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SAIL RSP BLAST FURNACE NO. 5 - A GREENFIELD PROJECT IN A BROWNFIELD OPTIMIZATION CONTEXT*

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Abstract
Rourkela Steel Plant (RSP), which is operated by the Steel Authority of India Limited (SAIL), was inaugurated in 1959 and was the first Integrated Steel Plant in the public sector in India. In 2013, RSP commissioned their No. 5, 4060 m³ Blast Furnace, India's largest. It was built as a turn-key project by a consortium consisting of Danieli Corus and Tata Projects Ltd. and is entirely based on the technology and know-how of Danieli Corus. The new Blast Furnace is the key element of an expansion program that doubles the plant's production capacity and with much of the existing ironmaking capacity reaching the end of its technical and economic life span, it enables RSP to meet existing as well as growing demand for its products. This article discusses how this greenfield Blast Furnace was built in an existing and operating Integrated Steel Plant. It covers the accommodation of land, planning of the new installation to fit the available plot as well as the updated logistical lay-out of the plant. Technical details of the installation are presented, including their consequences for RSP's environmental performance and new perspectives for campaign planning.
Keywords: Blast furnace; Greenfield; Brownfield; Expansion; Construction.

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1 INTRODUCTION

Rourkela Steel Plant (RSP), operated by the Steel Authority of India Limited (SAIL), was inaugurated in 1959 and was the first Integrated Steel Plant in the public sector in India. In 2013, RSP commissioned their 4060 m³ Blast Furnace No. 5, India's largest. It was built as a turn–key project by a consortium consisting of Danieli Corus and Tata Projects Ltd. (TPL) and is entirely based on the technology and know–how of Danieli Corus.

The new furnace is the key element of an expansion program that doubles the plant's capacity. With much of the existing ironmaking capacity reaching the end of its technical and economic life span, the new furnace enables RSP to meet existing as well as future demand for its products.

2 ROURKELA STEEL PLANT

RSP was set up in 1959 by Hindustan Steel Limited, a company that would be integrated into SAIL upon its formation in 1973. The plant's initial capacity was around 1 Mtpa, which over the following decades would grow towards 2 Mtpa with four blast furnaces and two BOF plants operating at the plant's hot side.

India's current accelerated economic growth accelerates the country's steel consumption: in the 2001–2012 period, India saw a growth of annual steel consumption from 28.5 MT to 73.6 Mt for an average annual growth rate of 9.0%. With the country's per capita consumption at around 25% of the global average and at around 12.5% of that of China, there is substantial growth potential for the near future. SAIL decided on an expansion plan in 2006, with the objective to double the company's total capacity. Table 1 below presents key figures for this ambitious expansion plan with respect to the integrated steel plants operated by SAIL.

Table 1. Expansion Plan for SAIL Integrated Plants (hot metal production figures in Mtpa)

Plant	Production 2011–2012	After Expansion	
Bhilai	5.1	7.5	+47%
Durgapur	2.1	2.5	+19%
Rourkela	2.3	4.5	+96%
Bokaro	4.0	5.8	+45%
Burnpur	0.5	2.9	+480%
Total	*14.0*	*23.2*	*+66%*

RSP set out on an expansion program towards 4.5 Mtpa for the site. In addition, RSP initialized modernization to reduce the environmental emissions of e.g. the coke batteries and sinter plants. When the expansion program for RSP was started, the upstream hot metal capacity was produced by four blast furnaces, three with an inner volume of 995 m³ and one with an inner volume of 1448 m³. All of these are of a 1960s design of German origin. For the expansion, RSP decided upon a fifth, greenfield blast furnace of substantially larger inner volume and in full accordance with best available technology principles.

3 BLAST FURNACE NO. 5

The new blast furnace was designed with a 4060 m³ inner volume for an average production of 8000 thm/d. The pulverized coal injection system is rated for 150

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kg/thm with a design provision for 200 kg/thm. Hot blast is provided by three hot blast stoves with internal combustion chambers operating at a 1425°C dome temperature. The furnace has four tapholes, operated in two casthouses.

