3.4.1 Sourcing of pellets

Pellets can be made available through direct purchase from the market or through conversion agents or through in-house production of pellets from Pellet Plant. Audit observed that SAIL did not have any captive Pellet Plant and the intermittent use of pellet was soured either from purchase or through conversion basis. SAIL Board accorded in-principle approval to set up three Pellet Plants at Gua mines of Bokaro Steel Plant, at Rourkela Steel Plant and Dalli mines of Bhilai Steel Plant in March 2010, November 2013 and October 2014 respectively. Audit noted delays in installation of all above Pellet plants as explained below:

- At Gua mines, contract for installation of Crushing, Beneficiation and Pellet Plant was awarded (April 2014) to L&T which was terminated (August 2019) due to efflux of time. Management was unable to provide clear front and had awarded the work without ensuring forest clearance. The agency approached (September 2021) the International Court of Arbitration. SAIL was directed (17 March 2023) to pay ₹504.90 crore including interest to compensate the contractors for loss or damages caused by breach of contract by the company. SAIL deposited ₹499.49 crore in May 2024 on the direction of High Court. The case is pending at Delhi High Court. Management revisited the scheme to change it from Engineering Procurement and Construction basis to Mine Developer and Operator basis and the detailed project report submitted by MECON (September 2024) was approved (February 2025) by SAIL Board and tendering process was under progress.

- At Rourkela Steel Plant, the project for setting up of Pellet Plant along with Beneficiation Plant was accorded in-principle approval (November 2013) by SAIL Board. The tender was cancelled thrice on the ground of failure of lead consortium to extend validity period and non-submission of documents in support of eligibility (January 2017), considering depressed financial condition of the Company (September 2017) and due to high price quoted by the bidders (August 2023). The mode of implementation of the project was also modified on multiple occasions from Engineering, Procurement and Construction (EPC) to Build, Own and Operate (BOO) and finally to Construct, Operate and Maintain (COM). As a consequence of delays in tendering process and frequent change in mode of implementation of project, the pellet plant was yet (March 2025) to be installed.

- At Dalli mines, SAIL Board accorded (October 2014) in-principle approval of the project for 'Installation of Pellet Plant along with Slime Beneficiation system. The tender was cancelled twice on the ground of non-submission of requisite documents (January 2017) and not being economically prudent in view of large capital expenditure (August 2018). Bhilai Steel Plant took seven years to finalize the mode of setting up of the Pellet Plant till another proposal was initiated (June 2021) to install one mtpa Pellet Plant on Build-Own-Operate basis at Dalli mines. SAIL Board accorded Stage-II approval (September 2022) for a contract period of 12 years from the date of commissioning. The setting up of the Plant at Dalli mines was under progress.

Management replied (November 2023) that technically pellet input was always favourable in blast furnace operation, but while purchasing cost effectiveness factors were always taken into consideration. The contract for installation of Pellet Plant at Gua Mines was awarded to L&T in anticipation of early Stage-II Forest Clearance which was delayed due to reasons beyond the control of SAIL. In respect of Rourkela Steel Plant, Ministry replied (July 2024/February 2025) that SAIL Board accorded (January 2025) Stage II approval for installation of Pellet Plant. It further stated that Pellet Plant at Dalli mines was expected to be commissioned by November 2024 whereas Pellet Plant at Gua mines was under process. In the Exit conference (February 2025), Management stated that SAIL Board has accorded in-principle approval for installation of Pellet Plant in Gua mines and installation at the Dalli mines and at Rourkela steel plant are in process.

The replies may be viewed in the light of the fact that frequent changes in mode of execution of the contract and business model caused delay in execution of the project. Management was not able to get the Forest Clearance timely at Gua mines. After receipt of Stage-II approval at Rourkela, the agreement was signed (February 2025) with an agency to construct, operate and maintain the Pellet Plant for 22 years. Audit noted that Pellet Plant conceptualized at Dalli mines in March 2010 was yet to be commissioned (March 2025). Installation of Pellet Plant at Rourkela and Bokaro Steel Plant (Gua mines) was under process.

3.5 Consumption of Sinter

3.5.1 The Blast furnaces of SAIL receive Sinter from the Sintering Plants of their respective steel plants. Sinter, with 53-54 *per cent* of *Fe* content, is used in the Blast Furnace burden[19]. Use of sinter increases furnace permeability[20], better reducibility, increases Blast Furnace productivity, improves quality of hot metal, and reduces coke rate.

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[19] ***Burden is the furnace charge of iron-bearing materials (e.g. iron ore, pellets and sinter) to produce liquid iron and slag.***

[20] ***Permeability is the characteristic of the burden in the blast furnace which determines the smooth upward movement of the gases in the blast furnace.***

Figure 4: Sinter

Figure 5: Transfer of Sinter over Sinter bed

Audit noted that consumption of sinter was intermittently more than the norms[21] in all the steel plants during 2017-2024. It was noted that if the targeted iron ore lump or pellets were not available, the same was compensated by the use of Sinter. With the depletion of iron ore mines the *Fe* percentage in the iron ore fines and resultantly the *Fe* percentage in the Sinter also decreased. This led to excess consumption of Sinter. The desired quantity of sinter as per Annual Business Perspective was not ensured by the Management which led to net excess consumption of 3.023 million tonne[22] of sinter above the norms by all the steel plants valuing ₹1,636.41 crore[23]. This also impacted the cost of production of hot metal adversely during the period 2017-24.

Management replied (November 2023) that high consumption of sinter was due to proportional high availability consequent to lower hot metal production, non-usage of pellets in the burden, impact of COVID 19 during 2020-21 etc. Also, higher usage of Sinter increases the Blast Furnace productivity. Steps like setting up ore beneficiation facilities in Dalli mines for silica reduction, use of pellet in blast furnace and initiation of mining activities in Rowghat mines had been taken to improve the *Fe* percentage in iron fines and lumps.

Ministry added (July 2024/ February 2025) that consumption of sinter with lower *Fe* content than planned and non-availability of pellets led to its higher consumption. Decision of sinter percentage in burden is dynamic and taken by plant as per prevailing situation. To increase the *Fe* percentage in iron ore fines, Iron ore crushing unit was started (December 2023) in Ore Handling Plant, Silica Reduction Plant in (March 2024) and the Pellet plant was expected to be commissioned by November 2024 at Bhilai.

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[21] ***Consumption of Sinter was more than the norms in Bokaro Steel Plant (2017-24), Bhilai Steel Plant (2017-18 & 2023-24), Rourkela Steel Plant (2018-19 & 2022-24), Durgapur Steel Plant (2018-20 & 2022-23) and IISCO Steel Plant (2017-18 & 2019-24).***

[22] ***Total excess consumption of 4.441 million tonne minus less consumption of 1.418 million tonne of sinter.***

[23] ***Value of excess sinter consumed than norm (₹2,301.72 crore) minus saving on less sinter consumed than norm (₹665.31 crore).***

The replies may be viewed in the light of the fact that consumption of sinter more than the norm would increase the cost of production of hot metal. The incidence of COVID pandemic did not impact the consumption of sinter as burden ratio should have been maintained during blast furnace operation. The installation of Pellet Plants has been delayed (*as discussed in Para 3.4*). Moreover, the facilities mentioned in the reply relating to Bhilai Steel Plant and Dalli mines were commissioned recently or were yet to be commissioned and therefore their impact was not available at this stage.

3.5.2 Sinter is in the form of a large cake which is further broken into smaller pieces for use in the blast furnace. During transfer of sinter from Sintering Plant to the blast furnace through conveyor belt, undersized sinter (-5 mm) is generated due to friction and collision among sinter pieces, which are sent back from blast furnace to Sinter plant/Raw Material Handling Plant for reuse and reprocessing. This return of undersized sinter more than norm increases the cost of production due to additional cost of processing.

Bokaro and Durgapur Steel Plant fixed norm of 18 *per cent* and IISCO Steel Plant fixed 10 *per cent* for sinter return generated at the blast furnaces. Norms for sinter return were, however, not fixed by the Rourkela and Bhilai Steel Plant in absence of which Audit has considered the norms fixed for similar capacity blast furnaces of other steel plants. Audit noted that return of undersized sinter from the blast furnaces was more than the norms in all the steel plants. Audit observed that the norms were not adhered to and during 2017-24, 14.357 million tonne[24] of sinter return from blast furnaces were reprocessed incurring an additional expenditure of ₹1,003.71 crore[25].

Management/Ministry replied (November 2023/ July 2024/February 2025) that sinter return at Bhilai Steel Plant has increased significantly due to depletion of quality of iron ore fines, quality of sinter and its handling etc. For continuous running of sinter machine, reliability of Intermediate Sinter Storage Bunker feeders was being enhanced at Bokaro Steel Plant, Iron Ore Crushing unit had been started in Ore Handling Plant of Bhilai Steel Plant. Corrective measures and efforts are being taken by Bokaro, Durgapur and IISCO Steel Plant to reduce the generation of Sinter return.

The replies may be viewed in the light of the fact that the *Fe* percentage had not improved significantly even after commissioning of iron crushing unit at Ore Handling Plant at Bhilai. Quality of Sinter and its handling could have been minimized by effective quality control measures, better raw materials and handling practices. Reply of the Management/Ministry were however, silent on non-fixation of norms for sinter return at Rourkela and Bhilai Steel Plant.

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[24] ***Bokaro Steel Plant (4.956 million tonne), Rourkela Steel Plant (4.362 million tonne), Bhilai Steel Plant (3.272 million tonne), Durgapur Steel Plant (0.204 million tonne) and IISCO Steel Plant (1.563 million tonne).***

[25] ***Considering excess generation of sinter return than the norm multiplied by processing cost on making of per tonne of sinter (Rourkela Steel Plant- ₹341.69 crore, Bokaro Steel Plant: ₹315.66 crore, Bhilai Steel Plant - ₹ 251.31 crore, IISCO Steel Plant: ₹80.10 crore and DSP: ₹14.95 crore).***

3.6 Consumption of Coke and Coal Dust Injection coal

Metallurgical coke is an important ingredient for the functioning of blast furnace which is used as a fuel to maintain temperature. It supplies chemical reactant (primarily carbon monoxide) to reduce iron ore and carbon dissolved in the hot metal. SAIL imports coal for making coke in its coke oven batteries and for producing Coal Dust Injection Coal through its grinding mill. Considering quality of coke, production process involved, operating condition etc., the steel plant wise norm for consumption of coke and Coal Dust Injection coal was laid down in the Annual Business Perspective for each year.

Coal Dust Injection coal, which is cheaper than coke, is injected by the Company as an auxiliary fuel. It replaces the costly coke by 1:1 ratio (1:0.8 in case of IISCO Steel Plant) and thus reduces the cost of production. The company has installed and linked all working blast furnaces with the Coal Dust Injection system.

Audit noted that all the steel plants consumed coke in excess of the target as per Annual Business Perspective during 2017-24 except Durgapur Steel Plant which achieved the target in 2017-18 and 2018-19. Also, the consumption of average Coal Dust Injection at all the steel plants except Bhilai Steel Plant and Durgapur Steel Plant in 2022-23 and 2023-24 respectively was lesser than the Annual Business Perspective target during 2017-24. Consumption of coke was ranged between 397 kg/thm to 496 kg/thm as against the norm of 373 kg/thm to 483 kg/thm and the consumption of Coal Dust Injection coal was ranged between 38 kg/thm to 127 kg/thm as against the norm of 59 kg/thm to 150 kg/thm. The steel plants consumed 2.945 million tonne more coke than the norm and 2.235 million tonne of lesser CDI coal than the norm fixed by plants during 2017-24. There was potential extra expenditure of ₹6,259.25 crore during 2017-24 (₹8,858.45 crore[26] against consumption of coke beyond norms *minus* ₹2,599.20 crore[27] on less consumption on CDI coal) due to non-achievement of norms for coke rate and utilization of CDI coal in the blast furnaces.

The high coke rate was attributed by Management to use of low sinter burden, frequent off/low blast, low hot blast temperature[28], less oxygen enrichment, high gangue input, non-availability of raw materials etc. The less utilization of CDI coal was on account of less availability of CDI coal in plants, mill interruption due to maintenance, delay in execution of projects for up-gradation of stoves and other operational failure in blast furnace. Audit observed that the issues relating to high coke rate and less utilization of CDI coal could have been better managed through operational controls.

Management replied (November 2023) that excess consumption of coke was due to throttling of furnace regime, non-availability/inferior quality of raw materials, delay in commissioning and stabilisation of facilities for CDI Injection, running of old furnaces,

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[26] ***Excess consumption of coke per tonne of hot metal over the ABP norm (Production of hot metal multiplied by differential of norm and actual consumption of coke) multiplied by cost of coke.***

[27] ***Quantity of CDI coal consumed less than the norms (for consumption of CDI coal) which could have replaced the quantity of coke consumed extra per tonne of hot metal multiplied by cost of CDI coal.***

[28] ***Hot Blast Temperature is the temperature of the air which is heated in the hot blast stoves and fed into the blast furnace through the tuyeres for combustion of fuel.***

COVID 19, poor off take by Steel Melting Shop etc. Ministry also stated (July 2024/February 2025) that the annual CDI rate and coke rate are showing improving trends. Consistent efforts are being made to reduce coke rate and to increase CDI consumption.

Reply of the Management/Ministry may be viewed in the light of the fact that Coke rate improved at Rourkela and Durgapur Steel Plant during the last three years and also at Bokaro Steel Plant during the last two years. However, at Bhilai and IISCO Steel Plant, the coke rate increased during the last two years. However, in all these years the actual coke rate was more than the norm. Coal Dust Injection rate was also on an increasing trend in all the Steel Plants, but remained below the norm except in case of Bhilai Steel Plant during 2022-23 and Durgapur Steel Plant during 2023-24. Also, to accommodate the impact of Covid pandemic, the production target and operational parameters for the year 2020-21 were revised by the Management. The other reasons cited by Management were operational and project related issues which should have been mitigated by adopting better operational practices and project management.

3.7 Consumption of Services

Annual Business Perspective of the Company specifies specific consumption rates of services for all the steel plants. Audit noted higher consumption of services against the respective norms in blast furnaces as discussed below:

3.7.1 Consumption of Power

In steel making, cost of power (electricity) consumed is an important element of cost of production (0.71 *per cent* to 1.31 *per cent* of expenditure for production of hot metal). Audit noted that norms fixed by the management for specific power consumption[29] could not be achieved in most of the years during 2017-24. While the norm for specific power consumption ranged between 23.00 and 50.90 (kwh/thm), the actual specific power consumption ranged between 24.50 and 63.50 (kwh/thm). High specific power consumption was due to non-achievement of targeted production of hot metal. Such higher specific power consumption adversely impacted the cost of production of hot metal.

