ECONOMICAL ANALYSIS OF REFRACTORY LINNINGS FOR SMALL BLAST FURNACES(1)

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ABSTRACT

Mini Blast Furnaces (furnaces with working volume up 350 m^3), in order to obtain low production cost at reduced scale, usually have refractory lining made out with materials with 45 up to 62% alumina and external cooling. Although this option corresponds to a low investment, it has a reduced working life, about 36 months. Another possible option would be to use high alumina refractories, with higher cost but resulting in a longer life (about 48 months). Many times these two opposed factors make difficult to the blast furnace operator to decide which option is the most economical. This work makes an economical analysis for these two types of lining, varying the interest rates, furnace productivity and margin of contribution. Thé results show that, for situations where the interest rates are low and the productivity is high, high alumina refractories are the most economical option, particularly when the furnace operation aims a longer campaign.

Key words: refractory, blast furnace, production cost.

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1. INTRODUCTION

One of the main characteristics of the Mini Blast Furnace (MBF) (furnaces up to 350 m^3 of working volume) is its low operational cost. In order to obtain low costs, in such small production scale, the MBF utilizes low cost refractory lining e external cooling. Although these systems present lower specific investment (per unity of iron produced), compared to the usual lining and cooling systems used in large blast furnaces, lining working life is considerably shorter. In many occasions these two factors, low investment and durability, are questioned and the operator has some difficulties to decide if the lower capital cost overcomes the benefits of a longer working life. Seeing under the economical point of view, there are three factors that will decide which refractory lining is the most economically suitable: furnace productivity, interest rates and margin of contribution. In order to determine under which conditions two different types of refractory (low and high alumina) is more economically attractive, an economical analysis is developed in this paper.

2. METODOLOGY

Figure 1 shows, schematically, the cash flow resulting of (1) an initial investment for buying and mounting of the refractory lining at the start up of the campaign and (2) the financial losses due to production stoppage for a new refractory change.

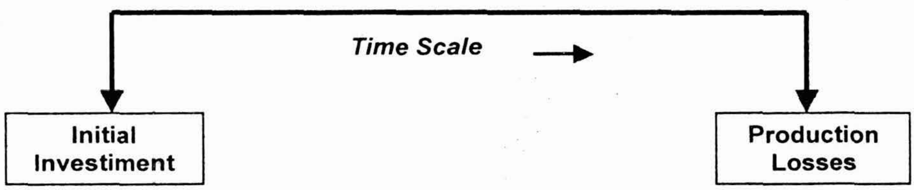

Figure 1 – Cash flow corresponding to the cash expenditures during the blast furnace campaign.

In order to compare the two lining options, it was calculated, initially, the present value of the expenditures showed in the figure, using the following equation:

$$PV = I_{initial} + \frac{L_{prod}}{(1+i)^n}$$

Where:

PV = present value of the expenditures, in US$

$I_{initial}$ = initial cost of the refractory lining, including labor, in US$

L_{prod} = Value corresponding to the financial looses due to interruption of the production for repair, in US$

i= interest rate in % @ month.
n = duration of the campaign, in months

The value corresponding to the financial looses, due to interruption of the production for repair, can be calculated through the equation:

$$L_{prod} = P \,.\, Vw \,.\, t \,.\, MC$$

where:

P = productivity of the blast furnace, in t per day per m^3 of working volume
V_w = working volume, in m^3
t = time for a new repair, in days
MC = margin of contribution, in US$/t

Once the present value has been calculated, since the duration of the campaigns are different for the two types of lining, the Uniform Liquid Cost (ULC) was calculated (that is, the value corresponding to a monthly expenditure along the campaign) according to the equation:

$$ULC = PV\left[\frac{(1+i)^n - 1}{i(1+i)^n}\right]$$

Using such criteria (ULC), the most economical option will present the lower ULC.

3. REFRACTORY LINING CHARACTERISTICS

The most usual refractory lining for the MBF is based on materials with 45 to 62% alumina. However, in some particular situation a refractory with higher alumina content can be used. Table I shows these two types of refractory for a MBF with 250 m^3 working volume.

Table I – Characteristics of the two options of refractory lining for a 250 m^3 working volume MBF.

