HIGH PERFORMANCE OPERATION OF THE NEW JINDAL SOUTH WEST BLAST FURNACE WITH A BELL-LESS ROTARY CHARGING UNIT BRCU[1]

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Abstract

During the second half of 2006 two new blast furnaces (1462 m3 WV) from the Jindal Group were successfully blown in. Both furnaces are identical and are equipped with a bell less rotary charging unit BRCU, an innovative new charging apparatus. During the filling of the furnace before the blow-in experiments were performed to demonstrate the effect of different charging modes of the BRCU on the layer build up. The ultimate goal is to achieve a high productivity (>2.5 tHM/24hr/m3WV) at high PCI rates (>150 kg/tHM) which is challenging with local raw materials available. This will secure a place for JSW in top 5 of Indian blast furnace performance. Together with the state of the art design and operations, a campaign life of over 15 years is targeted. This paper describes the results of the JSW blast furnace in the first 8 months of operation.

Key words: Material distribution; Rotary charging unit.

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INTRODUCTION

In August and November 2006 two blast furnaces of 1462 m^3 of working volume had been commissioned successfully at Jindal South West (JSW) and Jindal Steel and Power Limited steel plants (JSPL) in India. Two bell-less rotary charging units (BRCU) were installed on both the furnaces which was the first experience of this kind in the world. Hereinafter there is an analysis of research carried on the basis of performance data, generated on blast furnace No.2 at JSW.

The general view and basic dimensions of the unit are shown in Figure 1. The makeup of BRCU is as follows: a receiving funnel, upper and lower banks of valves, transfer hopper, burden gate with compensator, central gearbox, rotor and its drive. While designing BRCU attempts were made to simplify it as much as possible, as to make the equipment more dependable. The main (central) gear box of BRCU has only one cylindrical gear in combination with a bearing, two sealing rings and quiescent water cooling system. The upper and lower banks of valves are of the same design; they consist of burden gates and gas sealing valves. The gas sealing valve is a closing device with "metal-to-metal" contact, there is a provision to change this principle and make it as "metal-to-rubber" contact.

The BRCU components are arranged in such a way that burden stock is fed strictly along the charger central line, which would decrease segregation and improve the circular uniformity in distributing stock in the blast furnace top.

The salient features of the charging technology with the help of BRCU that make it more advantageous as compared with the other existing charging apparatuses are as follows:

a) A multi layer charging of material in wide streams which makes it possible to average the charged batch of stock. As one batch is being charged, five vanes of the rotor will lay down up to 40 and even more layers of stock;
b) high circular uniformity, which is achieved thanks to the fact that the stream of material is split by the rotor into 5 equal rotating flows;
c) Soft dumping of stock on the surface, which would not destroy the profile of the preceding batch of material. This is achieved thanks to the splitting of stream into 5 flows and laying stock in wide flows of small thickness. The soft dumping of stock makes it possible to forecast better how it is distributed layer after layer.
d) A flexible control of stock distribution along the radius. It is achieved thanks to the smooth variations of rotor RPM.

RESULTS AND DISCUSSIONS

Before blow-in, the performance parameters of the charging apparatus were studied. When the cold furnace was being filled, the profiles of burden in the stack and top were measured. It was done with the help of a profile meter, consisting of a movable pipe, elastic rope and weight. The burden profiles were measured after dumping each batch of the last 18 batches. Figure 2 shows the measuring results. All in all 22 batches were measured. Visually it was observed that the circular uniformity of layers proved to be very high. The burden surface was smooth, with no ends and traces of rings. It was established that the speed of the rotor had a distinct impact upon the distribution of material along the radius. This impact appeared to become more and more conspicuous as the furnace was being filled. A comparison of the profile of batch 15 as coke was dumped on ring 2 and batch 17 as coke was dumped on ring 4 shows that the thickness of layer in the periphery in the second case became substantially bigger.