Management/Ministry replied (November 2023/July 2024 & February 2025) that shortfall in targeted hot metal production led to the increase in specific power consumption. In Durgapur Steel Plant there is an improving trend of specific consumption of power from 2020-21. IISCO Steel Plant has achieved the Annual Business Perspective in FY 2023-24.

Replies may be viewed in the light of the fact that while Bokaro Steel Plant achieved the target for consumption of power during 2021-2024, Durgapur Steel Plant achieved the same during 2017-18 and 2020-2024 respectively, IISCO Steel Plant could achieve the specific power consumption target in 2023-24 only. Rourkela and Bhilai Steel Plant

[29] ***Specific power consumption is the power consumption per tonne of hot metal produced (kwh/thm).***

could not match the target during 2017-24. Excess consumption of power than the norm in the steel plants led to potential avoidable expenditure of ₹310.48 crore during 2017-24.

3.7.2 Consumption of refractories

Refractories are non-metallic material that retain its strength on elevated temperature and resistant to heat and pressure. The target of refractory (per tonne of hot metal) to be used in the blast furnace is defined every year considering the capital repairs of furnaces, converters, ladles, castable, shotcretes[30], tapping the holes of furnaces and day to day operational maintenances.

Audit noted that in Bokaro Steel Plant, the norms for consumption of refractories used in blast furnace during 2018-24 was between 1.75 kg/thm and 1.98 kg/thm while actual consumption was between 2 kg/thm and 2.34 kg/thm. Consumption of refractory was within the norm in Rourkela Steel Plant during 2018-21 whereas it was more than the norms in 2017-18 and during 2021-24. Norm for consumption of refractories was not fixed in Bhilai, Durgapur and IISCO Steel Plant.

Audit observed that the reasons for increase in consumption of refractories in blast furnaces of Bokaro Steel Plant were frequent problems in furnaces which required extra shotcreting of furnaces, excess consumption of mudgun mass, castables and ladle insulation powder etc. Poor health of BF#4 and maintenance of hearth and taphole strength of BF#5 were the reasons in Rourkela Steel Plant. These factors could have been addressed through regular capital repair/hot repairs and excess consumption of refractories could have been minimized.

Management replied (November 2023) that relining of Torpedo Ladle at blast furnace was under stabilizing phase (in the FY 2019-20) at Bokaro Steel Plant and contributed to excess refractory consumption, while at Rourkela Steel Plant, refractory consumption was high as the production of hot metal was on the lower side. Ministry added (July 2024/February 2025) that efforts were being made to reduce specific consumption of refractory. Establishing norms for refractory consumption was challenging due to varying factors influencing consumption, however, it was actively working to establish robust norms for the Annual Business Plan targets.

Replies of the Management/Ministry may be viewed in the light of the fact that specific consumption of refractory was not only dependent on the hot metal production but also on the number of tapping[31]. At Bokaro Steel Plant, the specific consumption of refractory was more even after the stabilisation of the torpedo ladle after 2019-20. Due to consumption of 11,799 tonne refractories beyond norms, there was potential avoidable expenditure of ₹67.76 crore (BSL-₹55.73 crore, RSP- ₹12.03 crore) during 2017-24.

[30] Shorcreting is a technique used to repair the refractory lining of Blast furnace stack area.
[31] Tapping is the process of draining or pouring molten metal from furnace.

Recommendation 1: To achieve the norms fixed in the Annual Business Perspective for consumption of raw materials, fuel and services, the Company may expedite the setting up of Beneficiation Plants, Silica Reduction Plants and Pellet Plants and may also adopt better operational practices.

Summing up

Raw materials consumed in the blast furnace constitute 48 *per cent* of expenditure of the Company and are core to the efficient operation of the Blast furnace. Annual requirement of major raw materials was planned adequately except CDI coal. It was however, noted by Audit that SAIL was unable to ensure the consumption of raw materials, fuel and services as per the norms. The consumption of iron ore lump was intermittently more or less than the Annual Business Perspective norm due to variation in *Fe* content of iron ore and unplanned shutdown of Blast Furnace due to electrical, mechanical and operational failures. Although pellets were a substitute for iron ore lump and could reduce the coke rate and improve productivity leading to cost reduction, efforts of SAIL to set up Pellet Plants were delayed. SAIL was also unable to source pellets for its blast furnaces as recommended by RDCIS and also emphasized by the National Steel Policy. It was also noticed that although CDI coal was cheaper than coke and could replace it in the Blast furnace in a specified ratio, there was excess consumption of coke vis-à-vis the norms whereas the norm for CDI coal was not achieved. The excess consumption of power and refractories than the norms also led to potential avoidable expenditure of ₹378.24 crore.

Chapter IV

Operational Performance of Blast Furnaces

CHAPTER IV

Operational Performance of Blast Furnaces

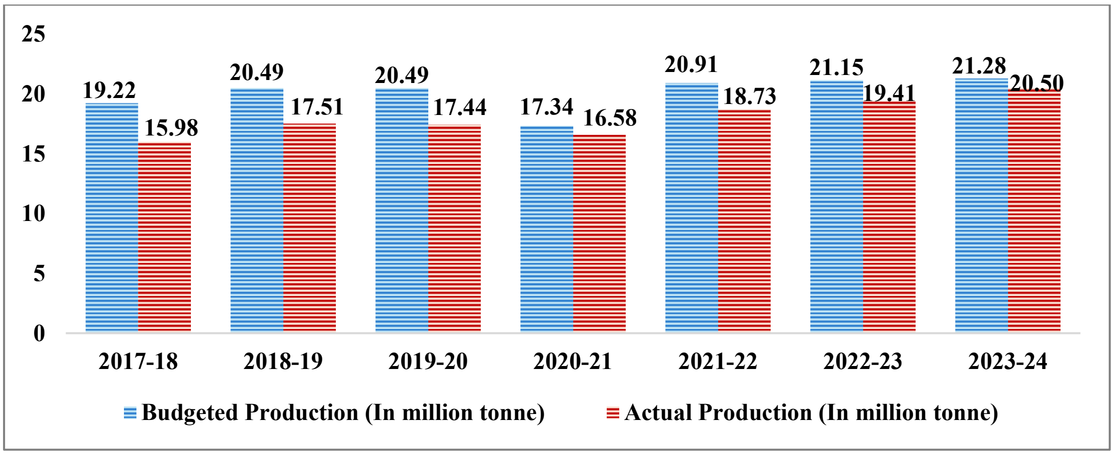
4.1 The Performance of Blast Furnace is assessed by the production of hot metal and the productivity of the Blast Furnace. The Annual Business Perspective lays down the production target of hot metal and the productivity considering operating condition of blast furnace, availability of furnaces, raw materials and market demand of finished products etc. The low production achieved will result in loss of contribution margin while low productivity indicated lower efficiency of blast furnace with higher cost of production.

Figure 6: Hot metal flowing through main trough from BF#8 of Bhilai Steel Plant

Steel plants are required to ensure availability of furnaces through scheduled repair & maintenance, undertaking and completing capital repairs of blast furnaces as per schedule and maximizing the utilization of the Plant available hours to achieve the production targets. The performance of a blast furnace depends on desired level of techno-economic parameters like hot blast temperature, oxygen enrichment, blast volume and blast pressure.

SAIL had the installed capacity to produce of 23.07 mtpa of hot metal (31 March 2024). During the period 2017-2024 the planned production as per Annual Business Perspective was 140.88 million tonne as against which the actual production achieved was 126.15 million tonne. Budgeted and actual production of hot metal in SAIL during 2017-2024 is given in the chart 3.

Chart 3: Budgeted vis-à-vis Actual production of Hot Metal for SAIL for the period 2017 to 2024



Source: Data furnished by Management.

The budgeted production of hot metal marginally increased over the years from 19.22 million tonne to 21.28 million tonne during 2017-2024. During this period the actual production also consistently showed marginal increase except during 2019-20. During 2020-21, Management reduced the budgeted production by 15 *per cent* considering the impact of Covid pandemic.

The audit was conducted with the objective to assess whether the blast furnaces were operated economically, efficiently, and effectively as per the Annual Business Plan/ Perspective. Capital repairs, preventive repairs & maintenance of blast furnaces were carried out as per schedule and techno-economic parameters were achieved. Audit examined records relating to production capacity of blast furnace, production performance of blast furnaces with respect to the Company's Annual Business Plan/Perspective, Blast Furnace productivity, Shutdown plans and its adherence, capital repair projects and techno-economic parameters.

4.2 Production capacity of Blast furnace

SAIL implemented (2008) a Modernization and Expansion Plan of Bokaro, Bhilai, Durgapur, Rourkela, Salem and IISCO steel plant at a cost of ₹76,152 crore (incurred till February 2024). As per the plan, production capacity of hot metal in SAIL was to be increased from 13.83 mtpa (2006-07) to 23.46 mtpa (by 2010). Hot Metal production capacity *vis a vis* actual production during 2017-24 is given in the table below:

Table-4: Production capacity envisaged in MEP vis-à-vis actual

(Qty in million tonne)

Name of the Steel plant	Hot Metal Capacity before MEP (2006-07)	Hot Metal capacity targeted after MEP (2009-10)	Hot Metal capacity as on 31 March 2024
Bokaro	4.59	5.77	5.25
Bhilai	4.08	7.50	7.80
Durgapur	2.09	2.45	2.45
Burnpur	0.85	2.91	2.70

Name of the Steel plant	Hot Metal Capacity before MEP (2006-07)	Hot Metal capacity targeted after MEP (2009-10)	Hot Metal capacity as on 31 March 2024
Rourkela	2.00	4.50	4.65
Bhadravati	0.22	0.33	0.22
Total	**13.83**	**23.46**	**23.07**

Source: Data furnished by Management.

**** Blast Furnace at VISP, Bhadravati has been closed since January 2017; Hot metal is not produced in Salem Steel Plant.***

Audit observed that production capacity in Bokaro, Burnpur and Bhadravati steel plants was not created as envisaged. IISCO steel plant created blast furnace capacity of 2.70 mtpa against the envisaged capacity of 2.91 mtpa as SAIL Management decided (417 Board Meeting held in April 2015) to phase out Blast Furnace #2 of capacity 0.21 mtpa due to economic consideration. Bokaro steel plant also could create blast furnace capacity of 5.25 mtpa against the envisaged capacity of 5.77 mtpa as Bokaro steel plant operates four blast furnaces at a time considering its downstream facilities and one blast furnace remained under capital repair. Bhilai, Durgapur and Rourkela steel plants achieved the envisaged capacity as per the Modernisation & Expansion Plan.

4.3 Production performance of Blast Furnace

The target for production of iron and steel (saleable steel) is stated in the Memorandum of Understanding (MoU) signed by SAIL with Ministry of Steel. Besides this, the production target of hot metal is also laid down in the Annual Business Perspective. During the Exit conference (February 2025) Management stated that the Annual Business Perspective targets were internal and intentionally ambitious, while formal production targets were established through MoU with Ministry.

Audit noted that while the MoU stipulates only the quantitative targets, the Annual Business Perspective also includes other operational and techno-economic parameters. Production of hot metal and achievement of major operational and techno-economic parameters is reviewed periodically by the SAIL Board considering Annual Business Perspective targets. In view of above, Annual Business Perspective serves as a yardstick to assess the performance and therefore, Audit has considered the production target as set in the Annual Business Perspective of SAIL as the benchmark to assess/judge the performance of the blast furnaces of the Company.

- **Production of Hot Metal**

Annual production of hot metal in SAIL was between 15.98 million tonne and 20.50 million tonne during 2017-24 which was less than production plan as per Annual Business Perspective. There was a shortfall in production of hot metal by 14.73 million tonne than the plan during the above period. Further, there was a shortfall of 4.81 million tonne of hot metal than the MoU quantity.

The production target and achievement of production of hot metal during 2017-2024 is given in table 5.

Table 5: Details of the total targeted production of Hot Metal as against the total actual production achieved during 2017-2024

(Qty in million tonne)

Steel plant	Annual Business Perspective Target for Hot Metal	MoU Target for Hot Metal	Production of Hot Metal	Percentage of actual production of Hot Metal with respect to Annual Business Perspective	Percentage of actual production of Hot Metal with respect to MoU
Bokaro	32.71	30.56	29.64	91	97
Bhilai	43.35	39.28	35.14	81	89
Durgapur	17.57	16.22	17.05	97	105
Burnpur	18.43	17.21	16.57	90	96
Rourkela	28.82	27.60	27.75	96	101
Bhadravati	0.00*	0.09	0.00	0	0
Total	**140.88**	**130.96**	**126.15**	**90**	**96**

Source: Data furnished by Management.

*** Blast Furnace at VISP, Bhadravati has been closed since January 2017; Hot metal is not produced in Salem Steel Plant***

The percentage of actual production vis-à-vis the Annual Business Perspective targets ranged between 81 *per cent* (Bhilai Steel Plant) and 97 *per cent* (Durgapur Steel Plant) during the period 2017-2024. The performance of the steel plants with respect to the MoU targets were better and ranged between 89 *per cent* (Bhilai Steel Plant) and 105 *per cent* (Durgapur Steel Plant) during this period.

- **Productivity of Blast Furnace**

Blast Furnace productivity is a performance indicator of the blast furnace measured in terms of hot metal produced per cubic meter of blast furnace working volume per day (tonnes/m^3/day). The Company prepares Annual Business Perspective wherein the Blast Furnace productivity is fixed considering operating conditions of the blast furnace. The table below summarizes the Annual Business Perspective target and average productivity of the blast furnaces of SAIL steel plants.