Region	Low Alumina	High Alumina
Stack	45% alumina	45% alumina
Lower Stack	62% alumina	70% alumina
Belly	62% alumina	70% alumina
Bosh	62% alumina	70% alumina
Hearth	62% alumina	alumina carbon
Bottom	62% alumina	alumina carbon
Campaign (months)	36	48
Time for repairs (days)	30	30
Total Cost (US$)	460.000	640.000

4. RESULTS

Using this methodology, it was, initially, calculated the conditions for which both options would be economically equivalent. Figure 2 shows the results, for different interest rate and productivity. It can be observed that the high alumina option is economically viable, for a determined productivity level, as the margin of contribution increases along with the interest rates. This graph also permits to determine the most economically suitable lining under certain conditions: knowing the margin of contribution and interest rate a point can be marked in the graph. If the point is located above the curve, for a fixed productivity, the high alumina option is more interesting. If the point is located below the curve, low alumina refractory should be used.

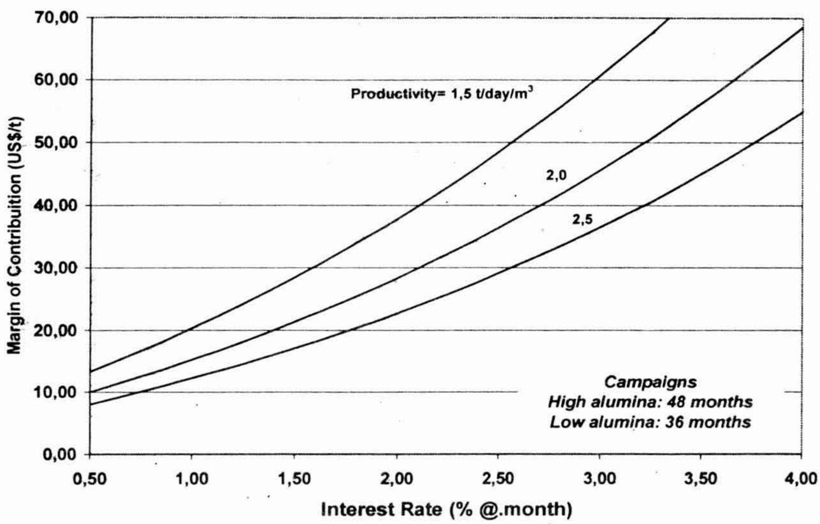

Figure 2 – Margin of contributions necessary for high alumina refractory lining to become the most economical option for a 250 cu. m. MBF for different interest rates and productivity.

Another way to compare the two lining options is to calculate what would be the minimum duration of the high alumina campaign in order to be economically equivalent to the lower alumina lining. Figure 3 shows the minimum campaign for the high alumina lining (keeping constant the campaign for the low alumina lining) necessary for economical equivalence between the two options. It can be noticed that, when the margin of contribution is high, the productivity is of minor importance for deciding between the two types of refractory. However, for low margin of contributions, productivity is of extreme importance, particularly when the interest rate is high.

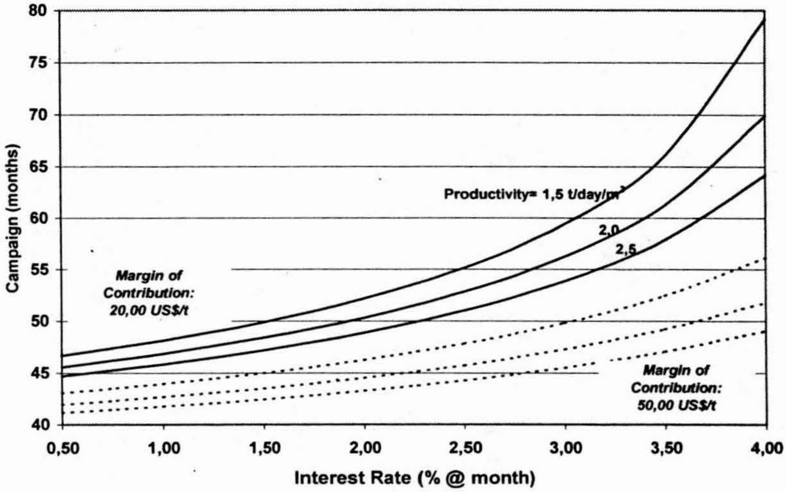

Figure 3 – Minimum duration of the campaign necessary to make the high alumina refractories the most economical option compared to the low alumina lining (36 months campaign) for two levels of the margin of contribution.

5. CONCLUSION

Although refractories with low alumina content (36-month campaign) are usually used for the lining of mini blast furnaces, refractories with higher alumina content (48-month campaign) can also be an economical option when the interest rates are low and the furnace operates at high productivity. If the operation of the MBF is made to aim a longer campaign, high alumina refractories is the most economical option, even for lower margin of contribution and intermediary productivity.