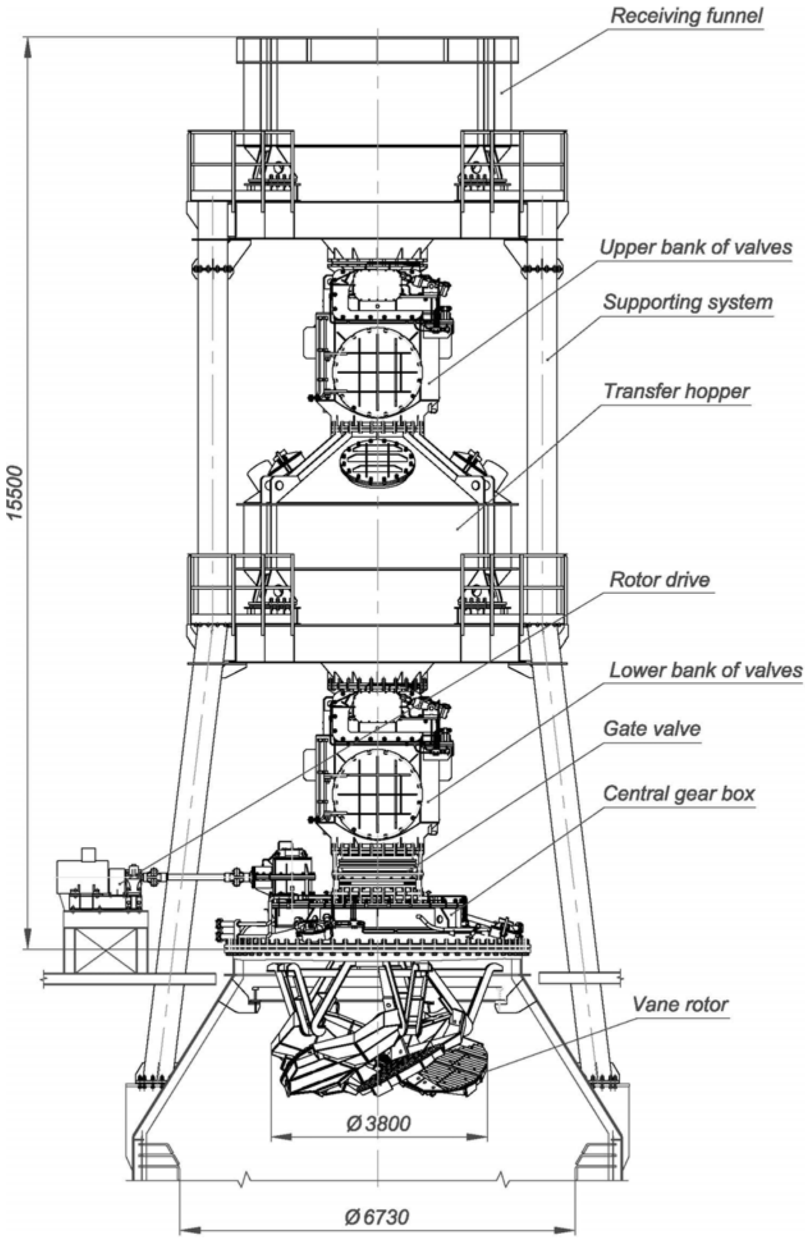
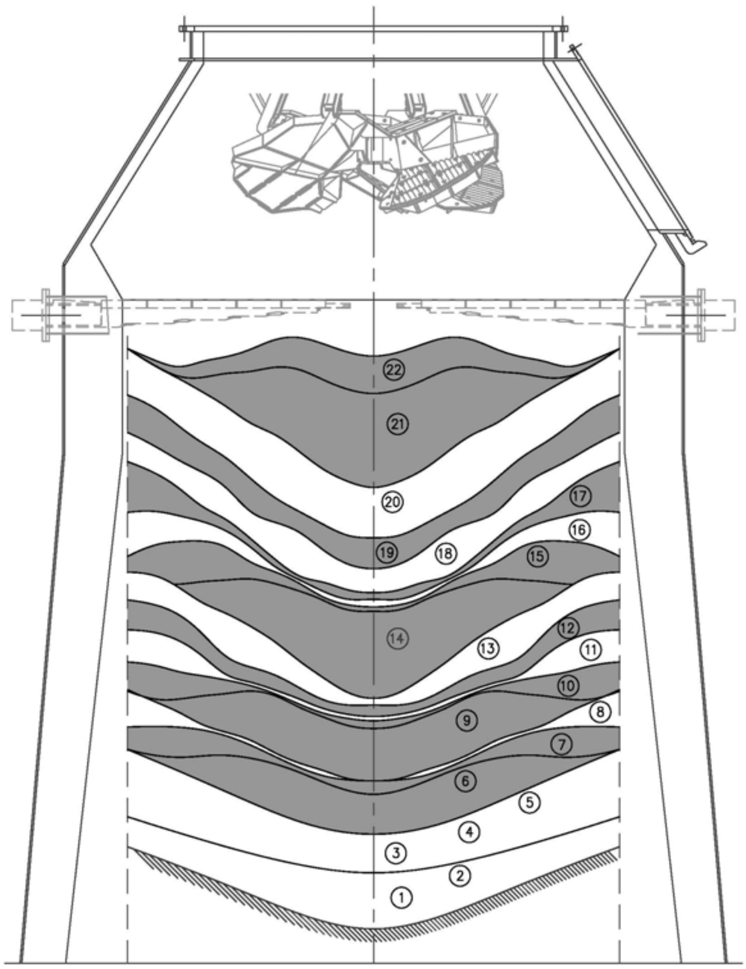