Table 6: Blast Furnace Productivity at steel plants during the period 2017-24

(tonnes/m^3/day)

Plant	2017-18		2018-19		2019-20		2020-21		2021-22		2022-23		2023-24	
	ABP	Actual	ABP	Actual	ABP	Actual	ABP	Actual	ABP	Actual	ABP	Actual	ABP	Actual
Bokaro	**1.70**	**1.70**	1.89	1.62	1.78	1.70	1.80	1.74	1.89	1.66	1.90	1.72	1.92	1.82
Bhilai	1.73	1.56	1.84	1.50	2.03	1.81	1.91	1.79	2.00	1.73	1.91	1.78	1.94	1.78
Durgapur	**1.72**	**1.76**	1.92	1.78	1.92	1.75	**1.75**	**1.76**	1.86	1.75	1.88	1.87	1.92	1.86
Burnpur	1.89	1.62	2.14	1.74	2.16	2.01	2.05	1.75	2.23	2.02	2.21	2.09	2.27	2.18
Rourkela	1.93	1.88	2.09	1.77	2.08	1.81	**1.88**	**1.98**	2.00	1.92	2.01	1.88	2.05	1.96
SAIL	**1.78**	**1.70**	**1.94**	**1.65**	**1.98**	**1.80**	**1.87**	**1.81**	**1.98**	**1.79**	**1.96**	**1.84**	**2.00**	**1.88**

Source: Data furnished by Management.

It was seen that Bokaro and Rourkela Steel Plant in 2017-18 and 2020-21 respectively and Durgapur Steel Plant in 2017-18 and 2020-21 could achieve the Annual Business Perspective target for Blast Furnace productivity and in rest of the period there was shortfall in achievement. Bhilai and IISCO Steel Plant could not achieve the productivity target during 2017-24. Lower productivity not only reduced the production performance of Blast Furnaces but also increased the coke rate (*discussed in para 3.6*).

Audit observed that lower blast furnace production/productivity was due to excess time consumed on capital repair, unplanned shutdown, non-availability of desired quality and quantity of raw materials, poor offtake by Steel Melting Shop, breakdown of equipment, low blast pressure and blast temperature etc. (*discussed in detail in para 4.5).*

Management replied (November 2023) that SAIL's output had been steadily improving over the years. Regarding non-achievement of productivity, it cited reasons like delay in project execution, commissioning and its stabilization, poor techno-economic parameters, shortage of raw material and spread of COVID-19. Ministry replied (July 2024/February 2025) that Annual Business Perspective targets are set with the aim to achieve higher production with better efficiency. It further stated that actual gangue content in iron ore was higher than anticipation during formulation of the Annual Business Perspective which adversely affected the blast furnace productivity and fuel rate. Corrective action had been initiated by addressing bottlenecks (augmenting downstream facilities), improving the quality of raw materials, oxygen enrichment, use of pellets, higher usage of Coal Dust Injection to improve production/productivity. Consistent improvement in blast furnace productivity in all units was being observed with best blast furnace productivity of 1.88 tonne/m^3/day in SAIL during 2023-24. During the Exit conference (February 2025) Management stated that to maintain Blast Furnace productivity they were planning to install one extra stove at each of the new Blast Furnaces at IISCO Steel Plant, Rourkela Steel Plant and Bhilai Steel Plant.

The replies may be viewed in the light of the fact that SAIL finalises Annual Business Plan/Perspective considering availability of furnaces, raw materials and market demand of finished product etc. Audit took note of the fact that the plan as well as the actual production had shown a marginal increase consistently over the last three years. Also the productivity of blast furnace in SAIL had consistently improved over the last three years but remained below the target and none of the plants could achieve the target in last three years.

To achieve the targeted production and productivity, Management needs to increase the available hours of the Blast furnace by controlling the reasons for unplanned shutdowns and ensuring timely completion of the capital repairs. The techno-economic parameters like hot blast temperature, oxygen enrichment, blast pressure and blast volume also need to be maintained at the desired levels to achieve the targeted production and productivity of blast furnace, as discussed in paras below.

4.4 Factors affecting Blast Furnace Performance

Blast Furnace performance depends mainly on furnace availability/working hours considering the planned/unplanned shutdown, oxygen enrichment, hot blast temperature, blast pressure etc. Capital repair and preventive repair and maintenance are planned and executed from time to time to ensure uninterrupted operation of the equipment. Excess time taken than planned for capital repair and preventive repair and maintenance reduces the available hours.

The table below indicates total calendar hours[32], time consumed for capital repair, scheduled maintenance, and available hours[33] in respect of all operational blast furnaces in SAIL for the period 2017-24.

Table 7: Furnace availability and utilization hours of blast furnaces during 2017-24

Year	Calendar Hours	Scheduled Shutdown hours	Shutdown hours due to Covid	Capital Repair hours	Availability and utilized hours		
					Available Hours	Unplanned Shutdown Hours	Utilized Hours
1	2	3	4	5	6=2- (3+4+5)	7	8=(6-7)
2017-18	1,62,312	5,436	0	28,687	1,28,189	12,136	1,16,053
2018-19	1,63,176	5,739	0	23,140	1,34,297	16,067	1,18,230
2019-20	1,58,112	3,635	432	38,001	1,16,044	10,833	1,05,211
2020-21	1,57,680	4,708	16,674	25,176	1,11,122	8,325	1,02,797
2021-22	1,57,680	4,741	1,680	17,300	1,33,959	9,952	1,24,007
2022-23	1,57,680	4,214	0	21,396	1,32,070	6,227	1,25,843
2023-24	1,58,112	3,907	0	19,192	1,35,013	6,185	1,28,828
2017-24	**11,14,752**	**32,380 (3%)**	**18,786 (2%)**	**1,72,892 (15%)**	**8,90,694**	**69,725 (8%)**	**8,20,969 (92%)**

Source: Data furnished by Management.

It was seen that 15 *per cent* of calendar hours was consumed in capital repair of blast furnaces, 3 *per cent* in scheduled shutdown hours and 2 *per cent* of calendar hours lost on account of Covid pandemic leaving 80 *per cent* of calendar hours available for plant operation during 2017-24. The Blast furnaces were utilised for 92 per cent of available hours for production of hot metal. The available hours increased from 2021-22 onwards due to less time taken for capital repair works and reduction in scheduled shutdown hours as compared to earlier years.

4.4.1 Planned Shutdown

Planned shutdowns majorly include capital repairs besides the scheduled routine repair and maintenance. Capital repair of blast furnaces has been classified into three categories. The table 8 shows the types of repair and activities involved:

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[32] ***24 * no. of days in a year * no. of operational blast furnace in each year.***

[33] ***Total calendar hours less actual hours taken for schedule capital repair, preventive repair & maintenance.***

Table 8: Showing details of the types of Capital repair and activities involved

Type of Repair	Activities conducted	Duration
Category - I	All Activities performed during Category II capital repair. In addition, the furnace hearth is further exposed and all the carbon blocks along with cooling plates in the hearth area are changed.	100-120 days
Category - II	Involves relining of furnace up to hearth level including changing of cooling plates, throat segments, dome liners & top charging equipment.	75-90 days
Category - III	It is conducted mainly to change top charging equipment.	7 days

Source: Data furnished by Management.

4.4.1.1 Policy for Capital Repair

The technical specification of the contract agreement of blast furnaces stipulated a defined campaign life in terms of number of years of operation of blast furnace or in terms of quantity of production. However, there was no structured policy/manual for capital repair of blast furnaces of SAIL plants. Audit observed that in absence of any structured policy/manual for capital repairs in SAIL, there was lack of clarity in taking up of repair work based on fixed years of operation or threshold limit of production. For example, Audit noted that the capital repair of BF#4 of Bokaro was deferred upto 2019-20 (planned to be taken up in 2015-16) due to delay in capital repair of BF#1, which led to operation of the BF#4 at lower productivity.

Management replied (November 2023) that it was difficult to have a centralized uniform policy for repairs of blast furnaces because these were supplied by different suppliers with varied design, volumes, technology, and repair schedules. Ministry replied (July 2024/February 2025) that capital repair of blast furnace was being planned based on the actual condition of the equipment and its refractory regardless of the actual production volume and any uniform policy for the same would not be feasible. The Ministry, however, noted the suggestions of Audit for further study and to explore the possibility of implementation. During the Exit conference (February 2025) Management stated that the structured approach for planning of capital repairs of Blast furnaces by taking age and condition of Blast furnaces, existing broad guidelines and operational status of downstream facilities would continue.

The reply may be viewed in the light of the fact that structured policy for capital repair would ensure synchronized planned shutdowns of blast furnaces to avoid deferment of capital repairs and maximize the efficient operations of blast furnaces.

4.4.1.2 Annual Shutdown Plans

Annual shutdown plans with respect to Capital repair and Preventive repair & maintenance of different components of blast furnaces is indicated in the Annual

Business Perspective for the integrated steel plants. Additional time consumed in capital repair and preventive repair and maintenance than planned, impacts available hours and overall Blast Furnace performance. Further, capital and preventive repairs are planned and undertaken to minimize the unplanned shutdown hours to ensure a high percentage of furnace availability.

On review of capital repair of blast furnaces initiated/completed during 2017-24 and in-progress as on 31 March 2024, Audit observed that extra hours were taken for capital repair of Blast Furnaces than the planned hours. The capital repair planned hours vis a vis actual hours consumed during the period 2017-24 are as below:

Table-9: Hours planned for Capital repair vis-à-vis actual hour consumed during 2017-24

(in Hours)

Year	Capital Repair Plan	Capital Repair Planned but not taken up	Plan hour available for capital repair	Hours saved in capital repair against plan	Hours Utilized for Capital Repair	Extra Hours Taken for Capital Repair	
						Taken up in absence of Plan	Taken up beyond plan
1	**2**	**3**	**4= (2-3)**	**5**	**6**	**7**	**8**
2017-18	18,408	1,896	16,512	0	28,687	8,760	3,415
2018-19	22,752	10,032	12,720	0	23,140	888	9,532
2019-20	26,952	576	26,376	2,040	38,001	40	13,625
2020-21	17,160	1,632	15,528	0	25,176	8,760	888
2021-22	12,384	6,696	5,688	144	17,300	8,760	2,996
2022-23	15,696	3,888	11,808	156	21,396	3,912	5,832
2023-24	14,616	4,587	10,029	312	19,192	8,784	691
2017-24	**1,27,968**	**29,307**	**98,661**	**2,652**	**1,72,892**	**39,904**	**36,979**

Source: Data furnished by Management

As seen from table above, though overall SAIL consumed extra hours on capital repair projects during 2017-24, some projects were completed in lesser time than what was planned for. Also, some capital repair projects were planned but not taken up while some others were taken up despite not been planned for. During 2017-2024, against the plan of 1,27,968 hours for capital repair, 1,72,892 hours were taken. The Company had not taken up capital repairs of 29,307 hours that were planned initially. In some of the projects SAIL completed the capital repairs in lesser time than planned and thereby saved 2,652 hours. Overall SAIL consumed 76,883 extra hours (Col. 7 + Col. 8 in table above) on capital projects.

Out of the 39,904 hours consumed for capital repairs in absence of plans, 30,256 hours were consumed at Bokaro Steel Plant for BF#3, 4 & 5 and 9,648 hours were consumed at BF#1 of Rourkela Steel Plant.

Further, out of 36,979 extra hours consumed on capital repairs beyond the planned hours, maximum of 20,926 hours was consumed at Bhilai Steel Plant followed by 13,965 hours at Bokaro and 1,152 hours at Rourkela Steel Plant. Only 936 hours were consumed at Durgapur, and IISCO Steel Plants. This has resulted in loss of production of hot metal as the Blast furnaces were remained off blast during the period of extra hours taken for capital repair.

The delay was mainly in Bhilai, Bokaro and Rourkela Steel Plant which are discussed in detail below:

Table-10: Capital Repair of Blast Furnaces

Name of the Plant	Reasons for delay	Impact of delay
BF #1 of Rourkela Steel Plant Planned during **July 2014 to April 2016 for 22 months** Actual repair during **July 2014 to May 2018 for 47 months** Additional time taken: **25 months *plus***	Audit noted that the Project Department took 15 months (three months for opening of tender, six months for technical evaluation, two months for commercial evaluation and plant level approval and four months for approval of Corporate office and award of work) in finalization of the order as against six month time approved by the Board. The blast furnace was blown in (May 2018) after 25 months from the scheduled completion period due to delays in tendering and in supply and erection of equipment.	The potential gross margin[34] envisaged by the Company (@₹195.82 crore per year) for the delayed period of 34 months is ₹554.82 crore.
BF#4 of Rourkela Steel Plant Planned for **14 months including furnace shutdown of 3 months (90 days)** Actual **Shutdown for 374 days** Additional time taken: **284 days**	Audit noted that Rourkela Steel Plant took 18 months in award of work after approval of the SAIL Board. The Company initially decided to execute the work on turn-key basis in contrary to the decision of the Board to carry out repairs through different sections/ departments. Staggered supply orders (between April 2019 and August 2020) and receipt of material (between August	Potential loss of contribution of ₹882.73 crore (0.601 million tonne[35] of hot metal equivalent to 0.503 million tonne[36] of Saleable Steel @₹17,558/tonne)

[34] *As calculated by Management considering contribution on additional Pig Iron and savings due to less coke consumption less additional expenditure.*

[35] *@ 2,115 tonne per day for 284 days.*

[36] *@ 83.7 per cent of hot metal in 2020-21.*

Name of the Plant	Reasons for delay	Impact of delay
	2019 and March 2021) contributed towards delay in capital repair.	
BF#1 Bokaro Steel Plant[37] Planned for **October 2016 to January 2018** Actual repair **October 2016 to January 2020** Additional time taken **24 months**	The Management attributed reasons for delay on (i) extra time taken in finalisation of change order for repairing of Bustle pipe by six months and (ii) delay in commissioning (January 2020) of project even after completion of work in July 2019 due to sluggish market condition.	Potential loss of contribution of ₹197 crore (0.31 million tonne[38] of hot metal equivalent to 0.26 million tonne of Saleable Steel) at BF#1.
BF#4 Bhilai Steel Plant Planned for **812 days – (2017-18 to 2021-22)** Actual repair **1311 days (7 January 2018 to 11 August 2021)** Additional time taken **499 days[39]**	Audit noted that Bhilai Steel Plant was unable to synchronize and integrate up-gradation of three Stoves and capital repair of BF#4, which resulted in prolonged shutdown of blast furnace.	Potential loss of contribution of ₹1,579.01 crore (1.396 million tonne of hot metal equivalent to 1.147 million tonne of Saleable Steel)

Source: Data from records furnished by Management.