Table 2. RSP Blast Furnace No. 5 in numbers

	Metric	US
Inner Volume	4060 m³	143378 cuft
Working Volume	3470 m³	122542 cuft
Hearth Diameter	13.2 m	43.3 ft
Production (avg.)	8000 thm/d	8840 thm/d
Production (peak)	8320 thm/d	9193 thm/d
PCI rate (target)	150 kg/thm	300 lbs/thm
PCI rate (design provision)	200 kg/thm	400 lbs/thm
Hot Blast Stove dome temp.	1425 °C	2600 °F

The furnace lining design is based on the “Hoogovens” high conductivity integrated cooling and lining concept with copper cooling plates and graphite refractory. This modern lining design minimizes sliding effects in the bosh and the equilibrium lining profile enables the creation of a stable accretion, which protects against erosion. The belly and lower stack include a combination of graphite and silicon carbide refractory and machined copper plate coolers, which enables the creation of an accretion, but also provides sufficient erosion resistance if the accretion may not be present. 25 year campaign lives can be achieved at high PCI and productivity levels and/or when operating on lower or varying quality raw materials. Figure 1 illustrates the General Arrangement of the furnace, Figure 2 the design of the bosh and belly.

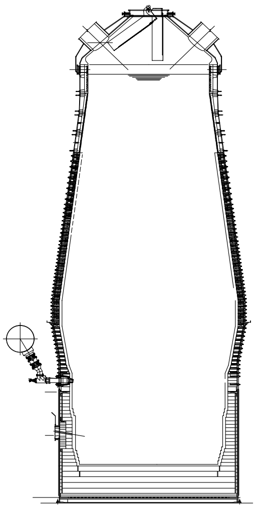

Figure 1. General Arrangement

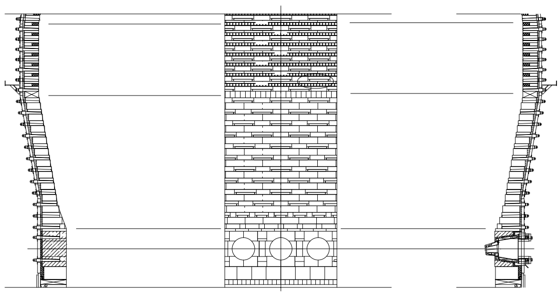

Figure 2. Bosh & Belly Design

The gas cleaning system is based on the Danieli Corus cyclone dustcatcher with a single tangential inlet and an annular gap scrubber. The main advantage of this type of dustcatcher as opposed to traditional, gravity–based dustcatchers is that the characteristics are such that all of the zinc poor fraction of dust is separated here (i.e. 85%), leaving the smallest possible zinc contaminated fraction for the scrubber. With gravity dustcatchers, 50% of the dust is separated, with the other 50% still made up of zinc poor dust for about two–thirds; this introduces a far larger amount of dust that cannot be recycled to the sinter plant and/or strongly increased additional cost for processing.

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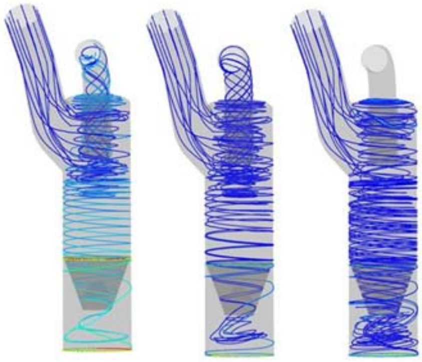

Figure 3. Tangential Cyclone: paths of 5 micron, 15 micron and 30 micron particles

Finally, the plant is equipped with a slag granulation system based on a dewatering wheel, a Top Gas Recovery Turbine (TRT) and raw materials are belt–charged to the bell–less top.

Figure 4. 3D overview of Blast Furnace Plant

4 THE PROJECT

On October 2nd 2008 (M.K. Gandhi's birthday), RSP signed a contract with a consortium consisting of Danieli Corus and TPL for the lump–sum turn–key supply of the new Blast Furnace No. 5. Danieli Corus was responsible for the engineering and supply of technological items as well as erection supervision, operational assistance and training. TPL was responsible for the engineering and supply of the balance of the scope (e.g. civil) as well as erection. In projects of this magnitude, project management is pivotal in coordinating all processes pertaining to areas such as but not limited to engineering, procurement, inspection, logistics and erection. This particular project was executed under conditions that called for specific measures.

