A NEW APPROACH FOR PRESHAPED BLOCKS FOR COMBUSTION CHAMBERS IN IRON ORE PELLETS INDURATING FURNACES [1]

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Abstract

The traditional design for pre shaped blocks allows a relative instability of the pieces that move toward the furnace center line during operating time. As this movement results in an air gap in the cold face of the blocks, a strong thermal tension occur leading to cracks forming and pieces falls. This paper reports the development of a new block design focused in a better overall set stability. The pieces dimensions and weights were lowered and the installation became more comfortable and productive, allowing to shorter plant shutdown times. Materials and manufacture challenges were surpassed and two sets were installed in the last April 2008, so as to permit it to be followed and evaluated in situ.

Key words: Combustion chambers; Iron ore pelletizing, Refractory.

NOVO CONCEITO PARA CONSTRUÇÃO DE CÂMARAS DE COMBUSTÃO EM FORNOS DE PELOTIZAÇÃO DE MINÉRIO DE FERRO

Resumo

A movimentação relativa dos blocos tem sido um fator determinante na vida das câmaras e o ciclo de paradas das plantas. Dessa movimentação resulta uma tensão térmica e o aparecimento de trincas e quebra das peças. O presente trabalho descreve sucintamente o desenvolvimento de formatos que restringem essa movimentação, possibilitando uma melhoria da estabilidade do conjunto. As dimensões das peças e os respectivos pesos foram diminuídos contribuindo para uma condição mais confortável do trabalho de montagem e propiciou uma redução importante no tempo de montagem e no tempo total de parada. O desafio de fabricação e acerto de materiais já foi superado e dois conjuntos dessa nova concepção já está em operação desde abril/2008 na Usina CALE UPSL (São Luís), o que permitirá acompanhar a evolução e o comportamento real do projeto.

Palavras-chave: Câmaras de combustão; Pelotização; Refratários.

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1 INTRODUCTION

Brazil has experienced a strong growth in Iron ore pellets production since the end of 60's. Nowadays there are 12 plants running as can be seen in Table 1. All plants run linear furnaces frequently referred to as "Lurgi-Dravo" technology.
So far, there are no grate-kiln plants in Brazil ("Allis-Chalmers" technology) certainly due to regional hematite ore predominance.

Table 1 – Pellet plants running in Brazil – Nominal Capacity [1]

Plant	Location	Cap. Mt/year
VALE 1	Vitória – ES	2.1
VALE 2	Vitória – ES	3.1
VALE 3 – ITABRASCO	Vitória – ES	3.3
VALE 4 – ESPANOBRAS	Vitória – ES	3.8
VALE 5 – NIBRASCO	Vitória – ES	4.2
VALE 6 – NIBRASCO	Vitória – ES	4.2
VALE 7 – KOBRASCO	Vitória – ES	4.3
VALE UPSL	São Luís – MA	6.0
SAMARCO 1, 2 and 3	Anchieta – ES	20.6
VALE MINA DE FABRICA	Congonhas – MG	3.5
VALE VARGEM GRANDE	Nova Lima – MG	6.0
TOTAL CAPACITY		**59.5**

According to ILAFA,[2] Brazilian actual production reached 70.0 Mt in the last 2005' and this 2008 another record is expected.
Furthermore, new installations are on the way such as Vale-8, Casa de Pedra, MMX and Samarco 4 - 5, nearly adding more 5 new units and some 20 Mt to the whole production capacity.
At the same time, new requirements and challenges arise to manage plant shutdown schedules in order to optimize resources and decreasing non productive times.
In this scenario refractory plays an important role, specially the combustion chamber linings, what has being a key point to determine the furnace's campaign life. Currently the target average life of these chambers is typically 36 months in the critical region.
In Brazil the linings use mostly pre shaped blocks instead of monolithic materials for the sake of reliability and cost effectiveness. However, this technology remains calling for improvements to assure longer campaigns life of say, 48 or even 60 months.
This paper intends to contribute with this goal, by means of a new design for combustion chamber lining, aiming better construction stability.