Management/Ministry replied (November 2023/July 2024/February 2025 & April 2025) that the project of BF#1 of Rourkela Steel Plant was a complex brown field project executed for the first time with new technology and advanced features in the vicinity of existing operating furnaces and in respect of BF#4 stated that due to the complicated nature of technical and commercial details, the project took longer time. It also stated that the notional contribution loss of ₹882.73 crore calculated by Audit was purely theoretical as during 2017-18 Indian Steel industry was going through a challenging phase. It further stated that, BF#1 of Bokaro was ready for commissioning by August 2019 but due to sluggish steel market condition, it was blown in on 8 January 2020. Delay in capital repair of BF#4 at Bhilai was mainly due to delay in supply of refractory for stove and delay in project execution by the agency. During the exit

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[37] ***Blast furnace was blown down since May 2012.***

[38] ***Production loss of BF#1: of 0.31 million tonne (1.64 million tonne from BF#1 after adjustment of 1.33 million tonne from BF#4 during deferment period).***

[39] ***Plan for capital repair 812 days - 2017-18 (150 days), 2018-19 (183 days), 2019-20 (91 days), 2020-21 (365 days) and 2021-22 (23 days) and the days consumed in capital repair from 7 January 2018 to 11 August 2021 for 1311 days. Excess days taken against plan were 499 days (1,311 days minus 812 days plan).***

conference (February 2025) Management accepted the views of Audit with respect to delays in capital repairs at BF#1 & 4 of Rourkela Steel Plant and BF#4 of Bhilai Steel Plant. With respect to BF#1 and 4 of Bokaro Steel Plant, during Exit conference (February 2025) Management stated that there was no actual loss of hot metal as the plant runs with four furnaces and one always remained under capital repair.

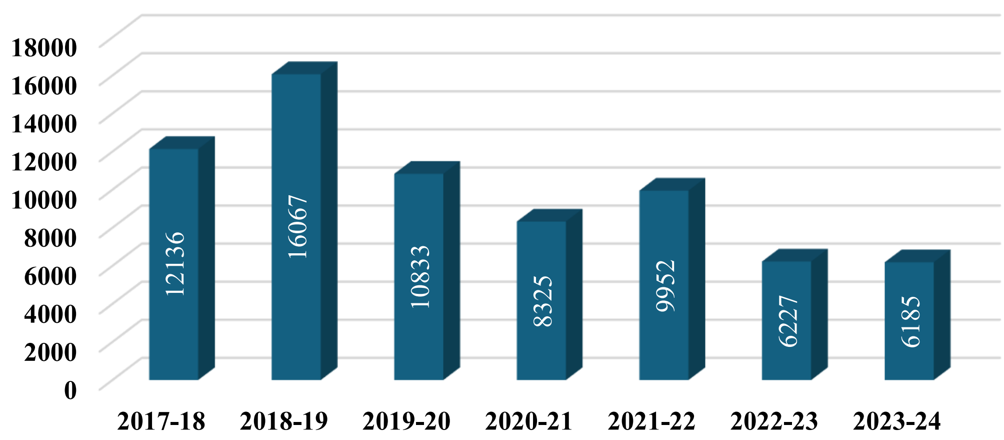
The replies may be viewed in the light of the fact that Management was aware of the scope of work, the site condition and that the project of BF#1 at Rourkela was a brownfield project. Moreover, the potential loss of contribution has been calculated for the period December 2019 to September 2020 and not for the period 2017-18. The reply regarding BF#4 of Rourkela was silent on execution of the project on turnkey basis contrary to the decision of the Board. In respect of BF#1 of Bokaro Steel Plant, it was noted that there was growth in Steel industry between 2019 and 2023. Also, the potential loss of contribution due to delay in the capital repair of BF#1 at Bokaro has been calculated after considering the production of hot metal by BF#4 during the deferment period. In respect of BF#4 of Bhilai Steel Plant refractory material was to be supplied by Bhilai Steel Plant to the contractor and it did not hand over the stoves at planned intervals.

Recommendation 2: The Company may prepare a structured policy for capital repair of blast furnaces and timely completion of capital repairs to ensure synchronized planned shutdowns of blast furnaces to avoid deferment of capital repairs and maximize the efficient operations of blast furnaces.

4.4.2 Unplanned Shutdown

Unplanned shutdowns is the off blast[40] period of the blast furnace which was not planned and directly impacts production performance.

Chart 4: Year-wise Unplanned Shutdown Hours for SAIL for the period 2017-2024

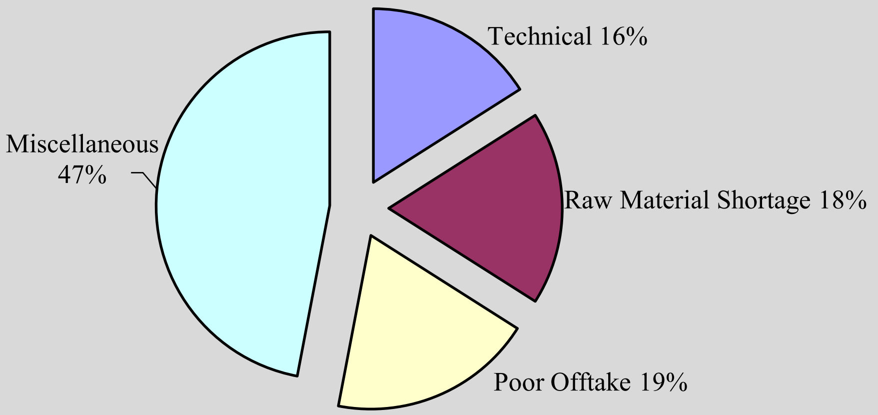


[40] *Temporary period for which the blast furnace is not in operation for a situation when the full production capacity of the furnace is either not required or to perform various maintenance activities is termed as off blast period.*

High off blast/idle hours were noted in three years up to March 2020 while it improved marginally during 2020-24. Improvement of 43 *per cent* in idle hours in 2023-24 was noted as compared to the year 2019-20. Out of total 8,90,694 available hours for plant operation, the blast furnaces were utilised for 8,20,969 hours and for balance 69,725 hours (8 *per cent*) the blast furnaces remained off blast on account of unplanned shutdowns during 2017-24 (*Table 7*). Among the steel plants, maximum duration of unplanned shutdown was noted in Bhilai Steel Plant for 30,290 hours followed by Bokaro Steel Plant (14,927 hours), Rourkela Steel Plant (12,655 hours), Durgapur Steel Plant (9,028 hours) and IISCO Steel Plant (2,825 hours).

Details of break-up of reasons of unplanned shutdown hours in SAIL steel plants (except IISCO Steel Plant[41]) is given in the chart below.

Chart 5: Percentage of Unplanned shutdown hours in SAIL during 2017-2024



Source: Data furnished by Management.

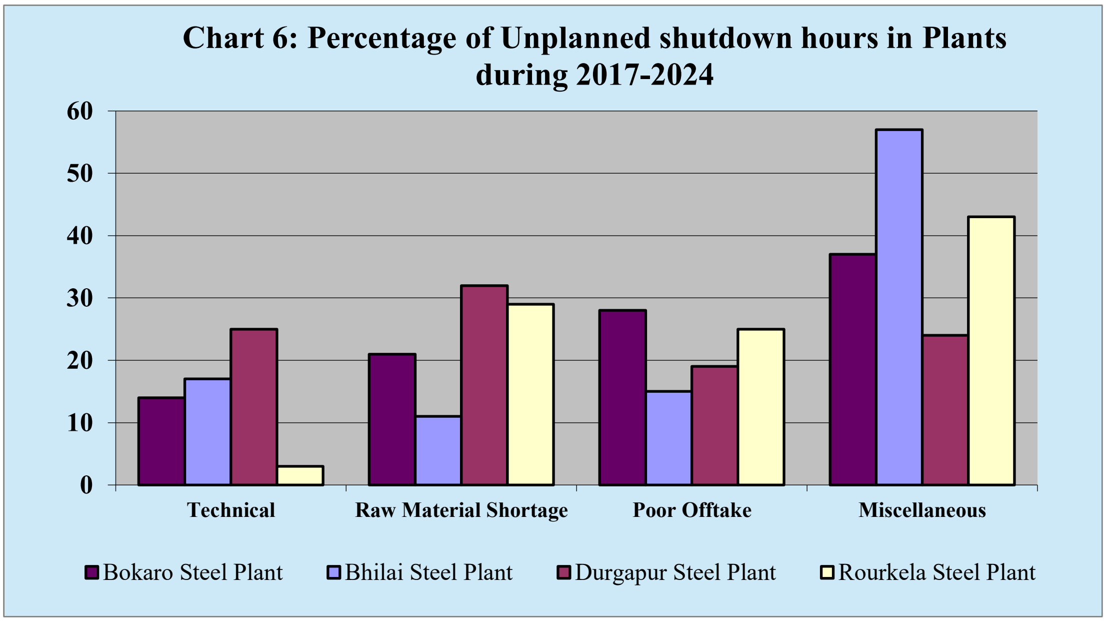
High unplanned shutdown hours left less hours for plant utilization for hot metal production. Audit noted that these were mainly attributable to the shortage of raw materials, poor off take of hot metal by Steel Melting Shops, technical (electrical/mechanical/ operational/ instrumentation failures) and other miscellaneous issues. It was noted that Bhilai, Bokaro, Rourkela and Durgapur Steel Plant did not separately identify the reasons in 47 *per cent* of the delay hours. During unplanned shutdowns production from blast furnaces remained temporarily ceased which resulted in inability to produce 6.993 million tonne of hot metal and inability to gain potential contribution margin of ₹ 7,986.97 crore[42] during 2017-24.

[41] ***IISCO Steel Plant did not segregate the reasons for delays till 2019-20 and all delay hours were put under miscellaneous reasons. Though reasons for delay were identified during 2020-22, 98 per cent of delay was attributed to miscellaneous reasons without analysis of the exact reasons.***

[42] ***Considering loss of production of hot metal (Average hot metal production per hour * Unplanned shutdown hours) and loss of contribution on saleable steel (quantity of saleable steel that could have been produced from the hot metal * Contribution per tonne of saleable steel). This excludes the loss of production of 1.513 million tonne of hot metal with contribution margin of ₹1,728.01 crore on account of shortage of raw materials as this was included in Para 3.3(A) of CAG Report No. 10 of 2025 'PA report on Inventory Management in SAIL'.***

It was seen that poor off take of hot metal by steel melting shops and shortage of raw material caused maximum delays followed by technical issues. Audit noted that out of the 11,253 hours (16 *per cent*) of unplanned shutdown due to technical reasons, 491 hours (4 *per cent*) was on account of electrical, 3,264 hours (29 *per cent*) on account of mechanical, 7,251 hours (65 *per cent*) on account of operational failure and 247 hours (2 *per cent*) on account of instrumentation failures during 2017-24. Apart from above, delay under miscellaneous category was 47 *per cent* of total delay hours mainly due to low/off blast and reduced wind which resulted in operation of blast furnace at reduced capacity.

Plant-wise break-up of unplanned shutdown hours on account of various reasons in SAIL steel plants is given in the chart.



Source: Data furnished by Management

Audit noted that more than 20 *per cent* of total delay hours was attributable to technical reasons in Durgapur Steel Plant, shortage of raw material in Bokaro (during 2017-22), Durgapur, Rourkela and IISCO Steel Plant and poor off take by Steel Melting Shop in Bokaro, Rourkela and Durgapur Steel Plant during 2017-24 (2020-24 for IISCO Steel Plant). Reasons either not identified or multiple categories of reasons attributed to shutdowns were kept under the miscellaneous category which was between 22 *per cent* and 58 *per cent*.

Such unplanned shutdown of the Blast furnace which is over and above the scheduled planned shutdown leads to lesser availability of the blast furnace for hot metal production. Better availability of blast furnace could be achieved by preventing such occurrences through periodical repair & maintenance, ensuring availability of raw materials as per plan, addressing the logistical issues downstream etc.

Management/ Ministry replied (November 2023/July 2024 & February 2025) that the reasons for unplanned shutdowns were being addressed through commissioning of downstream facilities, shortage of raw material was being addressed by maintaining coal stock at plants by augmenting rake availability, Inter Plant transfer of coke and sinter from plants, purchase of coke if required, etc. It also added that Standard operating practices had been modified based on the learnings. The measures implemented are yielding positive results, as evidenced by the consistent year-on-year improvement either in furnace availability percentage or utilization percentage. During the Exit conference (February 2025) Management while stating that unplanned shutdowns were on a decreasing trend, assured to examine the reasons to minimize the same with revision of operational disciplines.

Reply may be viewed in the light of the fact that there has been improvement in the unplanned shutdown hours over the last four years and it reduced by 4,648 hours (43 *per cent*) in the year 2023-24 than the year 2019-20. Thus, through consistent efforts, Management can further control the unplanned shutdown hours and thereby achieve better availability of the blast furnace.

Recommendation 3: The Company may minimise the unplanned shutdown hours by ensuring better availability of blast furnace through periodical repair & maintenance, ensuring availability of raw materials and addressing the off take issues downstream.

4.5 Non-achievement of techno-economic parameters

Hot Blast Temperature, Oxygen enrichment, Blast Pressure and Blast Volume are important techno-economic parameters for blast furnace operation. The production and productivity of the Blast furnace depends on desired level of above indices which are discussed below:

4.5.1 Hot Blast Temperature

Hot Blast Temperature is the temperature of the air which is heated in the hot blast stoves and fed into the blast furnace through the tuyeres for combustion of fuel. Blast Furnaces are fed with preheated air (from 900^{0}C to 1250^{0}C) through tuyeres which increases the temperatures to about 1650°C. As per the general plant operation manual, high hot blast temperature increases the productivity of the blast furnaces and decreases the consumption of coke whereas decrease in hot blast temperature of 100^{0}C results in higher coke consumption by 2-3 *per cent* which increases the cost of hot metal.