Figure 1. General View of BRCU

When material was loaded into the furnace centre (ring 1) batches 5, 9, 21, and 22, there was no pronounced pick of coke; the layers looked flat, just repeating the preceding profile. However if this profile is developed, (Fig.3) it may be seen that the profile has a pronounced centre and with more material being charged, the centre would become more conspicuous. This behavior of material can be explained by the fact the material leaves the rotor not as a stream of a small diameter, but rather in wide and flat flows, with the furnace centre being filled gradually. As was mentioned earlier, this is the advantage of the rotary charging technology (by thin wide layers).

As coke is loaded on R1, the batch would be distributed on rings in the following order (mean value of 3 batches: 8, 9 и 14): R1 – 28,8%, R2 – 25,5%, R3 – 21,2%, R4 – 13,4%, R5 – 7,4%, R6 – 3,8%. R1 is not only effective instrument in loading coke to the center with any stock level, but it also makes possible to distribute coke batch with gradual decrease of the layer height along the whole radius and to create coke interlayer in between of two ore batches. If there is a deep pit at the burden surface (batch 21, pit depth 1,8 m) then coke fills up the pit and is being distributed in following order: R1 – 45%; R2 – 36,2%; R3 – 15,9%; R4 – 2,9%.



1. C-R1-9,57 t
2. O-R2-R6-(25-17-17-8-33)-27,5 t
3. C-R1-9,57 t
4. C-R2-R3-(70-30)-9,54 t
5. O-R2-R6-(33-17-17-8-250-27,74
6. C-R1-9,91 t
7. C-R6-R2-(26-17-7-7-43)-9,83 t
8. O-R3-28,19 t
9. C-R1-10,32 t
10. C-R2-R6-(53-7-7-7-26)-9,91 t
11. O-R2-28,53 t
12. C-R2-R3-(50-50)-10,50 t
13. O-R2-28,95 t
14. C-R1-10,56 t
15. C-R2-10,82 t
16. O-R2-28,07 t
17. C-R4-10,24 t
18. O R5-28,51 t
19. C-R2-R6-(53-7-7-7-26)-9,63 t
20. O-R5 29,4 t
21. C-R1-9,54 t
22. C-R1-4,56 t

Figure 2. The burden profiles

BRCU is equipped with a captive automatic control system, which consists of the rotor controlling mathematical model, which in turn is based on controlling the rotor speed. For that reason experiments were carried out to determine the corrective factors to be inserted into the mathematical model so that it could be adapted to the production conditions. To this end first of all the rotor RPMs had to be determined, when material would reach the upper rim of the top cylindrical section. The diagram of the experiment is shown in Figure 4. As the research showed, when coke was charged this speed was 15 RPM, in case of ore-bearing material it was 13.2 RPM. Table 1 shows the position of the loaded material ridge (on equal-in-area rings), depending of the rotor speed).

