

## CHARGERS FOR BLAST FURNACES DOUBLE BELL VS. ROTARY CHUTE

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### ABSTRACT

*The distribution of materials at the mouth of the loading of a furnace is decisive for its operation at optimal efficiency. For this operation using charging devices that can be of several types is useful. The paper presents a case study from ArcelorMittal Galati, the blast furnace no. 5, where a double bell charging device was changed with a type of rotating Paul Wurth channel, thereby achieving improved productivity.*

KEYWORDS: blast furnaces charging device, double bell vs. rotating chute

### 1. Introduction

Developing a continuous process of pig iron is done by supplying the furnace with raw materials and coke achieving a rhythmic descent of material column, due to the combustion of coke, smelting and periodic evacuation products.

The furnace charge is done with the goal to alternate ore and coke. Load size is determined by the volume of the furnace, installation of transmission and distribution of load module at the mouth of the furnace. Establishing the optimal size of the load and charging system is made for each furnace gas after analyzing traffic, maintaining ratios between the gas temperature in the central and the peripheral.

The types of charging systems may be different, the most famous being the dual locking hopper and cone (Fig. 1), or loading facilities without Paul Wurth bell-type (Fig. 2).

Lately there have been proposed solutions that are dropped cones, using closure flaps for symmetrical distribution of material in the furnace.

Closing the furnace mouth funnel-con systems results in deficient gas pressure exceeding 1.5 atm. The large cone has the role of ensuring the settlement material in the furnace so that a uniform movement of gas could be obtained.

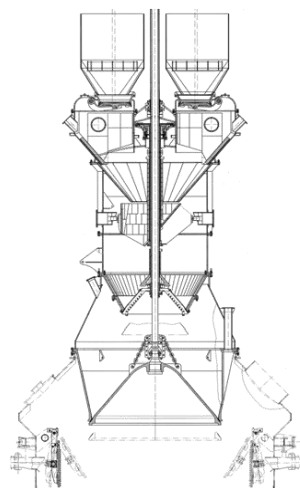
Unlike loading apparatus, bell charging devices with rotating chute is best suited to supply the furnace with tape, and portions of coke and ore are loaded into a separate furnace, the whole amount by a single movement of the trough rocker.

It is designed to distribute in a controlled manner into the furnace raw materials. This can print

a rotational motion in both directions by 360° and move vertically from 0° to 50°. The vertical motion can be achieved in 11 preset position, rotation and tilting movements are independent.

To withstand, the wear side is covered with wear plates stacked circularly and in the area wear plates are mounted in a circular type ("honeycomb").

Functioning with rotating chute: Raw materials are brought and unloaded in bunkers supply of materials flowing into the bunker. The bunker material is provided at the top with two superior sealing flaps (keyboard tray).



**Fig. 1.** Device charging the cones [1]

After downloading materials from the materials skip bunker, the upper sealing flap (flap plate) corresponding to the skip that transported raw

materials and the hopper closes with blast furnace gas and is pressurized by opening the flip equalization.

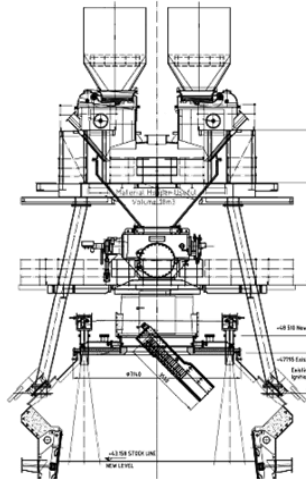


Fig. 2. Device charging with cones [1]

If the furnace is ready for loading (condition of furnace goal is met), it will start the sequence regulating the flow of material discharged into the furnace, by opening the bottom seal, followed by flap material that opens up in a certain given position which controls the flow rate of the various materials.

Raw material loaded into hopper material flow from the hopper through the flap of material, flap bottom sealing and operator trough rocker (box mechanisms pan and tilt trough distribution), which is protected against wear by a feeding tube central distribution chute during turning.

The raw materials can be loaded at any point desired trough distribution and can be performed simultaneously by a completely independent movement of rotation around the central axis of the furnace and a rolling movement, to the surface of the column materials.

The use of this device requires continuous control of the charging load level and composition of blast furnace gas. That charging with this type of machine offers the most opportunities for sharing materials at the loading mouth.