The desired hot blast temperature and actual achieved by the steel plants during 2017-24 is as below:

Table-11: Plant wise average Hot Blast Temperature

(Measured in ^{0}C)

Steel Plants	Year	2017-18		2018-19		2019-20		2020-21		2021-22		2022-23		2023-24	
	BF No.	Desired	Actual	Desired	Actual	Desired	Actual	Desired	Actual	Desired	Actual	Desired	Actual	Desired	Actual
Old Blast Furnaces															
Bokaro Steel Plant	**BF#1**	-	-	-	-		1005	1150	1046	1150	1068	1100	1074	1100	1062
	BF#2	970	963	950	949	970	951	970	937	970	914	950	920	950	908
	BF# 3*	***900***	***905***	***900***	***901***	900	869	***900***	***909***	900	862	900	753	0	0

Steel Plants	Year	2017-18		2018-19		2019-20		2020-21		2021-22		2022-23		2023-24	
	BF No.	Desired	Actual	Desired	Actual	Desired	Actual	Desired	Actual	Desired	Actual	Desired	Actual	Desired	Actual
	BF#4*	900	899	900	849	850	802	-	-	-	-	1000	986	1000	1044
	BF#5	***1000***	***1021***	1000	994	1000	990	1000	964	1000	986	1000	987	1000	1010
Bhilai Steel Plant	**BF#1**	920	914	***920***	***926***	950	897	920	865	920	823	-	780	-	810
	BF#2*	920	861	-	-	-	-	-	-	-	-	-	-	-	-
	BF#3*	920	873	920	861	-	-	-	-	-	-	-	-	-	-
	BF#4*	900	776	925	-	-	-	-	-	1000	959	-	954	-	979
	BF#5	900	857	925	905			1000	935	1000	931	-	934	-	956
	BF#6	***960***	***975***	980	950	1000	981	1000	965	1000	956	-	934	-	931
	BF#7	960	954	***980***	***985***	1000	974	1000	955	1000	903	-	907	-	949
Durgapur Steel Plant	**BF#2**	***1000***	***1001***	1000	992	1000	969	1000	952	1000	934	1000	950	1000	923
	BF#3	1000	983	1000	988	1000	979	1000	959	1000	962	1000	954	1000	898
	BF#4	1000	800	975	969	1000	952	980	946	980	921	950	931	950	934
Rourkela Steel Plant	**BF#1**	1150	-	1150	1056	1150	1138	***1150***	***1150***	***1150***	***1156***	1150	1141	1150	1116
	BF#4	1000	947	1000	912	1000	905	1000	979	1000	993	1000	981	1000	966
New Blast Furnaces															
Bhilai Steel Plant	**BF#8**	-	993	1100	1074	1150	1114	1150	1127	1150	1102	1150	1108	1200	1152
IISCO Steel Plant	**BF#5**	1200	1199	1200	1137	1200	1081	1200	1108	1200	1146	1200	1139	1200	1155
Rourkela Steel Plant	**BF#5**	1200	1178	1200	1143	1200	1171	1200	1158	1200	1137	1200	1140	1200	1137

Source: Data furnished by Management.
****BF#2&3 of Bhilai Steel Plant was phased out, BF#4 of Bhilai Steel Plant was under capital repair till August 2021, BF#4 of Bokaro Steel Plant was under capital repair till August 2022 and BF#3 of Bokaro Steel Plant was under capital repair since September 2022.***

Audit noted that none of the three new blast furnaces at Bhilai (BF#8), Burnpur (BF#5) and Rourkela (BF#5) could achieve the desired hot blast temperature during 2017-24. Further, the old blast furnaces of SAIL also could not achieve the desired level of hot blast temperature except in case of the following during 2017-24.

- In Bokaro Steel Plant, BF#3 (2017-18, 2018-19 & 2020-21), BF#4 (2023-24) and BF#5 (2017-18 & 2023-24).
- Bhilai Steel Plant -BF#1, 6 & 7 in 2018-19, 2017-18 & 2018-19 respectively;
- Durgapur Steel Plant- BF#2 in 2017-18 and
- Rourkela Steel Plant -BF#1 in 2020-21 & 2021-22.

The reasons attributable for low hot blast temperature were under performance of stoves and associated blowpipes due to ageing, high skin temperature of stoves shell and dome shell due to poor health of refractory lining etc. Also, there were delays in capital repairs of the blast furnaces (as *discussed in para 4.4.1.2)*.

Management replied (November 2023) that it had taken measures like gunning[43] and one layer refractory lining at Bhilai Steel Plant and repair rebuilding of Stoves at Durgapur Steel Plant was taken up. Ministry added (July 2024/February 2025) that new stove at IISCO Steel Plant was expected to be commissioned by May'2025. Level of hot blast temperature would increase after commissioning of new stove in BF#4 of Durgapur Steel Plant. During the Exit conference (February 2025) Management informed that necessary steps like installation of stoves in different large Blast furnaces was being done to address the issue.

The replies may be viewed in the light of the fact that most of the stoves were in operation for more than 15 years. Measures for relining of refractories, replacement, repair, and rebuilding of stoves may be carried out in a timely manner. Further, despite measures been taken by the respective plant management, Audit noted that desired level of hot blast temperature was not maintained during 2017-24. The project for installation of 4th stove in BF#4 of Durgapur Steel Plant scheduled for completion by July 2022 was completed in August 2025.

4.5.2 Oxygen Enrichment

Oxygen enrichment of the blast furnace is an alternative method to increase thermal efficiency. It is the percentage of oxygen added to Blast volume to enrich it. Use of oxygen results in higher temperature, reduction in coke consumption and permits rapid attainment of metal temperature at the start of melting. SAIL envisaged an increase of about 2 to 4 *per cent* in production of hot metal for an increase of every one *per cent* of oxygen enrichment above the normal air blast (21 *per cent*).

The blast furnaces at SAIL could not achieve the respective desired level of oxygen enrichment except BF#5 (new furnace) of Rourkela Steel Plant in all the years during 2017-24, BF#2 and BF#3 of Durgapur Steel Plant in 2017-18 & 2022-24 and 2021-24 respectively and IISCO Steel Plant in 2023-24 as seen in table below.

Table-12: Plant wise Average Oxygen Enrichment

Name of Plant	Blast Furnace	Oxygen Enrichment (%)							
		Desired	Actual						
			2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24
Bokaro Steel Plant	BF#1	5	0	0	0	0.51	0.77	1.06	1.40
	BF#2	6	2.22	1.69	1.93	1.12	0.65	1.46	1.74
	BF#3	5	2.46	2.1	2.28	0.95	1.79	1.97	-
	BF#4	5	1.43	1.12	1.77	0	0	1.19	1.47
	BF#5	5	1.87	0.42	1.44	1.29	0.49	0.92	1.52

43 ***Gunning is the process of spraying refractory material onto damaged areas inside the stove to repair and maintain its lining.***

Name of Plant	Blast Furnace	Oxygen Enrichment (%)							
		Desired	Actual						
			2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24
Bhilai Steel Plant	BF#1	2.5-3.5	1.77	1.64	1.55	1.64	1.79	1.82	1.08
	BF#2	Phased out	0.15	-	-	-	-	-	-
	BF#3	Phased out	1.18	0.44	-	-	-	-	-
	BF#4	4	1.45	-	-	-	1.4	1.76	1.93
	BF#5	4	1.18	0.56	-	1.31	1.97	1.86	1.79
	BF#6	4	3.66	1.5	1.97	1.5	1.84	1.60	0.84
	BF#7	4	2.8	2.32	1.95	2.07	1.02	2.09	3.28
	BF#8	4-6			2.03	3.77	3.3	**4.41**	**4.87**
Durgapur Steel Plant	BF#2	2.5-3.5	**2.5**	2.3	2	2	2.4	**2.97**	**2.69**
	BF#3	3.5	2.9	3.3	2.7	3	**3.5**	**3.57**	**3.69**
	BF#4	4	2.8	3.2	2.9	3.5	3.8	3.73	3.65
IISCO Steel Plant	BF#5	4	1.8	3.18	3.37	2.19	3.65	3.81	**4.34**
Rourkela Steel Plant	BF#1	4	-	1.3	2.4	2.77	2.5	1.8	2.4
	BF#4	4	1.52	1.13	1.31	1.98	2.35	1.56	1.73
	BF#5	4 to 6	**5.08**	**4.32**	**4.47**	**4.08**	**4.99**	**4.8**	**6.07**

Source: Information furnished by Management.

It was seen that all the steel plants except Bhilai Steel Plant[44] have fixed oxygen enrichment parameters depending on the capacity and age of blast furnaces which was between 2.5 *per cent* and 6 *per cent*. Oxygen enrichment was not achieved due to:

- Lower capacity of the existing oxygen plant and delay in installation of new oxygen plant in Bokaro Steel Plant.
- Limited availability of enrichment facility in Durgapur Steel Plant.
- Non-achievement of targeted production capacities in Rourkela Steel Plant.
- Non-operation of the blast furnace as per design capacity and low hot blast temperature in case of new blast furnaces at Bhilai Steel Plant and IISCO Steel Plant.

The non-achievement of the desired level of oxygen enrichment during 2017-2024, while the Steel Plants of SAIL could not achieve the envisaged production targets as per Annual Business Perspective, indicates that the hot metal production could have been improved through better oxygen enrichment.

Management/ Ministry replied (November 2023/ July 2024 & February 2025) that low oxygen enrichment was due to delays in execution of projects related to blast furnaces, throttling of furnace regime due to weak furnace health. Oxygen enrichment has increased considerably in Bokaro Steel Plant after commissioning of Air Turbo

[44] ***In case of Bhilai Steel Plant, Audit considered the desired level of oxygen enrichment as 4 per cent for BF# 4 to 7 in line with BF#1 installed at Rourkela Steel Plant. For BF#1 of Bhilai Steel Plant, Audit considered the lowest parameters 2.5 to 3.5 in line with BF#2 at Durgapur Steel Plant. For BF#8, Bhilai Steel Plant has fixed norms 4 to 6 per cent oxygen enrichment.***

Compressor and Oxygen Turbo Compressor projects in October 2022 and the targeted level would be achieved from FY 2025-26 onwards after commissioning of the new Build Own and Operate plant. At IISCO Steel Plant, oxygen enrichment had gradually increased with increasing production level. Oxygen supply was reduced during COVID period. During the Exit conference (February 2025) Management informed that necessary steps like installation of new oxygen plants in different units was being done to address the issue

Reply of the Management may be viewed in the light of the fact that the management has accepted that there were delays in capital projects (*as discussed in para 5.2*) that impacted the oxygen enrichment. Besides, there was delay in award of contract of the new Oxygen Plant in Bokaro Steel Plant which was scheduled for completion in July 2024 but was commissioned in January 2025.

4.5.3 Blast Pressure and Blast Volume

Blast pressure[45] is the air pressure at which hot blast air is supplied from the stove system into the blast furnace through the tuyeres. Blast pressure ensures proper penetration of hot air through the burden (coke, sinter, pellets, ore) and improves gas permeability and drives the ascending reducing gases upward. Blast volume[46] is the quantity (flow rate) of hot blast air blown into the furnace, which controls the combustion of coke and injected fuel. Higher blast volume generates more reduction gas (CO, H_2) which supports higher productivity.

The desired blast pressure and blast volume and actual achieved by the steel plants during 2017-2024 is as below:

Table-13: Blast Pressure and Blast Volume and Actual achieved by the steel plants during 2017-2024

Name of Plant	Desired Level	Actual						
		2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24
Blast Pressure (Kg/cm^2)_Old Plants								
Bokaro Steel Plant	2.20-2.50*	1.92-2.45	1.95-2.48	1.87-2.37	1.87-2.22	1.97-2.21	1.70-2.20	2.13-2.19
Bhilai Steel Plant	-	1.10-2.12	1.20-2.22	1.23-2.61	0.81-1.80	1.54-2.05	1.39-2.37	1.57-2.49
Durgapur Steel Plant	1.65-1.70	1.45-1.64	1.46-1.60	1.42-1.60	1.57-1.85	1.46-1.63	1.53-1.62	1.44-1.66
Rourkela Steel Plant	1.70-3.00	1.48	1.2-1.44	1.30-2.32	1.57-2.64	1.56-2.75	1.51-2.55	1.58-2.80
Blast Pressure (Kg/cm^2)_New Plants								
Bhilai Steel Plant	-	1.95	2.77	4.07	3.48	3.73	3.97	4.00

45 Blast pressure refers to the force measured in Kg/cm^2 with which the hot air (blast) is injected into the blast furnace through the tuyeres.

46 Blast Volume refers to the amount of hot air (blast) that is blown into the blast furnace through the tuyeres per unit of time measured in Nm^3/Hour.

Name of Plant	Desired Level	Actual						
		2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24
IISCO Steel Plant	4.00	3.38	3.51	3.64	3.47	3.89	3.90	3.97
Rourkela Steel Plant	4.00	3.87	3.71	3.7	3.58	3.86	3.85	3.92
Blast Volume ($10^3 Nm^3/hr$)_Old Plants								
Bokaro Steel Plant	162-240	157-221	165-222	116-225	173-219	172-214	161-223	178-231
Bhilai Steel Plant	-	71-203	95-210	95-202	93-192	97-179	96-202	56-201
Durgapur Steel Plant	125-140*	115-122	116-124	118-130	113-129	116-127	117-130	116-135
Rourkela Steel Plant	120-145	123	112-119	104-135	144-156	118-144	116-141	126-147
Blast Volume ($10^3 Nm^3/hr$)_New Plants								
Bhilai Steel Plant	330	176	296	339	341	339	356	353
IISCO Steel Plant	306	291	302	327	313	333	340	341
Rourkela Steel Plant	330	306	305	303	308	310	312	344

Source: Data furnished by Management.

* *For the period 2022-2024 only.*

Durgapur, Rourkela, IISCO Steel Plant and Bokaro Steel Plant (for 2022-24) had fixed the desired level of blast pressure for each of their blast furnaces while Bhilai Steel Plant had not fixed any norm. Audit noted low blast pressure between 0.81 and 2.80 Kg/cm^2 against the desired level between 1.65 and 3.00 Kg/cm^2 in old blast furnaces. The blast pressure was between 1.95 and 3.97 Kg/cm^2 against the desired level of 4 Kg/cm^2 in the new furnaces except BF#8 of Bhilai Steel Plant in 2019-20 and 2023-24 which achieved blast pressure of 4.07 Kg/cm^2 and 4 Kg/cm^2 respectively.

Desired level of blast volume was fixed by Rourkela and IISCO Steel Plant for 2017-24 and by Bokaro & Durgapur Steel Plant for 2022-24 whereas Bhilai Steel Plant for the entire period of 2017-24 and Bokaro & Durgapur Steel Plant for 2017-22 had not fixed the desired level of blast volume during 2017-24. Audit noted that blast volume was between 71 and 231 (10^3 Nm^3/hr) against the desired level of 120 and 240 (10^3 Nm^3/hr) in old furnaces and between 176 and 356 (10^3 Nm^3/hr) against the desired level of 306 and 330 (10^3 Nm^3/hr) in the new furnaces.