4.1 Client's Engineer

Mecon, an organization operated by the Government of India and based in Ranchi, acted as the Client's Engineer on behalf of SAIL. Mecon has specific know–how on the various packages, leading to many interesting discussions on technology. In those, the various parties challenged each other's views to get the best result for the project. This established a solid technical base between the parties and prevented lack of clarity during the construction phase.

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4.2 Co–Operation within Consortium

Since the majority of the scope was with TPL, this party acted as Consortium Leader, taking care of all communication with the Client on behalf of the Consortium. Extensive document control systems were set up within all parties (TPL, Danieli Corus, Mecon and RSP) as well as between them. Numbering systems were established for engineering documents but also for email messages and letters. Furthermore, much attention was paid to tracking of documents and issues to be solved. This has proved to pay, since not a single document was missed and not one single issue was left unfinished. Finally, the contractual planning was detailed into a Level 4 Planning, in which the schedules of the Consortium members and their subcontractors were merged. Monthly meetings were organized by RSP's Project Department, which kept tight control.

4.3 Logistics

A total of 950 containers and various break bulk transports with foreign supplies landed at Kolkata, to be trucked to Rourkela. The haul from the Kolkata Dock System (KDS) to RSP is around 350 miles and given the time consuming nature of road travel in India, transport had to be scheduled meticulously, also with respect to the site's maximum ability to accept containered as well as oversized shipments at the same time.

Foreign materials came from all continents. Canadian and Northern European winters brought challenges given the risk of waterways and vessels freezing. At one point, a ship had to be chartered from the warmer Mediterranean area to pick up cargo in Antwerp, Belgium, since all ships in that area were suffering from frozen cranes and decks.

Besides the above and the extensive exercise required for importing goods into India, logistics ran relatively smoothly.

On site, two indoor storage facilities were made available specifically to Danieli Corus for the dry storage of materials, the larger of which was designated for the storage of refractories. In addition, RSP stored an amount of materials in other facilities within the plant, some of which were areas in the open air.

For the pre–assembly of larger components, such as segments or rings of the blast furnace and hot blast stove shells, lay–down areas were allocated within the final plot plan of the blast furnace plant. With designated areas for each of the several pre–assembly activities, scheduling and execution of these activities could be optimized.

Figure 5. Lifting of Bosh Segment of Shell

Figure 6. Construction Activities

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4.4 Climate/Monsoon

Temperatures well over 100 degrees Fahrenheit in the May–July period and monsoon rains in the July–September period added a level of complexity to the project execution. Day–time work was shifted towards the early morning and late afternoon. Lighting was set up to enable work in the darker, yet cooler hours. Work on refractories inside the furnace shell and stoves was mostly carried out in cooler seasons.
In the hot seasons, wind may at times make working outside impossible given the risk of facial burns in case of prolonged exposure. Foundations and cable tunnels needed to be finished before July, and ditches for water evacuation were excavated every year before the start of the monsoon. Finally, blowing in a furnace during monsoon requires special safety measures to avoid steam explosions, e.g. in the slag pits and dry pits. These measures will be discussed further on in conjunction with the furnace's blow–in and ramp–up.

5 TIE–IN IN EXISTING SITUATION

As indicated in the plot plan in Figure 7, the new furnace and its ancillary equipment (in color) had to fit existing plants (in black). Space available was sufficient for the entire blast furnace plant, albeit with adjustments to accommodate existing logistics for the supply of coke and ferrous raw materials and tie–ins with routing for hot metal transfer towards the steel plant and downstream slag processing. Whereas during the early phases, the plot plan was sufficiently spacious to carry out several erection activities (with or without requirement for lay–down area) simultaneously, the final revised plot plan for the plant is clearly a precise and tight fit. However, none of the logistical movements are hampered and the lay–out proved to be well–thought–out.

