"HIGH PRODUCTIVITY AND LOW FUEL RATE OPERATION AT CST BLAST FURNACES". (1)

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ABSTRACTS

The Companhia Siderurgica de Tubarao since the start up with a ingot casting and slabing mill to the near future with its new hot strip mill has been transformed, according to the its strategic plan, during these eighteen years of operation. And the Blast Furnace area has performed its play increasing productivities, reducing costs and mainly extending the furnace life.

The present paper shows the results that has been obtained in the blast furnaces during these years.

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INTRODUCTION

The Companhia Siderurgica de Tubarão is an integrated steel works for production of slabs, located in the Espírito Santo. Its operation began on November 30, 1983 with the blow in of your No1 Blast Furnace.
On that moment CST's main equipments were :
-1 Coke Plant with 3 batteries of 49 ovens,
-1 Sinter Machine with 440 m²
-1 Blast Furnace
-1 Steel Shop with 2 converters
-1 Ingot Casting and slabing mill

The production foreseen to this plant it was of 3 000 000 t / year of slabs.
In 1995 the first Continuous Casting started, and the plant has improved its slabs quality. Em 1996 pulverized coal injection system was started and also the top gas recovery turbine. With those new equipments and the development of the operational control, the plant production has reached 3,5 Mt/year.
Face to a favorable situation the installation of No2 Blast Furnace was decided, this one a small size furnace just to cover the overcapacity of the steel shop, with your 2nd continuous casting machine. With small improvements in equipments the productivity of the coke plant and sinter plant has risen in order to supply the new needs of raw materials. New equipments are also added Steel Shop for ennoblement of the product, and as shown in fig 1 CST reached its actual configuration.
To produce slabs to the international market, your project incorporated the most modern technology of the seventies, that allied to your strategic location, has allowed to CST the highest level of international competitiveness.
And due to this competitiveness CST looks for constant improvements in your operational results and in the use of resources, especially water and energy, placing the company in the vanguard of the steelmaking in the 3rd millennium.
With the start up of your hot strip mill in 2002, CST will change your production profile moving part of your production to the internal market.

BLAST FURNACE No 1

With a project of the decade of 70, CST No BF is a big blast furnace with 4415 m3 of inner volume and it was started up on November 30, 1983.
The main characteristics of BF are shown in the picture I, where we can detach the top type, with double cone and movable plates for control of burden distribution, and the cooling system with stave coolers, items that has become fundamental for the longevity of the campaign.
The figure 2 shows the results in the 1st year of operation. As the production elevation can be observed and the reduction of FR was made gradually. It can also be observed a certain difficulty in the operational control, with high values of CO/CO2 and
ΔP/V (FIG3).
On this 1st year there were many difficulties to control the BF operation, with the burden distribution. The figure 4 shows the evolution of the positions of the movable plates, where it can be noticed the intensity of the changes.
The burden distribution could be successfully reached a balance and BF began to improve its performance indexes. The figure 5 shows the evolution of the monthly results of productivity and FR.
With the operation of BF presenting good results (fig 6), it is constantly looked for mainly the reduction of costs through reduction of CR and use of alternative charging materials such as small coke, lump ore, etc.
With the increase of O/C, the control of the gas distribution became difficult since the competition among central and peripheral flow could not be avoided that leads to divisions of the coke in 2 batches.

C↓ O↓ TO C↓ C↓ O↓

that allowed a better control among the central and peripheral gas flow. Figure 7 shows the charging of the materials. After that, a long period of high productivity and low fuel consumption could be noticed. In terms of burden distribution several changes were done, with base in this new sequence C↓ C↓ O↓ , applying variations of sequences, armor positions, weights, and even changes of opening of the big bell and selective charging of materials.

ELONGATION OF FURNACE LIFE

Face to the good operational results, and to the point of all CST's production was based on BF 1 an intensive program for elongation of furnace life was started
The figure 8 shows the control for furnace life

The system BF is isolated from the universe by your shell. So, the end of a campaign will be when that " isolation " could not be more possible.
The rupture of that isolation will be consequence of a process of thermal fatigue of the shell after the collapse of the refractories and staves, or of a process of erosion of carbon blocks of the hearth.
In this way, a stable gas flow should be kept at furnace walls and a flow of liquids far away from the walls of the hearth. Then the key point of the prolongation of furnace life becomes the warranty of a stable gas flow . That gas flow is extremely influenced by the inner profile of the BF. So careful attention should be given to the charging system, as well as to the maintenance of the inner profile, mainly in the first 6 meters of the shaft , which will guarantee a good burden distribution.
The figure 9 shows the evolution of the refractory wear of the CST blast furnace.
In the figure 10 the main points that influence the furnace life are shown as well the adopted countermeasures.
Also, with an appropriate gas flow providing high furnace stability, it will keep the hearth in good condition. The figure 11 shows the evolution of the temperatures of the hearth.

And keeping the good operational performance through a good burden distribution control the pulverized coal injection system was started up, challenging the furnace life control.