2 A CASE STUDY

Inspections done on site during plant shutdowns and post mortem analysis of samples taken from used blocks demonstrate that the material high Alumina grade currently applied comply with local requirements[3-5] and has pointed out the main limitations for longer chamber campaigns:

- Process slag forming and sedimentation in the bottom of the chamber leading to remove it up by oxy flame and mechanical shock (Figure #1);

- Relative moving of blocks toward the center line of furnace, more evident in the upper semi circle and an air gap forming between chamber and side walls (Figure #2) leads to crack forming;

Figure 1 – Slag deposition in chamber bottom at campaign finish.

Figure 2 – Slipping process of chamber upper semi circle.

In first case, we consider it as a matter of mass balance and combustion control, related to both pellet physical degradation during burning process and aerodynamic gas equilibrium phases in the primary cooling and recovery zones.
This paper will not approach this case. Therefore, it directly affects refractory performance and certainly is a subject to be taken in account to elongate furnace campaign life. In addition, 90% Al_2O_3 grade refractory, shaped and burnt, has no longer records of failure in its physical chemical properties.(3-5)
Regarding blocks set stability, the second limitation, one can point out the following items:

1. Traditional pre shaped lining design, despite of the mortar applied, allows an “almost free moving junction” along the burner axle due to flat and continuous junctions, subject to successive chamber flame intensity variation (fig. 3).
2. Even more, the insulating layers are homogeneous along 360º of chamber cross section. In this way, the static pressure gradient between the bottom and top of section happens, creating an air gap in the upper region, leading the blocks to lose thermal contact, become stressed and break down.

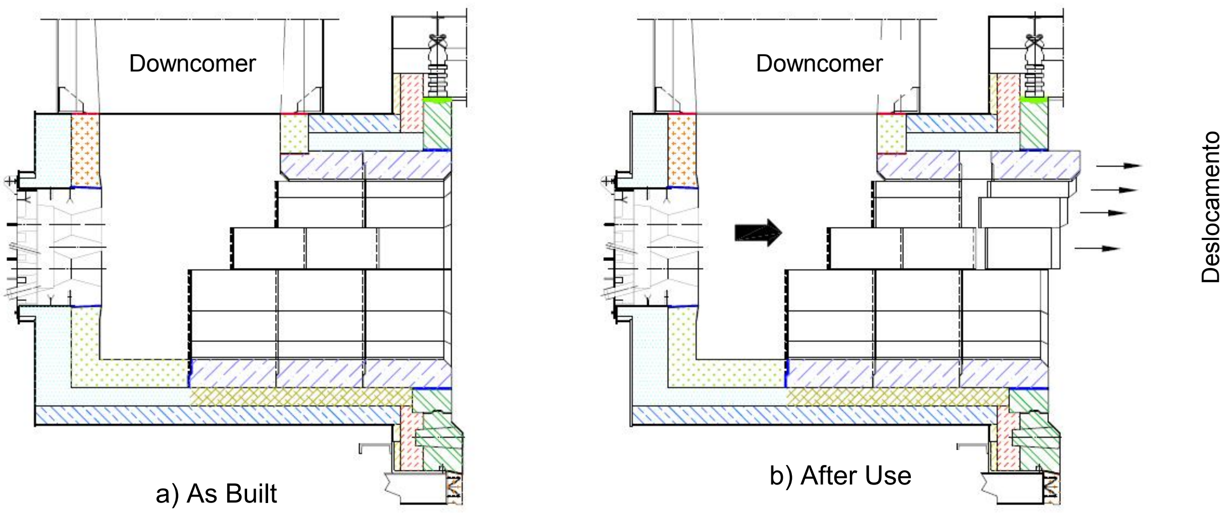

Figure 3 – “Traditional” design - new installation and after use - chamber blocks upper semi circle progressive displacement after use.