This type of apparatus has several technological advantages, including:

- weighing the material in the charging unit SAS sites;
- controlling the amount of material introduced into the furnace circumference;
- distributing the rings or spiral material loaded into the furnace;
- the possibility of surface loading cargo sectors;
- ordering and tracking computer charging schemes, the amounts entered;

- adjusting the speed and changing the angle for each of the 11 positions tipping.

## 2. Objective

Worldwide furnaces are equipped with Chargers bicameral bell or devices with rotating chute performance. Temperature protection action from the loading mouth is not strictly necessary since the furnaces have a stable and appliances bicameral upper chamber works with excess nitrogen [1-6].

Blast furnaces (F3, F5) from ArcelorMittal Steel Galati S.A. chargers are equipped with two bells and keyboards bicameral sealing. Charging devices are exposed to prolonged high temperatures and variable neck furnace against the background of deficiencies in operation [1].

In 1998 blast furnace no. 5 May 2700 m<sup>3</sup> was equipped with an upgraded battery charger, a Mannesmann - Germany, which has been provided with two working chambers (bicameral) and 2 sealing flaps that close to the upper chamber above the small bell. Furnace no. 5 may work from the beginning with batch consisting of two semi-loads of coke and ore each of three skips. Ferrous load weight ranged from 70-86 t.

From the start, after the explosion in November 2011, the furnace operates with high thermal losses and instability. One reason is implicit by the conceptual design of loading equipment: the large bell is too small in diameter at the mouth of charge and it is not possible to upload material to the periphery (wall).

The current load device with the second upper flap of the sealing bell is not able to distribute the charge material near the furnace wall and the gas distribution in the stack that is preferential to the wall. Heat losses are controlled.

The current loading device with the second upper flap of the sealing bell is not able to distribute the charge material near the furnace wall and the gas distribution in the stack is preferential to the wall. This promotes peripheral circulation inside the furnace, so a poor thermal condition with frequent reduction/burn can stop and cool the element. Heat losses are controlled.

Blast furnace productivity and low fuel consumption remain high.

It was decided to continue furnace operation following losses related to the replacement of the charging unit, with one powerful channel rotating outages to 04/27/2014.

This change aims:

- productivity: 5,600 tons iron / day;
- equivalent comb. Total 490 kg/t HM;
- report of use: 96%;
- increased life of the furnace;

- facilitate maintenance work.

### 3. Theoretical considerations

Material coating the entire section of the mouth of the opening bell loading requires maintaining high correlation between neck diameter and the diameter of the large bell furnace.

The differences between these two dimensions report the blast from various countries and from Furnaces 3 and 5 at ArcelorMittal Steel Galati S.A. They are shown in the table below:

**Table 1.** [1]

Difference Reports	CSI	SUA	Germany	ArcelorMittal Steel Galati	
				F3	F5
$d_g - d_{CM}$	<1.9	<1.7	<1.2	1.9	3.0
$d_{CM} / d_g$	0.55 - 0.76	0.65 - 0.81	0.7 - 0.8	0.72	0.65

where:

- $d_g$  - furnace neck diameter, m;
- $d_{CM}$  - great bell diameter, m.

The shape and dimensions of technological sub-assemblies are established on experimental basis. Thus, it was found that the volume of cargo storage space on the large bell to be approx. 2.5 to 3.0% of the volume of the furnace. At small furnaces (F3), the lower chamber volume is 54 m<sup>3</sup>, which represents 3.16% of the useful space and for the furnace F-5 (90 m<sup>3</sup>) this ratio is 3.3.

The great bell diameter  $d_{CM}$  of the charging unit is determined by the following two criteria:

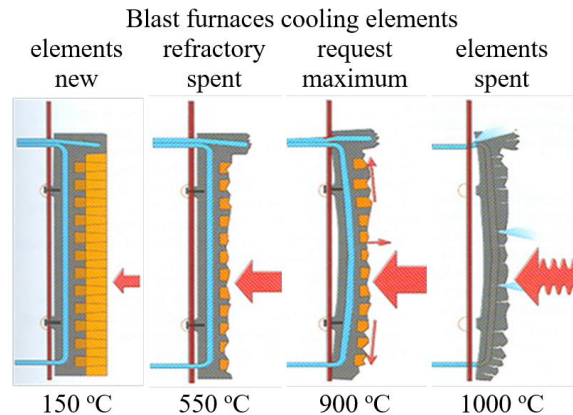
- after  $d_1 - d_0$  values:
  - 1.41 - small and medium furnaces ( $d_1 < 4.5$  m);
  - 1.34...1.4, furnaces and large intercede ( $d_1 = 4...8$  m);
  - 1.3 ... 1.35 - furnaces very large ( $d > 8$  m);
- after values and the difference between the diameters  $d_1, d_0$ :  $c = d_1 - d_0$