PULVERIZED COAL INJECTION

At 1996 pulverized coal injection was begun. As shown in figure 12, a series of difficulties could be expected, mainly concerning the control of gas distribution. That difficulty came to be confirmed. As CR went being reduced, the distribution control turned more and more difficult bringing a significant increase in the thermal load on the staves (fig 13).
That difficulty is associated to the lack of central gas flow that happens with the increase of the relationship M/C with the reduction of coke rate.
The burden distribution for the center of AF is based on the rolling materials toward to center, by means of repose angle and the material volume and, with the reduction of CR the ore volume increases (fig 14) that increases the ore presence in the center. To guarantee a strong central flow it is necessary to put the movable plates forward for the coke.
However, in a diameter of 10,5M, the maximum stroke is of 1,0 m so ore must push the coke to the center. Then, in order to make coke available to be pushed, charging sequence was changed to C ↓ O↓ C↓ O↓ changing weights and armor notches to maximize the " push coke ". The measure results into desired effects and the operational results could be kept or even improved.
However, nevertheless, with the increase of M/C the central flow has been reduced and also the renewal of the center of DEADMAN could be noticed leading to a decrease of the underhearth temperatures (fig 15). In the case of CST No1 BF this decrease of the temperature has been accompanied by the hearth wall temperatures, so that any compromising is not being expected to the furnace life.

Anyway, in case of long periods with the low temperatures, it is advisable a hearth cleaning operation , before it causes any charge descend instabilities.
In this way, operational results are obtained at No BF accomplishing your longevity targets.

THE BLAST FURNACE No2

With the second continuous casting and other improvements, Steelmaking shop would have a " over capacity " and in that way the implantation of the No blast furnace was decided.
The table I shows the main characteristics of BF-02.
This blast furnace was conceived incorporating several technological advances, that turn it very different from BF-01 and, the biggest concern became the understanding of the " new equipments ", believing that the acquired knowledge in BF-01 could be applied.
And, under a great expectation on July 01, 1998 the blast furnace was blew in. After 24 hours, the 1st tap and within 10 days the productivity of 2,0 t/d/m³ and FR below 500 kg/t (fig 16) were reached. The figure 17 shows the evolution of Si content , that reached normal values within 8 days.
With the raising of the productivity and reduction of CR the needs of control of the burden distribution has emerged , evidenced by the hanging and slips occurrences ; the differences for BF-01 began to be clear.
With the charging sequence C ↓ O ↓ C ↓ O ↓ at BF AF-01 a competition among the central and peripheral flow occurred , the Bell-Less top both should be controlled independently.
Increasing the relationship O/C (reduction of CR) the charge distribution starts to not to answer appropriately, due to an uncontrolled " segregation " of coarse material to the center of AF lowering the peripheral flow , that with a high cooling efficiency of the copper staves, caused a formation of inactive zones, changing the inner profile and leading to a unstable operation. (fig 18).
The solution for such was increase the peripheral flow. That has stabilized the BF operation, and the coal injection rate should be increased. For this, as it was said previously, it would be necessary a strong central flow, that leads to a change in the charging sequence to C ↓ C ↓ O ↓. The second coke was charged directly in the center of the BF (fig19). In that moment , basically the rings of the 1st coke and of the ore control the burden distribution (wall and intermediate) and the 2nd coke controls of the central flow.
CR = 315 kg/t with PCR = 170 kg/t could be reached in that way
With the productivity increase, due equipment capacity , top sequence had to be changed, so that it came back to the pattern C ↓ O ↓ C ↓ O ↓ and the central flow could not guaranteed, which leads to operational instabilities and hearth temperatures decreasing, and a hearth cleaning operation (increase of CR and reduction of B2) becomes unavoidable (fig 20).

To get the control of the central flow, an improvement that allowed the charge of the central coke during the coke charging was done , by closing LMG (low material gate) (fig 21).

As CR reduction is aimed and in case of the production increase , the weights of charged ore increase and without the possibility of reduction of the coke base, due equipments capacity, the alternative C ↓ O ↓ C ↓ O ↓ O↓ was developed, using this 3rd ore to control peripheral gas flow (fig22). So controlling the gas distribution with rings of bell less top for coke and ore, and special control of gas in the center with central coke and wall flow specially controlled with the 3rd ore CR as low as 285 kg/t at PCR of 185 kg/t at high productivity could be achieved.

CONCLUSION

After 15 years of operation of its BF-01, a big blast furnace, with double bell , CST has put in operation the BF-02 this small one with Bell-less top. It could be noticed on these 3 years of operation that the phenomena involved in the process of BF is independent of its size or equipment and although for different ways the control objectives are usually the same . It can be argued that the productivity of BF-02 as well as its coal injection rate is higher than BF-01, however it should be pointed out that the raw materials used are the same ones (table II) in both furnaces. Also the top type has been fundamental.
Nevertheless, the control objectives are the same ones. The cast house aims is the perfect drainage of the hearth with long and stables taps ; the charge distribution has as objective of adjusts on the thermal load, central flow , operational stability ,etc... and the result is accompanied by the probes (in burden or fixed) confirming or not the created image and leading BF's in a pursuit of minimum cost, maximum productivity and a longer useful life.