As stated by Management, low blast pressure and blast volume were attributable to furnace health, frequent breakdown of aged stoves and operating stoves with reduced capacity, raw material quality & availability and hot metal evacuation rate. Lower blast pressure and blast volume adversely impacted the Blast Furnace productivity, high coke rate and reduction in hot metal production.

Management/ Ministry replied (November 2023/ February 2025/April 2025) that fixation of separate norms was not necessary relating to pressure and volume of air as the furnaces were operated with optimum balancing parameters to safeguard the furnace by slowing down the production rate. Blast volume and blast pressure are maintained constantly to achieve higher productivity and higher production levels. Ministry further added that in view of variation in raw material properties, furnace condition and interplay between Hot Blast Pressure & Volume, setting fixed norms for Hot Blast Pressure & Volume was unviable and instead, a flexible range based on real-time process data and historical trends would be more effective for stable operations. During the Exit conference (February 2025) also Management reiterated this fact.

Replies may be viewed in the light of the fact that norms had been prescribed by all the Steel Plants of SAIL except Bhilai. As blast pressure and blast volume are critical techno-economic parameters of a blast furnace impacting its productivity, achievement of the laid down norms may lead to optimum performance of the blast furnace.

Recommendation 4: The Company may fix norms for all techno-economic parameters for all blast furnaces at the steel plants. Efforts may be made to adhere to the desired parameters to achieve desired level of hot metal production and Blast Furnace productivity.

Summing up

The production of hot metal and the productivity of the blast furnaces are the measures to assess the performance of blast furnace. The production capacity of hot metal in SAIL was not augmented as envisaged in the Modernization and Expansion Plan. There was less production of hot metal by 14.73 million tonne and 4.81 million tonne than the Annual Business Perspective and the MoU quantity respectively during 2017-24. The percentage of actual production vis-à-vis the Annual Business Perspective targets ranged between 81 *per cent* (Bhilai Steel Plant) and 97 *per cent* (Durgapur Steel Plant) during the period 2017-2024. The performance of the steel plants with respect to the MoU targets were better and ranged between 89 *per cent* (Bhilai Steel Plant) and 105 *per cent* (Durgapur Steel Plant) during this period.

The blast furnace productivity could be achieved by Bokaro and Rourkela Steel Plant in 2017-18 and 2020-21 respectively and Durgapur Steel Plant in 2017-18 and 2020-21 and in rest of the period there was shortfall in achievement. The excess time taken in planned and unplanned shutdowns affects the available hours for blast furnace operations. High unplanned shutdowns were mainly attributable to the shortage of raw materials, poor off take of hot metal by Steel Melting shops, technical (electrical/mechanical/operational/instrumentation failures) and other miscellaneous issues. Non-achievement of techno-economic parameters like hot blast temperature, oxygen enrichment, blast pressure and blast volume also adversely impacted the performance of the blast furnaces. Such shutdown of blast furnaces beyond planned periods or operations with techno-economic parameters below the desired levels resulted in loss of available furnace hours and consequent loss of production.

To enhance the performance of blast furnaces, SAIL may strengthen maintenance practices to minimize unplanned shutdowns and strictly adhere to schedules for planned shutdowns. Continuous monitoring and optimization of key techno-economic parameters such as hot blast temperature, oxygen enrichment, blast pressure and volume may also contribute towards the achievement of the hot metal production/productivity envisaged in the Annual Business Perspective.

Chapter V

Blast Furnace Output

CHAPTER V

Blast Furnace Output

5.1 Blast furnace produces hot metal, which is sent to Steel Melting Shop for production of Crude Steel which is either sent to Rolling Mills for production of Saleable Steel or sold as semi-finished product. The output of blast furnace (hot metal and slag) are dealt at different downstream units like Steel Melting Shop, Pig Casting Machine and Slag Granulation Plant set up at different locations inside the steel plant. In case of any problem noted in the Steel Melting Shop, hot metal is poured into Pig Casting Machine where pig iron is generated. In case where neither hot metal can be sent to the Steel Melting Shop nor poured into Pig Casting Machine, hot metal is dumped into sand pit and after recovery, it is sold as scrap. In the steel making process, impurities like slag is generated which is dumped as a waste or granulated and sold for use in cement industry.

In an integrated steel plant, the capacities of different upstream and downstream facilities[47] is required to be commensurate to maximise the overall production of steel. Any imbalance in the upstream and downstream facilities leads to under utilisation of plant capacity.

Audit examined the different outputs from blast furnaces of SAIL during the period 2017-2024 and assessed whether the projects relating to upstream and downstream facilities of blast furnace were planned judiciously and executed economically and efficiently. These issues have been further discussed in detail in the succeeding paragraphs.

5.2 Capacity imbalance in steel making process

Capacity imbalance in Blast Furnace operations occurs when the installed or upgraded capacity of the Blast furnace is not commensurate with the supporting upstream facilities such as Coke ovens, Sinter plants and Steel Melting Shops in the downstream. This results in operational bottlenecks, underutilisation of created assets, reduced efficiency of the integrated steel plant and higher specific consumption of inputs. The imbalance reflects deficiencies in capacity planning, synchronisation of projects, and monitoring of execution schedules.

Table 14 shows the capacity of blast furnace with its upstream and downstream facilities at the steel plants of SAIL during 2017-2024.

[47] *Upstream facilities include Raw Material Handling Plant, Sinter Plant, Coke Oven Battery and Downstream facilities include Steel Melting Shop, Pig Casting Machine, Slag Granulation Plant etc.*

Table 14: Year-wise capacity of blast furnace and its upstream and downstream facilities during 2017-24

(in mtpa)

Name of Steel Plant	Year	Existing Capacity (million tonne)					Required Capacity to match the BF capacity (million tonne)		Existing to Required Capacity (in %)	
		RMHP[48]	Sinter Plant	Coke oven Batteries	BF	SMS	Sinter Plant[$]	SMS[#]	Sinter Plant	SMS
Bokaro	2017-22	11.00	6.90	3.48	5.25	4.36	6.37	4.90	108	89
	2022-24	11.00	6.90	3.48	5.25	4.66	6.37	4.90	108	95
Bhilai	2017-18	14.60	10.00	3.30	7.80	5.50	9.46	7.28	106	76
	2018-24	14.60	10.00	3.30	7.80	7.00	9.46	7.28	106	96
Durgapur	2017-24	4.50	3.01	1.66	2.45	2.20	2.97	2.29	101	96
IISCO	2017-24	5.43	3.88	1.36	2.70	2.50	3.28	2.52	118	99
Rourkela	2017-24	12.00	6.76	2.17	4.65	3.60	5.64	4.34	120	83

Source: Information furnished by Plant Management

[$] As per MEP-2008: Sinter capacity of 7 million tonne for Hot Metal capacity of 5.77 million tonne of Blast furnace in case of Bokaro Steel Plant (@121.32 per cent of hot metal i.e. 7/5.77*100)

[#] As per MEP-2008: Steel Melting Shop of 4.2 million tonne for Hot Metal capacity of 4.5 million tonne of Blast furnace in case of Rourkela Steel Plant (@93.33 per cent of hot metal i.e. 4.2/4.5*100)

As seen from the table above, the upstream facilities of Raw Material Handling Plant, Coke oven batteries and Sinter Plant were commensurate to meet the requirements of the Blast Furnaces in all the Steel plants. However, in the downstream, capacity of the Steel melting shops could not meet the capacity of the Blast furnace at Bokaro and Rourkela Steel Plants. Such imbalance in the downstream capacity would lead to throttling of the blast furnace regime or generation of Pig iron and consequent loss of production of hot metal and contribution margin. Reasons for the capacity imbalance in the upstream and downstream facilities at Rourkela and Bokaro Steel Plant[49] are discussed below.

5.2.1 Delays in capital projects leading to capacity imbalance

5.2.1.1 Capacity imbalance at Rourkela Steel Plant

Rourkela Steel Plant has rated capacity of 4.65 mtpa[50] for production of hot metal, while the crude steel making capacity is 3.6 mtpa[51], with the commissioning (March 2022) of

48 Raw Material Handling Plant supplies base mix to the Sintering Plant and coal to the Coke oven batteries and Iron ore lump to Blast Furnace.

49 At Bhilai Steel Plant, imbalance in hot metal to crude steel capacity was noted only in 2017-18 and therefore, Bhilai Steel Plant was excluded.

50 BF#1: 1.01 mtpa, BF#4: 0.86 mtpa and BF#5: 2.78 mtpa.

51 SMS-I: 0.5 mtpa and SMS-II: 3.1 mtpa.

Hot Strip Mill-II, the capacity of rolling mills increased to 4.53 mtpa[52]. The entire hot metal produced could not be converted into finished steel and consequently there was potential loss of contribution margin.

Audit observed considerable delays in implementation of projects aimed at addressing the imbalance between hot metal and crude steel capacities at Rourkela Steel Plant.

Slab Caster #4: In the Modernisation and Expansion Plan it was envisaged (2008) to enhance the crude steel making capacity to 4.2 mtpa for which up-gradation of Casters #1 and #2 of Steel Melting Shop II was planned, but did not materialise. Center for Engineering & Technology[53] recommended (2012-13) installation of a new caster in Steel Melting Shop II to achieve crude steel capacity from 3.1 mtpa to 3.7 mtpa. Rourkela Steel Plant decided in February 2016 to install the 4th Slab Caster for which Stage-I approval was accorded in May 2019 at a cost of ₹745.82 crore. Center for Engineering & Technology recommended a time period of 37 months for completion of the project at the stage of preparation of feasibility study (June 2017) which was reduced (May 2019) to 27 months in stage-I approval. Due to the reduction of timeline the tender was cancelled twice in January 2020 as no bidder agreed to complete the work in 27 months. Subsequently, the tender was cancelled in October 2020 due to restrictions imposed under Public Procurement Policy[54]. The project was awarded only in February 2022 at a revised cost of ₹922.31 crore and was expected to be completed by July 2025. There was a delay of over six years in installation of 4th Slab Caster from the initial recommendation of Center for Engineering & Technology. The imbalance in capacity of 0.6 mtpa (3.7 mtpa – 3.1 mtpa) of crude steel would continue till the installation of the 4th Slab caster and resulted in potential loss of envisaged annual savings of ₹633.78 crore.

Steel Melting Shop-III: The hot metal capacity of the blast furnaces of Rourkela Steel Plant increased to 4.65 mtpa[55] after commissioning of BF#5 in August 2013 and augmentation of BF#1 in May 2018. Despite being aware of capacity imbalances since May 2018, proposal for setting up Steel Melting Shop-III of one mtpa was initiated belatedly in February 2020 (with proposed closure of SMS-I). The Committee of Directors, SAIL returned (April 2021) the proposal submitted (February 2021) for stage-I approval to install Steel Melting Shop-III of one mtpa capacity, with the suggestion to explore feasibility to install Steel Melting Shop-III of higher capacity considering the layout as well as future expansion of steel plant. None of the three bidders submitted specified technical input/data along with the bid documents in response to Expression of Interest (May 2021) issued on suggestion (April 2021) of the Committee of Directors of SAIL. Subsequently, Rourkela Steel Plant asked (September 2022) CET to revise the Feasibility Report. Considering the preoccupation of CET, Rourkela Steel Plant engaged (August 2023) a private party to prepare Detailed Project

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[52] ***Plate Mill: 0.53 mtpa, New Plate Mill: 1.00 mtpa and Hot Strip Mill-II: 3.00 mtpa.***

[53] ***Centre for Engineering & Technology, Ranchi is an in-house consultancy wing of SAIL.***

[54] ***Restrictions under Rule 144 (xi) of the General Financial Rules (GFR-2017) issued (23 July 2020) by Department of Public Expenditure, Ministry of Finance, Government of India.***

[55] ***BF#1: 1.01 mtpa, BF#4: 0.86 mtpa and BF#5: 2.78 mtpa.***

Report and to provide consultancy services up to Stage-II approval for new Steel Melting Shop-I[56]. Rourkela Steel Plant Management was yet (March 2025) to submit the revised proposal to SAIL Corporate Office for stage-I approval to install Steel Melting Shop-III. The project was delayed due to inadequate bid responses, repeated revision of feasibility reports, and belated engagement of a private consultant (August 2023). The Detailed Project Report was under review (April 2025) and is likely to take another four to five years. The delay had resulted in continued imbalance in production capacities.

Delays in both installation of 4th Slab Caster and setting up of Steel Melting Shop-III reflect deficiencies in planning, tendering, and execution. Despite being aware of the capacity imbalance, protracted time taken in decision making and execution of the projects led to continued operations with capacity imbalance of 0.6 mtpa of crude steel production.

Management/Ministry replied (November 2023/July 2024/April 2025) that delays were due to complexities of brownfield expansion in respect of Caster #4. Order was placed and project was expected to be completed by July 2025. Delay in Steel Melting Shop - III was due to issues in site selection, exploring options for future expansion, change in consultants etc. Detail Project Report was under finalisation. Projected margins would eventually be captured over extended operational life.

Reply of the Management/Ministry may be viewed in the light of the fact that the Management was aware of brownfield complexities, capacity imbalance since May 2018, and Committee of Directors' recommendation (April 2021). Despite this, action was delayed, timelines were revised multiple times, and project execution was prolonged. Consequently, Rourkela Steel Plant continued to bear operational imbalance and continuing financial losses.

5.2.1.2 Capacity imbalance at Bokaro Steel Plant

Modernization & Expansion Plan of SAIL initially envisaged (December 2006) production of 7.44 mtpa hot metal at Bokaro Steel Plant which was subsequently (June 2009) reduced to 5.77 mtpa of hot metal[57] (for which 7 mtpa of gross sinter was required). Audit noted that production capacity from the Sinter plant in the upstream was 6.90 mtpa during 2017-24. In the downstream, the capacity of Steel Melting Shop was 4.36 mtpa (upto April 2021) and subsequently increased to 4.66 mtpa, which was 0.54 mtpa and 0.24 mtpa lesser than the required capacity respectively. Due to the capacity imbalance of upstream and downstream facilities, there was shortfall in hot metal production in comparison to the Annual Business Perspective during 2017-24.

Audit noted considerable delays in implementation of projects aimed at addressing the imbalance of upstream and downstream facilities at Bokaro Steel Plant.