3 DEVELOPMENT OF A NEW DESIGN

In order to get a more stable base for the blocks set, a simple analogy was established based on interferometry analysis[6] to replace part of insulating material by a more consistent one (Figure 4).

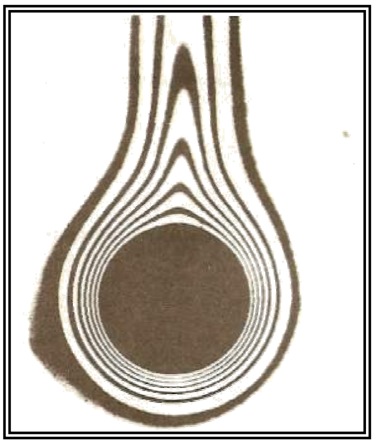

Figure 4 – Interferometry analysis – Heat flow in a horizontal tubular heater ([6]) associated to thermal behavior of combustion chamber.

From this viewpoint it was idealized a materials distribution to get a more stable foundation as presented in Figure 5, approximately keeping the same thermal profile. In that figure, $\underline{\alpha}$ stands for heat convection ratio, $\underline{\lambda}$ - thermal conductivity and CCS means compression strength.

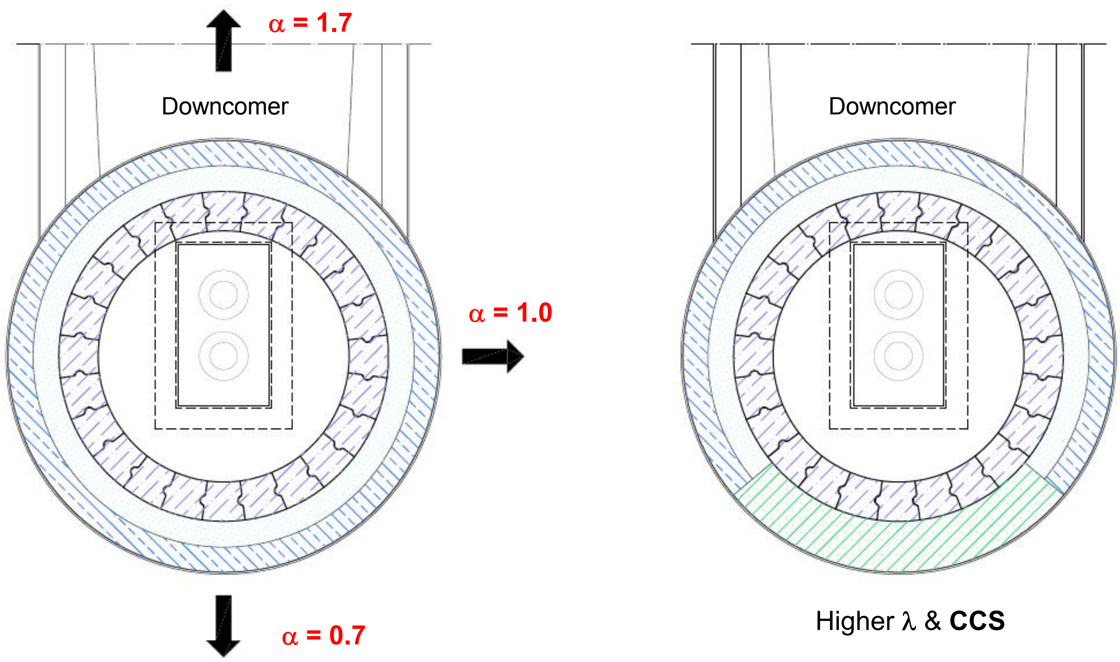

Figure 5 – Thermal model approach – (a) Losses ratio across main directions up, down and side by natural convection and (b) a foundation more consistent for set stability.

The following Figures 6 and 7 one can compare some details of the current (traditional) and new designs, oriented to avoid slipping or differential moving inter blocks.