that, for  $d_1 = 5...8$  m according to the equation:

$$c = 0.26 d_1 + 0.1 \text{ [m]}$$

$$d_0 = d_1 - (0.26 \cdot d_1 + 0.1) \text{ [m]}$$

Heat loss is not evenly distributed on the circumference and height of the furnace. This occurs due to damage to the cooling element.



**Fig. 3.** Blast furnaces cooling elements

The temperature of the cooling (Table 2) element is considered critical when:

- at least one face warm temperature of an item ranges within the ranks R1, R2, R3, R4 > 150 °C for a period longer than 5 minutes;
- at least one face warm temperature of an item ranges within the ranks S5, S6 > 350 °C;
- at least one face warm temperature of an item ranges within S7 > 300 °C;
- at least one face warm temperature of an item ranges within the ranks S8, S9, S10, T11 > 400 °C for a period longer than 10 minutes.

Cooling water temperature is considered critical when:

- at least for one of the 28 temperatures (temperature measured at the exit of the row), the elements T11 is greater than 65 °C;
- return water temperature (before entering the heat exchanger) is greater than 55 °C.

**Table 2.**

Description	Row	Symbol	Material	Temperature	
				Alarm	Critical
Stak	11	T11	Cast iron	350	400
	10	S10	Cast iron	350	400
	9	S9	Cast iron	350	400
	8	S8	Cast iron	250	400
	7	S7	Steel	300	300
	6	S6	cast iron	300	350
	5	S5	cast iron	350	350
Hearth	4	R4	Copper	125	150
	3	R3	Copper	125	150
Bosh	2	R2	Copper	125	150
Belly	1	R1	Copper	125	150

This will create a mask that contain table with temperatures cooling elements. Background boxes will turn yellow when the temperature will exceed temperature alarm, the element will become red when

the element temperature will exceed the critical temperature. When exceeding the critical temperature, a similar table will count exceeding duration.

#### 4. Case Study

When downloading material on an inclined plane from a certain height, there occur freely sloping angle cuttings depending on the nature and grain size of the material. Embankment angle is called the angle of natural embankment. When loading the furnace, where the flow conditions are different because the surface on which it falls is not right and is in motion, and lateral wall is lined at the mouth loading embankment angle; then the natural state changes. The angle cuttings from the furnace could be calculated with:

$$\operatorname{tg} \alpha = \operatorname{tg} \alpha_0 - K \frac{h}{R}$$

where:

- $\alpha$  = slope angle at the loading mouth;
- $\alpha_0$  = angle natural embankment in free fall from a low height, degree;
- $h$  = drop height, m;
- $R$  = radius of the charge opening, m;
- $K$  = coefficient, which depends on the conditions of fall, shape and material characteristics.

Travel position must consider, firstly, the gas flow diagram by section, and how loaded materials will settle will depend on different slope angle have (26 to 29° coke and 34-43° ores).

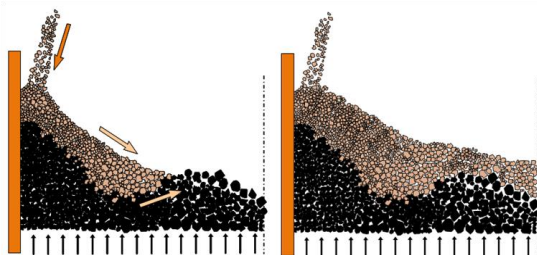


Fig. 4. Particle size segregation (ore, coke)

Peripheral circulation and the central one of the alignments is given by way of ore and coke layers in the charge opening, and that the gases always have the tendency to move against the wall of the furnace, where the hydraulic resistance of the column is lower. Whatever charging device would be used with simultaneous downloads (chargers bell) or successive round score (devices without bell), widely grain materials are subject to the phenomenon of segregation. As a result, larger pieces, particularly

coke, tend to be thrown to the periphery and center, and small grain will settle forming a ridge, dense, somewhere between the center and the wall.