[56] ***SAIL renamed the Steel Melting Shop-III project as new Steel Melting Shop-I.***
[57] ***Due to global economic slowdown during late 2008.***

- **Installation of new Sinter Plant:** To meet the envisaged production target of 5.77 mtpa hot metal, Bokaro Steel Plant required seven million tonne per annum of gross sinter. The SAIL Board accorded approval (March 2011) for installation of a 360 m² Sinter Plant (3.7 mtpa capacity) and contract awarded (June 2015) at a cost of ₹653.85 crore with scheduled completion by November 2017. The project which was expected to generate an annual gross margin of ₹248.16 crore, could not progress due to financial problems of contractor.–Risk and purchase action was initiated (April 2018) but not pursued for four years. After incurring expenditure of ₹361.79 crore, SAIL Board approved (June 2024) revised project cost of ₹2,224.18 crore. Litigation by consortium member before Hon'ble High Court (April 2023) restrained SAIL (May 2023) from recovering risk and cost, further delaying progress. As of January 2025, for balance work no order was placed.

- **Modernisation of Steel Melting Shop-I:** Considering the obsolete technology, and ageing of plant and equipment of old Steel Melting Shop-I of Bokaro Steel Plant, SAIL Board approved (May 2013) modernisation of Steel Melting Shop-I to produce 1.305 mtpa (against existing capacity of 0.818 mtpa) continuous casting slab by phasing out the obsolete ingot casting route[58]. The contract was awarded between July 2015 and September 2016 with scheduled completion in November 2017. The project envisaged an annual gross margin of ₹291 crore.

  Audit noted delay of 40 months in finalisation of contract as against stipulated nine month[59] period. Project scheduled for November 2017 achieved partial completion, viz the Basic Oxygen Furnace converter was installed (May 2019) and slab caster and ladle furnace was installed (April 2021) and old ingot route was phased out in June 2022.

  Delay was attributable to non-grant of environmental clearance (lapsed in October 2018) due to non-disposal of fly ash, absence of sewage treatment plant and non-construction of rainwater harvesting systems. In the absence of slab caster, liquid steel continued through ingot route from May 2019 to April 2021, resulting in avoidable extra expenditure of ₹418.18 crore, as ingot route was costlier by ₹4,460 per tonne to ₹7,101 per tonne as compared to the Continuous Casting route. Old ingot route was phased out only in June 2022.

Management took 48 months and 25 months upto May 2015, for the award of Sinter plant and Steel Melting Shop –I respectively. The delays in the execution of projects of new Sinter Plant and modernisation of Steel Melting Shop -I not only led to additional expenditure on account of cost escalation, legal issues but also led to non-realisation of

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58 Ingot casting is the traditional process where molten metal is poured into moulds to solidify into blocks as against continuous casting process which directly produces semis like billets, blooms, slabs etc.

59 The period for finalisation of tenders (from in-principal approval to order placement) was decided as 39 weeks (9 months) for open/ global tenders during the chairman review meeting held in May 2007.

envisaged potential gross margins of over ₹539.16 crore (Sinter Plant-II: ₹248.16 crore and Steel Melting Shop: ₹291 crore) annually.

Management/Ministry replied (November 2023/ July 2024/February 2025) that in the projects of the new Sinter Plant and of the modernization of Steel Melting Shop-I, complexities were involved in execution in brownfield environment, delays in shifting of existing facilities, delays in handing over of working fronts, environmental clearances and multiple rounds of discussions and deliberations were done at various levels of stakeholders. Steel market scenario was also not favorable during the mentioned period of planning and finalizing this proposal, which impacted the decision making. Ministry added that SAIL was in the process of finalization of Brownfield Expansion for synchronization of upstream and downstream facilities. Detailed Project Report had been finalized for the Brown field expansion of 2.5 mtpa hot metal and stage-I approval had been accorded (January 2025) by the SAIL Board. Opinion of Solicitor General of India was sought and progressive steps were initiated. During the Exit conference (February 2025) Management stated that they were approaching other parties for revival of the sinter project.

The replies may be viewed in the light of the fact that installation of new Sinter Plant and modernization of Steel Melting Shop-I were technological necessities to meet the production target of 5.77 million tonne of hot metal annually. After in-principle approval, the company took 25 months in award of work for Steel Melting Shop-I and 48 months for new Sinter Plant-II against the stipulated timelines of nine months. To ensure the achievement of the envisaged production under the Modernisation and Expansion Plan, Management needs to ensure that the capacity expansion projects are executed within stipulated timelines.

Non-synchronization of upstream and downstream facilities at Bokaro Steel Plant will continue till installation of new Sinter plant.

Recommendation 5: The Company may assess the imbalance in upstream facilities like sinter plant and downstream facilities like Steel Melting Shop and ensure timely completion of its capital projects to achieve optimum utilisation of its steel making capacity.

5.2.2 Production of pig iron

Hot metal is sent to Pig Casting Machine to make pig iron in case of non-acceptance of the entire quantity of hot metal by the Steel Melting Shop. Such inability of the steel plants to convert hot metal into saleable steel leads to potential loss of revenue as saleable steel has more contribution than pig iron. Steel plant wise production of Pig iron is planned in the Annual Business Perspective. The potential loss of revenue due to excess production of Pig iron over and above the target stipulated in Annual Business Perspective has been discussed in Para 6.5 of CAG Report No. 10 of 2025 (Performance Audit on Inventory Management in SAIL).

5.2.2.1 Yield of pig iron in Pig Casting Machine In the process of pig iron making, certain process loss is unavoidable. Audit noted that norm for yield of pig iron in Pig

Casting Machine was not fixed except at Rourkela Steel Plant (85 *per cent*) during 2017-24.

Details of hot metal sent and production of pig iron vis-à-vis yield percentage during 2017-24 is depicted in table below:

Table 15: Production of pig iron vis a vis yield percentage

Name of the Steel Plant	Hot metal sent to PCM (tonne)	Production of Pig Iron (tonne)	Range of annual yield of Pig Iron (in *per cent*)	Average yield (in *per cent*)
Bhilai Steel Plant	6,93,867	6,42,729	92.63	92.63
Bokaro Steel Plant	10,16,782	9,05,482	84.00-93.00	89.05
Durgapur Steel Plant	3,68,334	3,31,506	90.00	90.00
IISCO Steel Plant	4,84,705	4,26,728	83.47-89.42	88.04
Rourkela Steel Plant	10,03,311	8,64,135	84.81-88.00	86.13

Source: Data furnished by Management.

- The average yield percentage of pig iron in the Steel Plants of SAIL ranged between 86 to 92 *per cent* during the period 2017-2024.
- It was noted that Bhilai and Durgapur Steel Plants fixed the yield percentage of pig iron (92.63 per cent and 90 per cent respectively) irrespective of the actual pig iron generated. Bokaro Steel Plant also fixed the yield percentage (93 *per cent)* up to 2020-21. Thereafter the yield percentage ranged between 84 -88 *per cent* during 2021-24. In the absence of assessment of the actual pig iron generated, the operational efficiency of the pig casting machines could not be assessed by Audit.
- Year wise average yield loss[60] was between 7 *and* 17 *per cent* in the Pig Casting Machine across SAIL. There was less production of 77,870 tonne of pig iron in all the five steel plants (considering the norm in case of Rourkela Steel Plant and the minimum yield loss of 7 *per cent* in Bokaro Steel Plant achieved during 2017-21 for the other four steel plants) valuing ₹249.66 crore during 2017-24.

Management/Ministry replied (November 2023/July 2024/February 2025) that the yield of Pig Casting Machine depends on design of Pig Casting Machine, grade & temperature of hot metal and health of equipment. During the Exit conference (February 2025) Management assured that norms for pig iron yield would be established. Ministry in its reply (April 2025) provided the yield norms fixed for Pig Casting Machines in different units of SAIL.

Replies may be viewed in the light of the fact that although there was no norm for the yield of pig iron from Pig Casting Machine during the period of audit in four out of five integrated steel plants, the same had been fixed by the Management subsequently (April 2025) and ranged between 83.5 *per cent* and 92.6 *per cent*.

[60] ***It is the hot metal lost due to processes in the Pig Casting Machine expressed as a percentage of hot metal poured into the pig casting machine.***

5.2.2.2 Dumping of hot metal at sand pit in Bhilai and IISCO Steel Plant

In cases where neither hot metal can be sent to Steel Melting Shop nor purred in Pig Casting Machine, hot metal is dumped into sand pit and after recovery, it is sold as scrap.

Audit noted that Bhilai Steel Plant transferred 13.166 million tonne of hot metal to Steel Melting Shop-III during 2017-24. Due to absence of provision for Mixer (storage facilities of hot metal) and also because metal from the torpedo ladle could not be poured in the existing Pig Casting Machine, 0.039 million tonne of hot metal was dumped into sand pit. The evacuated hot metal in the sand pit was recovered as scrap. Similarly, 0.111 million tonne of hot metal was dumped at sand pit in IISCO Steel Plant during 2017-24 which includes 0.013 million tonne of hot metal sent to the sandpit during capital repair of BF#5 (April 2021 to May 2021). Since this hot metal could not be converted into saleable steel, SAIL suffered a loss of ₹ 51.29 crore (Bhilai Steel Plant- ₹35.90 crore and IISCO Steel Plant - ₹15.39 crore) being differential value of cost of production at blast furnace and scrap value.

Management/Ministry replied (November 2023/ July 2024 & February 2025) that in Bhilai Steel Plant, only in case of sudden breakdown in SMS-III metal already poured in torpedo ladle was diverted to sand pit. In case of IISCO Steel Plant, it was stated that after capital repair and subsequent ramping up of blast furnace, hot metal was not suitable for Steel Melting Shop or to be poured at Pig Casting Machine due to its very high silicon level, so it was poured in sand pit. During the Exit conference (February 2025) Management stated that there might not be any loss as there was insignificant difference in the price of sand pit material and pig iron.

Reply may be viewed in the light of the fact that the objective of the company is to convert hot metal to saleable steel optimally. Further, out of 0.111 million tonne of hot metal sent to the sandpit, only 0.013 million tonne was sent to the sand pit during capital repair of BF#5 of IISCO Steel Plant and the remaining 0.098 million tonne was sent due to other reasons.

5.3 Management of By-products

Gangue materials like Silica and Alumina are present in raw materials used in the blast furnaces. Gangue materials are separated from the metal in the form of slag in the process of iron making which is dumped as a waste or granulated and sold for use in cement industry or in road making. Other waste material like sludge, flue dust etc. are generated and either recycled internally in sinter making or sold outside (*discussed in para 6.2.3).*

5.3.1 Generation of Blast Furnace Slag and its disposal

Slag does not have much market value due to mixture of moisture and silica, it requires granulation either at Slag Granulation Plant (SGP) or at Cast House Slag Granulation Plant (CHSGP) to make marketable product and saleable in open market. Corporate Responsibility for Environment Protection issued by Central Pollution Control Board also issued action points in March 2003 in which it was stated that blast furnace slag should be utilized 100 *per cent* by the year 2007. Audit noted that Plants were not able to granulate entire slag generated and were dumped at pit; and thus, were unable to achieve 100 *per cent* utilization of slag as per the guidelines of Central Pollution Control Board issued in March 2003. The slag which could not be granulated is dumped at Slag Dump Post and Dry Pit and was an environmental hazard**.**

Audit observed that out of 51.33 million tonne[61] of slag generated at five integrated steel plants of SAIL during 2017-18 to 2023-24, 44.15 million tonne was granulated, 1.31 million tonne was sold as molten slag in Durgapur Steel Plant, 0.06 million tonne was sold by Bhilai Steel Plant and balance 5.81 million tonne[62] was not granulated and transferred to dry pit yard.

The reasons attributable for lower granulation of blast furnace slag was absence of granulation facility, delay in installation of Slag Granulation Plants, frequent capital repairs of previously installed Slag Granulation Plants, inability to granulate the total slag despite having facilities and inability to sell molten slag which was diverted to slag bank etc.

Audit observed that non-granulation of slag besides causing environmental pollution also resulted in loss of opportunity to earn potential revenue of ₹290.27 crore[63] due to non-granulation of 3.89 million tonne of slag in the years 2017-18 to 2023-24 in Bokaro, Rourkela, Durgapur and IISCO Steel Plant. At Bhilai Steel Plant, the non-granulated slag was saleable and often sold at a higher price than granulated slag. Therefore, potential loss of revenue due to non-granulation excludes Bhilai.

Management/Ministry replied (November 2023/July 2024 and February 2025) that Cast House Slag Granulation Plants are installed at five blast furnaces of Bokaro Steel Plant and being utilized gainfully. Ministry accepted (July 2024) that the delay in installation of Cast House Slag Granulation Plants Project at Bokaro Steel Plant led to non-granulation of slag during 2017-2022. It further stated (February 2025) that slag generated during maintenance of slag granulation units, slag runners and conveyor belts led to diversion of slag to the dry pits.

The reply of the Management/Ministry may be viewed in the light of the fact that although after the installation of Cast House Granulation Plants at Bokaro Steel Plant the slag granulation considerably increased during 2023-24, 100 *per cent* slag granulation was not achieved at any Steel Plant. The replies also do not provide a roadmap for minimising such diversions in future to achieve 100 *per cent* granulation as mandated by CPCB guidelines.

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[61] ***Bokaro Steel Plant- 11.75 million tonne, Bhilai Steel Plant-16.63 million tonne, Durgapur Steel Plant-5.93 million tonne, Rourkela Steel Plant-10.66 million tonne and ISP, Burnpur-6.36 million tonne.***

[62] ***Bokaro Steel Plant- 2.09 million tonne, Bhilai Steel Plant-1.92 million tonne, Durgapur Steel Plant-0.61 million tonne, Rourkela Steel Plant-0.74 million tonne and ISP, Burnpur- 0.45 million tonne.***

[63] ***Bokaro Steel Plant-₹106.01 crore, Durgapur Steel Plant-₹77.24 crore, Rourkela Steel Plant-₹60.13 crore and ISP, Burnpur-₹46.89 crore.***

Recommendation 6: The Company may ensure that 100 per cent granulation of slag as mandated by the CPCB guidelines is achieved by installation and modernization of slag granulation facilities. The diversion of slag to dry pits may be minimized to achieve the gainful utilization of blast furnace slag to safeguard the environment and also optimize revenue potential.