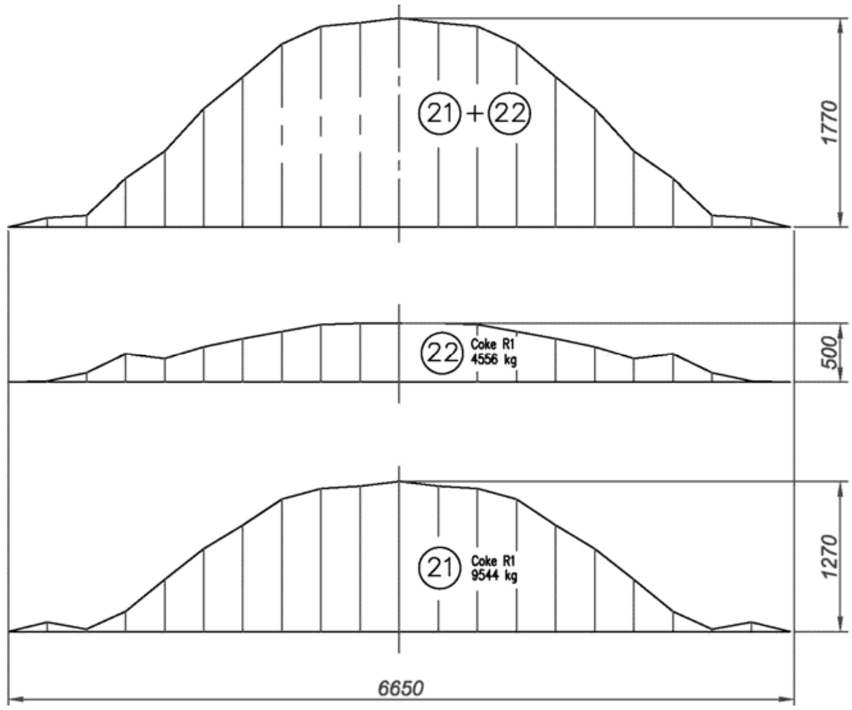


Figure 3. Profiles as developed

Table 1. Rotor speed impact upon the burden ridge position.

Ridge position	Centre, R1	R2	R3	R4	R5	R^
Coke RPM	In reverse	5.5	8.0	10.3	12.5	15.0
Ore, RPM	In reverse	4.8	7.4	9.7	11.5	13.2

On the basis of analysis of the radial distribution of stock correction were made in the rotor controlling algorithm.

The time factor is a very essential parameter for the radial distribution of burden. The longer is the time of distribution, the more layers would be laid into the furnace top.

During commissioning we determined the rate of material passing through the calibrated rings of 800, 725 and 6500 mm diameter. The results are given in Table 2.

As Table 2 shows, with the calibrated ring diameter dwindling from 800 mm to 650 mm, the material charging rate decreased in terms of coke by 1.9 times. In terms of ore bearing material - by 1.76 times. At that the circular distribution was improved. However, the measuring of the real time of stock charging and charging cyclograms showed that the burden charging rate maximum had exceeded the rated demand of the furnace for raw material by 30-40%. So, even in case of the calibrated ring being 650 mm, the charging rate will be sufficiently high and for that reason ultimately it was decided to go for a 650 mm ring.

Table 2. Impact of the calibrated ring diameter in the transfer hopper upon the charging rate

Ring diameter	800 mm	725mm	650mm
Coke, t/sec	0.486	0.379	0.249
Coke m^3/sec	0.75	0.61	0.402
Ore material t/sec	1.476	1.368	0.836
Ore material, m^3/sec	0.765	0.72	0.435