Distributions of gas above explain the tendency to move the peripheral and central. Setting the required gas to the center or the periphery can be done by distributing the mouth of charging layers to increase strength column, while increasing the efficiency of gas use. The main component of the cargo metal grit agglomerate is between 6-40 mm and the coke has a grain size ranging between 36-80 mm. When loading the furnace due to the graininess, broad sloping fabric takes place accompanied by the phenomenon of segregation.

The current load device with the second upper flap of the sealing bell is not able to distribute the charge material near the furnace wall and the gas distribution in the stack that is preferential to the wall. Heat losses are controlled. Charging device (Fig. 5) is not effective. Blast furnace productivity and low fuel consumption remain high.

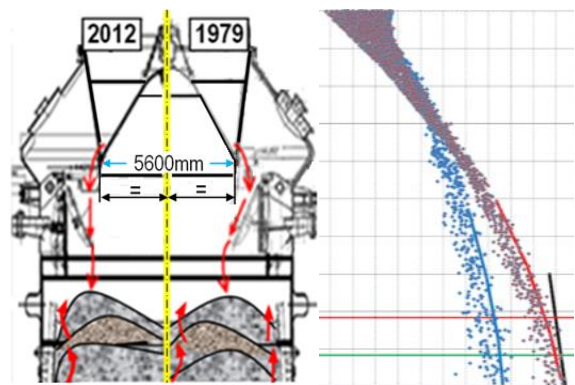


Fig. 5. The distribution of the material at the mouth of charging

Compared to other furnaces in operation, it shows that F5 draft report does not respect the usual great bell of diameter and neck diameter blast furnace.

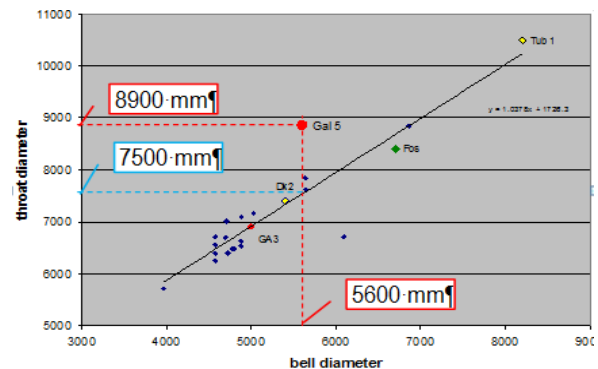
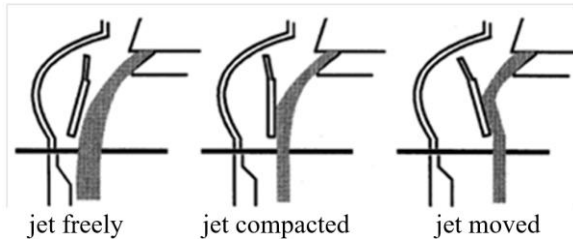


Fig. 6. Ratio of diameter bell vs. neck blast furnace



The following positions have no influence on the flow [1]:

- coke: pos. 2 to pos. 6;
- agglomerate: item 2 and item 7;
- pellets: pos. 3, pos. 5 and pos. 7.



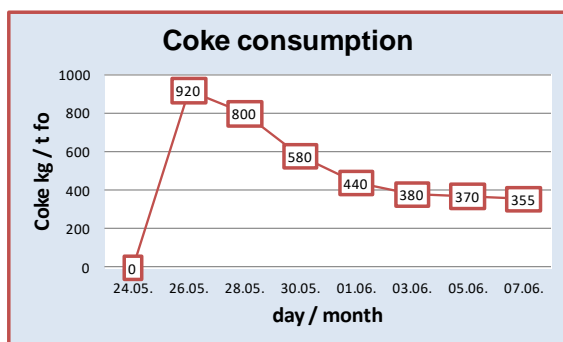
**Fig. 7. Armouring material influence on jet**

By convention were established:

- level "0" which is set at one meter below the bottom of the Jupe neck, adjustable in vertical position (position 2 adjustable neck);
- the "empty furnace" which is set at four meters below the bottom of the Jupe neck adjustable in vertical position (position 2 adjustable neck).