Summing up:

The capacity of different plants in an integrated steel plant need to be balanced to fully utilize the hot metal production capacity with downstream facilities for production of crude steel. The capacity of blast furnace and Steel Melting Shop of all the plants except in Rourkela and Bokaro Steel Plant were more or less balanced to receive the upstream production. The mismatch of capacities of upstream and downstream facilities led to potential loss of the envisaged gross margin of ₹1,172.94 crore (₹633.78 crore at Rourkela and ₹539.16 crore at Bokaro). Any imbalance in the downstream capacity also could lead to throttling of the blast furnace regime or generation of Pig iron and dumping of hot metal into sand pits and consequent loss of production of hot metal and contribution margin. SAIL was also unable to granulate 100 *per cent* of the slag generated which besides causing environmental pollution also resulted in loss of opportunity to earn potential revenue of ₹290.27 crore. To optimize the production of hot metal/crude steel, the Company may strive to synchronise its upstream and downstream facilities at all times, to eliminate any mismatch in the capacities and thereby maximize its revenues in the long run.

Chapter VI

Safety and Environment Issues

CHAPTER
VI

Safety and Environment Issues

6.1 Integrated Iron and Steel Industry has many inherent potential safety and environment issues which need to be mitigated and to ensure safe and environmental friendly operations, adherence to the safety and environmental laws is obligatory. Audit examined the safety and environment related issues based on Operational manual/Standard Operating Procedure of Blast Furnace Operations, Safety Audit reports on Blast Furnace operations, Corporate Environmental Policy and Consent to Operate issued by Central/State Pollution Control Board, etc. These issues and some other Plant specific issues have been discussed in detail in succeeding paragraphs.

6.1.1 Safety Audit

Corporate Safety Policy of SAIL stipulates safety audit to assess compliance to safety standards, mitigating plans, develop improvement plan and accountabilities for completion and follow up on timeline and recommendations. SAIL Safety Organization conducted safety audit of Blast Furnaces of all integrated steel plants during the years 2017-18 to 2023-24. Safety audit of blast furnaces was conducted once in Durgapur Steel Plant, twice in Bhilai, Rourkela and IISCO Steel Plant, and four times in Bokaro Steel Plant by SAIL Safety Organisation during 2017-24 as shown in table below:

Table 16: Showing details of Safety Audit conducted by SAIL Safety Organisation during 2017-24

Name of the Steel Plant	Safety Audit Period	Status of implementation of recommendations
Bhilai Steel Plant	February 2019 & July 2023	All 158 complied
Rourkela Steel Plant	February 2021 & October 2022	All 140 complied
Durgapur Steel Plant	March 2021	All 22 complied
IISCO Steel Plant	October 2019 & November 2022	83 out of total 84 recommendations complied.
Bokaro Steel Plant	January 2018, July 2019, February 2021 and August 2022	30 out of 40 recommendations were complied.

Source: Data furnished by Management.

Audit noted that Bhilai, Rourkela and Durgapur Steel Plant have implemented all the recommendations made during February 2019 & July 2023, February 2021 & October 2022 and March 2021 respectively. IISCO Steel Plant complied with 83 out of total 84 recommendations issued in October 2019 and November 2022. In Bokaro Steel Plant 30 out of 40 recommendations made in August 2022 were complied.

Audit further noted that the issue of non-working of Fire Detection and Alarm System in BF#5 of IISCO was not complied fully. In case of Bokaro Steel Plant recommendations like conducting test of Pressure Relieve Valves of pressure vessels, fluorescent signs in cable galleries, non-working of Fire detection alarm etc were yet to be complied. Non-compliance of these safety recommendations adversely impacted safe operation of the Plants.

Management replied (November 2023) that Safety Consultant had been hired to improve process safety; and Fire detection and Alarm Systems had been revamped at IISCO Steel Plant. De-dusting system of Stock House project at Bokaro Steel Plant could not be commissioned and the matter was sub-judice. A proposal had been initiated to revamp Air Pollution Control System which would help in reduction of dust in Stock House area.

Ministry replied (July 2024/February 2025) that replacement of faulty equipment at IISCO Steel Plant was to be completed by March 2025. At Bokaro, after studying the feasibility report of CET it was observed that the proposal for installation of De-dusting system of Stock House was not feasible due to space constraints and alternatives were being explored. During the Exit conference (February 2025), Management stated that Safety consultants had been appointed at all SAIL units and all Safety issues were being addressed on priority. It further added that SAIL remained committed to ensuring a safe working environment through continuous monitoring, expert consultation and proactive safety measures.

The reply may be viewed in the light of the fact that the issues raised by SAIL Safety Organization were not fully complied with by Bokaro and IISCO Steel Plants unlike the other Steel Plants and this could potentially undermine the safety of the operations of Bokaro and IISCO Steel Plants.

6.1.2 Violation of Statutory Provisions of the Factories Act/ Rule

The occupational health and safety policy of Durgapur Steel Plant has committed to provide safe and healthy work environment. It states that all accidents are preventable and all injuries can and must be prevented.

Section 7A of the Factories Act, 1948 stipulated that the place of work was to be maintained in such a way so as to be safe and without risk to the health of the workers. Rule 50 & 51 of The West Bengal Factories Rules, 1958 states that the plant & machinery was to be maintained to avoid risk of bodily injury and prohibit more than one work like transportation and maintenance to be carried out simultaneously without any traffic block.

Audit noted violation to the provisions of the Factories Act, 1948 and State Factories Rules, 1958 such as lack of supervision on live track, ignorance about prohibition carrying out of more than one work simultaneously without any traffic block. It was also noted that there was no clear Standard Operating Procedures for recording check points before handing over of slag ladles in blast furnace before movement. Also there was no Standard Maintenance Practice in respect of short duration jobs carried out on live track.

It was noted that a fatal accident occurred (20 November 2022) near the BF#2 area of Durgapur Steel Plant. There was spillage of molten slag from a moving ladle that fell on four workers standing in the vicinity to carry out maintenance and repair work of the railway track over which the molten slag ladle was passing. Three workers succumbed to the incident.

An internal committee of Durgapur Steel Plant constituted (November 2022) reported that the accident took place due to non-engagement of locking pin of the slag ladle, distortion of the top of the ladle, unevenness/undulations on the rail track and the presence of working groups very close to the ladle moving rail track. It was also reported that there was no supervision of work and blocking of the live track. The cause of incident and violation of statutory provisions of the Factories Act, 1948 and the State Factories Rules, 1958 was also confirmed by the Inspector of Factories, Durgapur in his inspection report of February 2023.

Ministry replied (February 2025) that corrective measures in the area of locking pin checks, safety communication enhancements, track maintenance improvements, permit to work, employee training and awareness, safety supervision and revised SOPs for Material Recovery Department regarding slag ladle operations and new Standard Maintenance Practices had been implemented by the Durgapur Steel Plant.

Ensuring that Standard Operating Procedures in line with the statutory provisions relating to ensuring safe working environment are effectively implemented by all units would go a long way in preventing the recurrence of any such accident in future.

Recommendation 7: Management may ensure periodical conduct of Safety Audits and continuous monitoring and follow up of the compliance to the recommendations of such audits. Effective implementation of Standard Operating Procedures in line with the Statutory provisions would ensure a safe working environment.

6.2 Environmental Issues

As per Corporate Environmental Policy, SAIL is committed to improve environmental performance. Each steel plant has Environment Control Department which monitors environmental issues and reports to the State Pollution Control Board and Central Pollution Control Board. The respective State Pollution Control Boards issue yearly Consent to Operate wherein standards for stack emissions, disposal of solid waste management in blast furnace are indicated.

6.2.1 Environmental Norms and its compliance

The Integrated Steel Plants are required to comply with the emission and discharge standard as laid down in Ministry of Environment and Forests, Government of India issued vide Gazette Notification No. G.S.R. 277(E) dated 31 March 2012.

As per the information provided, all integrated steel plants of SAIL viz. Bokaro, Bhilai, Rourkela and Durgapur steel plants (except IISCO Steel Plant) complied with the environmental norms with respect to emission and discharge standard as prescribed by Ministry of Environment and Forests.

Audit observed that IISCO Steel Plant was unable to maintain the effluent level from blast furnace cast house de-fuming system during 2017-21, however it was within the norm in 2021-24. Similarly, in blast furnace power blowing stack, the discharge was noticed to be more in all the seven years than the maximum discharge limit. Further, West Bengal Pollution Control Board (WBPCB) noticed high emission from tapping point, ladle loading point, stack attached to the Blast Furnace Cast House-I though Electrostatic Precipitators were provided for control of emission from BF#5. Very high fugitive emission was also observed from all sides of Blast Furnace during inspection by WBPCB. Due to non-compliance of environmental norms, WBPCB imposed (June 2022) penalty of ₹3.85 lakh in addition to submission of Bank Guarantee of ₹20 lakh separately. WBPCB again noted (February 2023) very high fugitive emission from the stacks attached to blast furnace Cast House I & II.

Management/Ministry replied (November 2023/July 2024) that IISCO Steel Plant had changed around 2,500 electrodes in Cast House and Stock House Electrostatic Precipitator, had improved process and operational discipline and this had decreased the output dust load, thereby leading to reduced emission. Ministry added (February 2025) that emission level in blast furnace in 2024-25 was within the norm.

The replies may be viewed in the light of the fact that non-compliance of environmental norms in operation of Blast Furnace at IISCO Steel Plant were noted (June 2022 and February 2023). Stack emission in Cast house I continued to be high and was 34.33 mg/Nm^3, Cast house II was 33.42 mg/Nm^3 and Stock house was 36.92 mg/Nm^3 against the norm of 30 mg/Nm^3 during the year 2024-25.

6.2.2 Excess emission of Carbon Dioxide gas

Coke is one of the major constituents in hot metal production. Management fixed norms/target for consumption of coal per tonne of hot metal in Annual Business Perspective not only to ensure economy in production cost but also emit less Carbon Dioxide (CO_2) into the environment.

Audit noted that the consumption of coal was more than norm in all the steel plants (except Bokaro during 2021-22 and Durgapur in 2021-22 & 2023-24). Further, burning of coal also generates harmful CO_2 gas (approx. 2.53 tonnes of CO_2 gas is generated on burning of one tonne of Coking Coal). Since CO_2 gas is not used in production process, it is released to environment. There was excess consumption of 5.52 million tonne[64] of coal as compared to the coal to hot metal ratio norm (stipulated in the Annual Business Perspective) which resulted in generation of 13.97 million tonne (5.52 million tonne x 2.53) of CO_2 gas during 2017-24[65]. The CO_2 gas was released to environment causing environmental hazard.

Management/Ministry replied (November 2023/ July 2024 & February 2025) that major reasons for excess emission were frequent off blast/low blast, inconsistent hot metal evacuation, high gangue content in raw material, delay in commissioning of the new blast furnaces with their peripheral facilities. Various steps like capital repair of stoves, increase of Coal Dust Injection rate, reduce coke rate, charging of pellet, installation of pellet Plant, overhauling cast house and stock house ESP systems etc had been initiated or were in pipeline for reducing the CO_2 emission. During the Exit conference (February 2025), Management assured that action plan had been prepared in all units to reduce the emission of CO_2 gas and same was being monitored regularly.

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[64] ***Bokaro Steel Plant-0.62 million tonne, Bhilai Steel Plant-2.50 million tonne, Durgapur Steel Plant-0.45 million tonne, Rourkela Steel Plant- 1.34 million tonne and ISP, Burnpur- 0.61 million tonne.***

[65] ***As per the information furnished by Management approximately 2.53 tonne of CO_2 is emitted on consumption of one tonne of coking coal in Blast Furnaces during making of steel.***

The reply may be viewed in the light of the fact that the constraints mentioned could have been mitigated through better operational and project management measures. Through consistent efforts Management could control the frequent offblast/low blast (*as discussed in para 4.4.2*) and by setting up ore beneficiation facilities the gangue content in raw material could be reduced. Despite taking various steps, consumption of coal and consequently that of coke was beyond the norms at the steel plants (*as discussed in Para 3.6*).

6.2.3 Management of solid waste generated in Blast Furnace

As per Consent to Operate issued by Pollution Control Boards, solid waste (Blast furnace sludge, Pig Casting Machine sludge and blast furnace flue dust) should be disposed off in environmentally safe manner. These waste materials are either used in the Sinter plant or sold.

Audit noted that Bhilai, Bokaro, Rourkela and IISCO Steel Plant used or sold the entire solid waste (BF sludge, Pig Casting Machine sludge and BF flue dust) generated during 2017-24. Durgapur Steel Plant used entire quantity of blast furnace flue dust till 2021-22 but used 98 *per cent* of blast furnace flue dust during 2022-24. The plant used only 45 *per cent* of blast furnace sludge during 2017-24. The dumping of solid waste occupies a large area of land and causes environmental hazards to the soil and water.

Management/Ministry replied (November 2023/ July 2024 & February 2025) that proposal to install Micro Pelletisation Plant was under consideration in Durgapur Steel Plant, where such dried blast furnace sludge along with other solid waste could be used for making micro pellet for use in sinter making.

Reply of the Management may be viewed in the light of the fact that while the other Steel Plants successfully used or sold the entire solid waste, Durgapur Steel Plant had stock of 55 *per cent* of blast furnace sludge yet to be disposed (March 2024).

Recommendation 8: The Company may put efforts to reduce the coke consumption through better operational and project management measures and thereby maintain the CO_2 emissions within the norms. Management may also ensure that the solid waste generated in the Blast Furnace are disposed as per the terms of the consent to operate.

Summing up:

SAIL Safety Organisation conducted safety audits of blast furnaces of all integrated steel plants. All the recommendations of SAIL Safety Organisation were complied by the integrated steel plants except Bokaro and IISCO Steel Plant. Such non-compliance affected the safety of operations in Steel Plants. Audit noted that violation of the provisions of the Factories Act, 1948 and the State Factories Rules, 1958 led to a fatal accident and loss of life at Durgapur Steel plant. High fugitive emission from the stacks attached to blast furnace Cast House I & II of IISCO Steel Plant was also noted. There was excess consumption of coal more than the norm which resulted in excess generation of 13.97 million tonne of CO_2 gas during 2017-24. The CO_2 gas was released to the environment causing environmental hazard. While Bhilai, Bokaro, Rourkela and IISCO Steel plants used or sold the entire solid waste, Durgapur Steel Plant could use only 45 *per cent* of blast furnace sludge during 2017-24.

(Anand Mohan Bajaj)
Deputy Comptroller and Auditor General
(Commercial & Report Central) and
Chairman, Audit Board

New Delhi
Dated: 12 December 2025

Countersigned

(K. Sanjay Murthy)
Comptroller and Auditor General of India

New Delhi
Dated: 15 December 2025

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