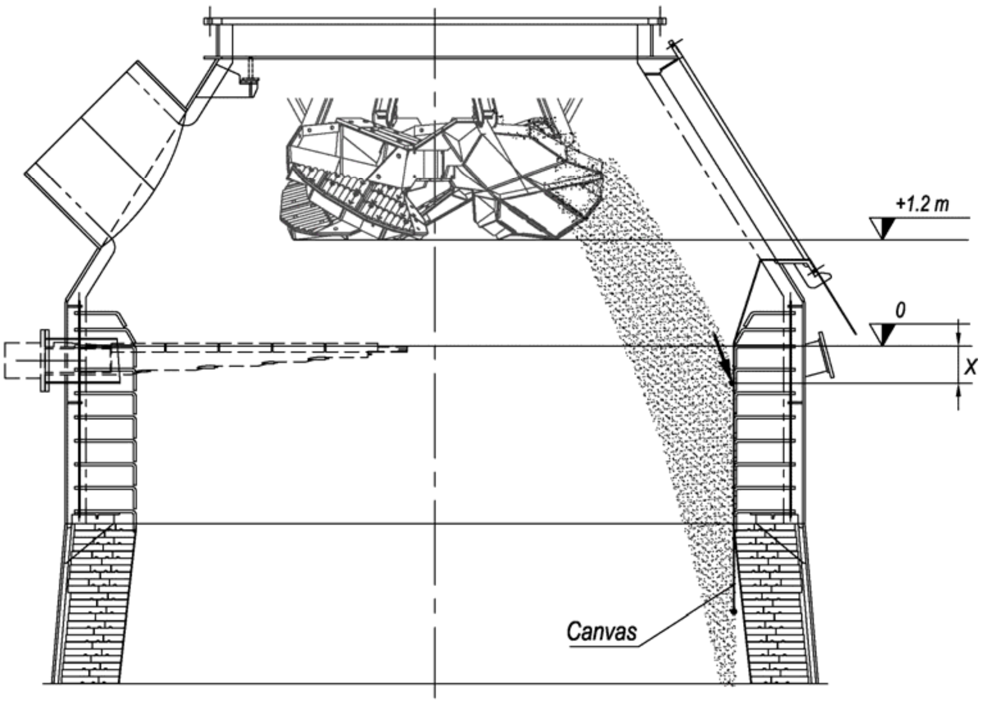


Figure 4. The diagram of experiment

In the running furnace, the charging time of each batch of material is picked by the sensors, detecting the emptiness of the transfer hopper and the system would be kept adapted to the variations in burden conditions.

Analysis of Heats

To analyse the smelting technology two periods were chosen when the furnace run was steady. The data acquired are shown in Table 3.

In the first period after blow-in the following charging pattern was implemented:

1) C1-R3-R5-(50-20-30) 9.7 t
2) O1–R4-R5-(50-50) 32.1 t

This means that coke was charged in the first batch, from ring 3 to ring 5. In brackets it is time spent by the rotor for each ring in percentage of the total charging time, and the last figure – 9.7 t is the weight of the batch. Further, in the second batch of the cycle an ore-nearing part was loaded onto ring 4 and 5, with time spent 50 -50%.

Table 3. Blast furnace performance

Technological parameters	Period 1 17-31.05.07	Period 2 22-28.02.07
1. Productivity, t/day	3248	3077
2. Coke rate, kg/t	528	467
3. CDI rate, kg/t	69	70
4. Total fuel rate, kg/t	592	537
5. Sinter rate, kg/t	617.8	1046
6. Pellets rate, kg/t	377	534
7. Iron ore rate, kg/t	364	-
8. Limestone rate, kg/t	11	9
9. Dolomite rate, kg/t	73,5	54
10. Quartzite rate, kg/t	44	42
11. Si in hot metal, %	0.96	0.64
12. Temperature of blast, C^0	1119	1055
13. Blast pressure, bar	2,7	2,69
14. Top pressure, bar	1,3	1,35
15. Oxygen in blast, %	25,4	23,4
16. CO content in top gas, %	26,3	24,4
17. CO_2 content in top gas, %	21,3	22,9
18. CO utilization rate, %	44.3	48,4
19. Temp-ure distribution on the top, C^0 1	167	118
2	160	81
3	123	100
4	100	171
Center 5	89	325

In the second period the charging pattern consisted of 6 batches.