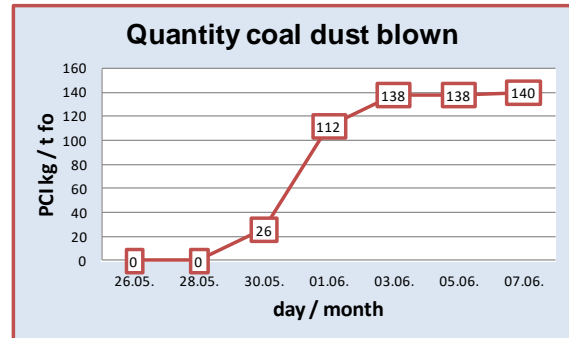
### 5. Obtained values

The specific consumption of coke is the second factor that depends on the productivity of the furnace and may vary within wide limits, depending on the nature of the cargo. The rate of coke has been reduced to start the furnace, the expected step 914 kg/t HM air blow at the beginning of the furnace was reduced to 354 kg/t HM.



**Fig. 8. Specific consumption of coke**

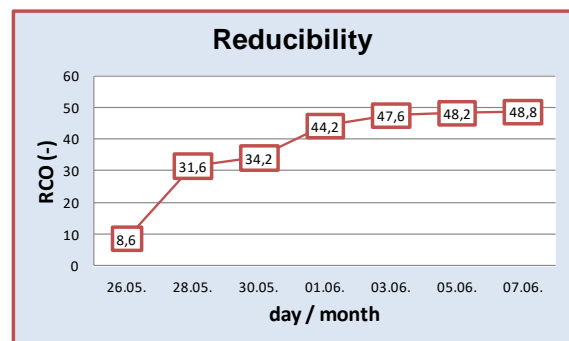
Pulverized coal injection (PCI) is a process that involves blowing large volumes of fine coal dust in the furnace. This operation provides an additional source of carbon to accelerate the production of metallic iron, reducing the amount of coke, thereby decreases the consumption of coke / TFO and emissions into the atmosphere.



**Fig. 9. Coal dust injected**

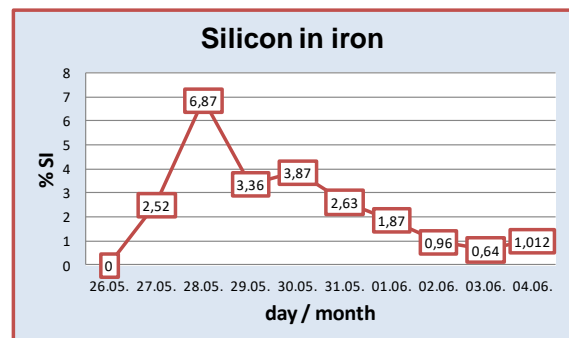
What may be reduced is expressed by the speed at which iron in its oxides is released by reduction reactions. It is dependent on the nature of oxides:

- hardly reducible ores (magnetite  $Fe_3O_4$ );
- average reducible ores (hematite  $Fe_2O_3$ );
- average reducible ores (limonite  $2Fe_2O_3 \cdot 3H_2O$ ).



**Fig. 10. Reducibility**

The silicon content in iron, [Si] content developed in the first batch was great - max 8.023% and reached 1% to 6.5 days running. Average daily bath and metal fell from 5.493 at 1.014%, a rate of 0.746% daily decline.



**Fig. 11. The silicon content in iron**

## 5. Conclusions

Blast furnace charge started from 23/05 to 25/04 (about 40 hours). Ignition and start was made with wind blowing through 12 holes. The first evacuation of pig iron was made on 26/05.

Using the skimmer began on 28/05 at 04:00. First delivery of BOF steel plant was done on 28/05 with [Si] content of 6.25. The furnace was restarted on 29/05 after an overhaul, with (32) nozzles opened.

PCI coal dust blowing began on 30/05 / at a rate of 26 kg / TFO, increasing the amount infused by up to approx. 140 kg/TFO.

The rate of coke charged to the furnace decreased from 914 kg/TFA, from start-up to a quantity of 354 kg/TFA over 8 days.

[SI] in the iron content was very high at a value of 8.023% max, but came to value of 1% at the end of the process.

The average temperature of the first batch of iron was 1438 °C, rising within 8 days until the furnace went into normal operating parameters, and the average temperature reached 1486 °C the next batch.

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