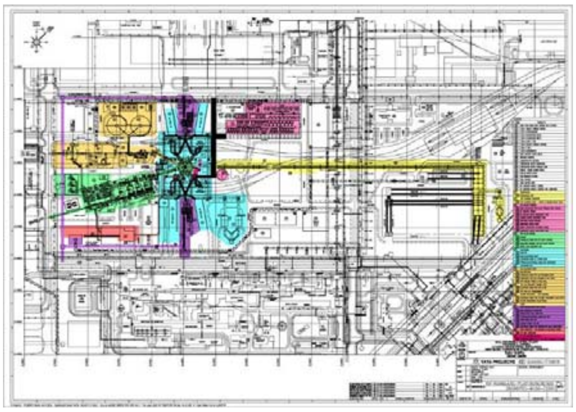

Figure 7. Plot Plan

Figure 8. Blast Furnace amidst existing plants

6 COMMISSIONING AND RAMP–UP

On August 6th of 2013, the new Blast Furnace No. 5 was blown in by a joint commissioning team consisting of RSP operators and Danieli Corus specialists. The furnace was filled with wood up to tuyere level and on top of that, a 1260 metric ton coke blank was charged (1389 short tons). The remainder of the working volume received a burden with an 800 kg/thm (1600 lbs/thm) coke rate. Around 29 hours after the furnace was lit, the first cast was made through Taphole No. 1. During the first hours, the coke rate was decreased relatively aggressively. As a consequence, hot metal–slag separation started faster than planned. Also, the lower coke rates

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ensured that all hot metal tapped after the start of separation had a sufficiently low silicon content to be used in the steel plant.

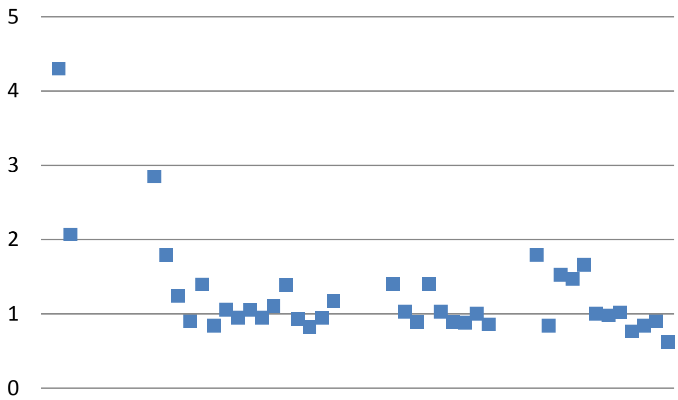

Figure 9. Hot metal silicon content (%) during first days after blow–in

Given the monsoon, there were large amounts of water in the blast furnace area, especially in the slag pits. Major safety precautions had to be taken. This was largely driven by SAIL management that wanted to make RSP No. 5 their flagship furnace. This paid off, as no accidents happened.

During the ramp–up, the furnace appeared to be very forgiving, accepting e.g. many low–blast periods with causes within and beyond the blast furnace complex. Danieli Corus had provided extensive training for RSP operational, maintenance and automation personnel, with good results; during the months after the blow–in, assistance was hardly required. RSP operators took over the furnace and proceeded forward.

After the blow–in and ramp–up periods, transition to normal operation was made quite quickly. With these labor intensive periods and the need to have direct access to the trough and runner systems belonging to the past, the several working areas and platforms could be cleared and housekeeping straightened out. Both of the casthouses set excellent examples, where the flush and flat design offers all of the intended ergonomic advantages now that the area is cleared and operations have normalized.

Figure 10. Flat Casthouse Floor

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7 CONCLUSIONS

- The RSP No. 5 project proves that plant capacity can be doubled within a few years in a smooth way with dedication of the workforce and provided that plant management is willing to demonstrate leadership. Especially under circumstances such as those described, these steps can be taken sustainably by investing in superior, best available technology as well as training of operational as well as maintenance personnel.
- Current technology allows for greenfield plants to be fitted into tight plot plans and tied in to existing plant logistics without problems. However, technology development may be beneficial for this process when equipment such as hot blast systems and gas cleaning systems would become more compact rather than allow for increasingly complicated connection and tie–ins.
- The perspectives for the Indian economy are promising for the medium and longer turn and more, similar projects can be expected where the lessons learned will prove their value in design as well as construction. In many other developing economies in the region, greenfield projects are expected on the slightly longer term, mostly without the brownfield aspects of those in India.

Figure 11. Inauguration by SAIL Chairman C.S. Verma.

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