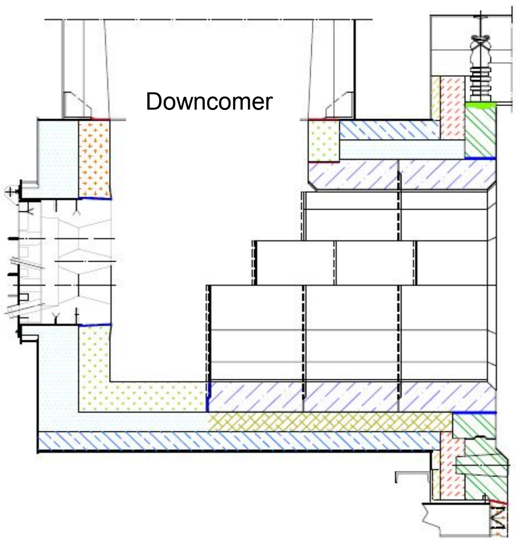

Figure 6 – Traditional design

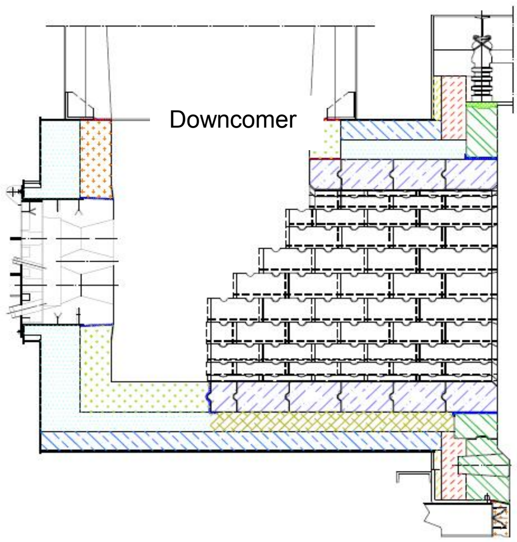

Figure 7 – The new one

4 THE PRACTICAL IMPLEMENTATION

After arranging a more consistent base to support about 3 t of blocks, the new working line blocks were developed to adopt special fits to not allow any moving inter blocks.
A pre assembling was performed for training purposes to assure a perfect installation as presented by Figures 8 and 9.

Figure 8 – Pre assembling blocks, detaches fitting and arrangement adopted.

Figure 9 – Detaching fitting inner side.

Due to complex geometry of new blocks, many prototypes developments and changes were carried out to overcome manufacture limitations and requirements,

such as mix grain size arrangements, dies & moulds dimension adjustments, preventing cracks forming (dry out profile, thermal treatment), to assure properties and structural homogeneity.
As it can be seen in figures above, the final block shape includes a weight reducing from 90 to 35 kg/piece consequently becoming easier and safer to handle and to install.

5 RESULTS

Figures 10 and 11 show the traditional and new implementations.

Figure 10 – "Traditional" design – detaching joint alignment

Figure 11 – New design – Lighter pieces and 3 axles fitting

The installation became more comfortable and productive, lasting 12 hours (new design) against 24 hours in the traditional one.
The following Figures 12 and 13 show actual installation at VALE UPSL, chambers #8 and #29, both according to new design.

Figure 12 – Installation on chamber #8 of VALE UPSL.

Figure 13 – Installation on chamber #29 of VALE UPSL.

6 CONCLUSIONS

Regarding refractory material used to make blocks, by its physical chemical properties is considered to match local requirements and based on history and post mortem analysis done(3-5) should not limit combustion chamber life.

One can point out the following conclusions:

1. New design leads to blocks hold on to each other and not allow any moving separately;
2. Installation time per chamber was reduced by 50% (24 to 12 hours);
3. Ergonometric conditions became more comfortable and lead to a safer way to do the labor.

Up to this moment the chambers behavior keeps at normal parameters and the campaign life is to be evaluated from this trial at VALE UPSL, started at April 16th, 2008.

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