1) C1-R2-100-9.1t - ring-wise charging of coke, 100% of time on ring2;
2) O1-R4-100-37t - ring-wise charging of ore-bearing material, 100% of time on ring 4;
3) C2-R3-R5 -(40-10-50) - 9.1 t, multi-ring charging of coke distribution by time
4) O2-R4-100-9.1t -ring-wise charging of ore-bearing material;, 100% of time on ring 4;
5) C3-R4-R5 (50-50) – 9.1 t , multi-ring charging of coke, distribution by time
6) 6) O3-R4-100-37 t - ring-wise charging of ore-bearing material, 100% of time on ring 4

A mathematical model was developed specifically to visualize the laying of burden in the upper section of the furnace. Account was taken of the impact by rotor performance parameters upon the burden distribution, as well as descends rate and angles of repose of material. In detail the impact of the rotor performance parameters upon the distribution of material are discussed in publication [1]. Figure 5 shows the diagrams of variations in ore/coke ratio along the furnace top radius, as calculated by the model in application to the conditions of periods 1 and 2 of heats.

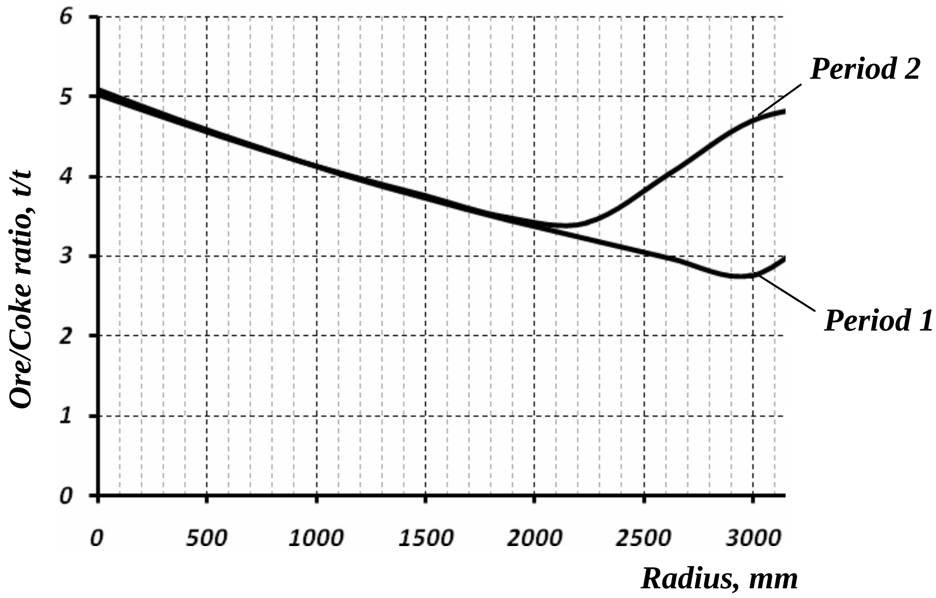


Figure 5. Full cycle Ore/Coke ratio

From the data of Table 3 it follows that in the second period the furnace performance indices in terms of fuel rate were substantially better. The summary rate of fuel in the second period was less by 55kg/thm as compared with the first period. This can be explained basically by a better burden stock. In the second period the summary rate of fluxes and quartzite was by 23.5kg.thm lower than it was in the first period. Besides, in the second period the raw ore was completely replaced with pellets and sinter. A positive impact was exerted upon the reduced fuel rate by a better distribution of material along the furnace central line in the second period. So, in the second period the ore/coke ratio in the furnace periphery was 5, while in the first period it was 3.5 (Figure 5). In both cases in the furnace centre the ore/coke ratio was almost the same. By increasing the ore/coke ratio in the periphery thus reducing the periphery flow of gas in the second period, the technologists managed to shift the gas flow towards the furnace centre. This shift is substantiated by the temperature of gas flow measured along the top radius. In the second period the gas temperature in the center was 325°C as compared with 89°C in the first period. A better distribution of material and gas flow along the radius had naturally resulted in a better use of CO in the blast furnace. In the second period the utilization of CO was 48.45%, while in the first period it was 44.3%. These data on heats operation show that a rotary method of burden distribution makes it possible to have a flexible control over the distribution of burden along the furnace radius.

CONCLUSIONS

The presented data that have been acquired during industrial trials, testify to the fact, that it would be possible to control effectively the charging of stock along the radius in the blast furnace top.

It should be noted that all the data given in this paper, pertain to the starting period when the bell-less charging apparatus was adopted. This research will be continued and there is a substantial potential for further improvements and optimization of the charging operation for this furnace.

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