ECONOMICAL CONSIDERATIONS FOR IMPROVING THE DURABILITY OF THE CUPOLA LINING

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Abstract: The cupolas have a good thermal efficiency because the metal to be melted is in direct contact with burning fuel. One very important problem of this melting furnace is the durability of the lining. Due to the fact that the repairing needs bricks but also mortar, the combination of these two kinds of refractory materials of different prices, the establishment of a good proportion is obvious. This paper presents some economical data to establish the optimum alternative in order to improve the durability of cupola lining, obtaining in the same time an important economy.

Key words: cupola, lining, iron charges, coke layers, ramming the lining, bricks, mortar, durability, economy.

1. INTRODUCTION

The heating and the melting of metals and alloys are realized in special installations named metallurgical furnaces. Generally, these equipments are made from a working space, a heating source, the control apparatuses and other annexes.

The furnaces for melting of metals and alloys may be classified after the following criteria: the thermal sources (solid, liquid or gaseous fuels, or by electrical power); construction (vertical furnaces-blast furnaces, cupolas, water-jackets; reverberatory furnaces-Siemens-Martin; others). The furnaces have to ensure: a) the chemical composition and the casting temperature of the alloy; b) reduced consumption of fuel; c) metal lost by burning as low as possible; d) synchronized melting speed with the demand of castings production. The repairing of these furnaces needs bricks but also mortar and the cost is different according to the materials used.

In this paper is presented some economical data to establish the optimum alternative in order to improve the durability of cupola lining.

2. SOME ASPECTS CONCERNING THE CUPOLAS

Because of its relatively simply construction, the cupola remains the most used furnace to obtain cast irons in foundries. The cupolas may be classified as follows: a) after the interior profile: cylindrical and trunk-conical; b) after the nature of lining: acid, semi-acid, basic; after construction characteristics: with rocking forehearth, with fixed forehearth receiver, without forehearth receiver, with cold air, with hot air. The cupolas are furnaces which run in countercurrent.

Through the charging door are introduced the raw materials on alternating layers of metals, coke and flux. The drops of metal are collected in the crucible. Here, the gray iron or is accumulated or is evacuated discontinuous in the ladle.

The main dimensions of cupolas are the diameter and the height. These dimensions are chosen according to the desired hourly production of melted iron (Table 1).

Table 1.

Dimensions	Gray iron hourly production (t\h)							
	1,5-2,5	2,5-3,5	3,5-4,5	4,5-5,5	5,5-8,5	8,5-12	12-16	16-18
Diameter (mm)	600	700	800	900	100	1300	1500	1600
Height (mm)	3,0-4,0	3,0-4,5	3,5-5,0	3,5-5,0	4,0-5,5	4,5-6,0	4,5-6,5	4,5-6,5

The main processes in the cupola are as follows: a) processes of burning and change of heat; b) processes of oxidation and reduction. The first process is running in four zones starting from the bottom (Fig.1): crucible zone (hc), burning or oxidation zone (hor), reduction zone (hr), preheating zone (hp).

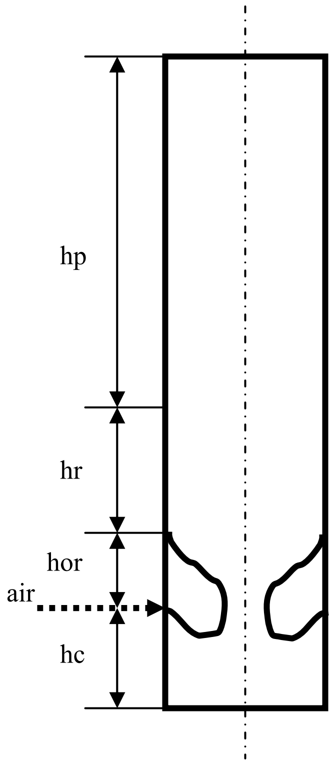

Fig.1
The four heating zones of the cupola

The melting of the metallic pieces starts when the temperature of the gases surpasses with 50-70°C the melting point of the alloy. The level where starts the melting depends on the temperature of gases; more the specified temperature is greater, upper is this level. The drops of metal must be overheated at the temperature of 1400-1500 °C. For this purpose are necessary 250kJ/kg.

The formation of the slag depends on the temperature of gases and the presence of the coke, fluxes, sand. and the oxidation products. The basic slag assure a greater speed of metallurgical processes than the acid slag.

The processes of oxidation and reduction are different at the four heating zones of the cupola. In the preheating zone, where the atmosphere is oxidant, may exist the reaction:

$$\langle Fe \rangle + \left\{ CO_2 \right\} = (FeO) + \left\{ CO \right\} \qquad (1)$$

In the burning zone may occur the reactions:

$$2[Fe] + \left\{ O_2 \right\} = 2\,(FeO) \qquad (2)$$

$$2(FeO) + \left\{ CO_2 \right\} = (Fe_2O_3) + \left\{ CO \right\} \qquad (3)$$

In the crucible zone may meet the reactions:

$$(Fe_3O_4) + \left\{ CO \right\} = (FeO) + \left\{ CO_2 \right\} \qquad (4)$$

$$(FeO) + \left\{ CO \right\} = [Fe] + \left\{ CO_2 \right\} \qquad (5)$$

Concerning the silicon, it oxidizes all the height of cupola:

$$[Si] + 2[FeO] = (SiO_2) + 2[Fe] \qquad (6)$$

$$(SiO_2) + [C] = [Si] + 2\left\{ CO_2 \right\} \qquad (7)$$

For the manganese are remarkable the reactions:

$$[FeO] + [Mn] = (MnO) + [Fe] \qquad (8)$$

$$(MnO) + [C] = [Mn] + \left\{ CO \right\} \qquad (9)$$

$$2(MnO) + [Si] = 2[Mn] + (SiO_2) \qquad (10)$$

The reactions of oxidizing of carbon are as follows:

$$< C > + \left\{ CO_2 \right\} = 2\left\{ CO \right\} \qquad (11)$$

$$< C > + ½\left\{ O_2 \right\} = \left\{ CO_2 \right\} \qquad (12)$$

$$[C] + (FeO) = [Fe] + \left\{ CO \right\} \qquad (13)$$

$$[C] + \left\{ O_2 \right\} = \left\{ CO_2 \right\} \qquad (14)$$

The sulphur reacts with metal in the preheating zone:

$$\left\{ \quad \right\}$$

$$3 < Fe > + \ SO_2 \ = < FeS > + 2 < FeO > \quad (15)$$

$$3[Fe] + \left\{SO_2\right\} = [FeS] + 2[FeO] \quad (16)$$

These reactions have a direct influence on the durability of cupola lining.

3. THE LINING OF THE CUPOLA

The lining of the crucible, the body and the stack is made with bricks according to STAS 1627/1-976, STAS 1627/2-1976, STAS 131/1978, STAS 136/1974.

The lining of the crucible is renewed after each working day. Considering that for each repairing of the crucible are necessary 300 bricks weighting 10 kg each, it is resulting that the daily consumption of refractory materials is as follows:

$$300 \text{ x } 10 = 3000 \text{ kg/day} \quad (17)$$

If the price of this material is 1,58 RON/kg, it is resulting that the daily cost of repairing is:

$$3000 \text{ x } 1{,}58 = 4740 \text{ RON/day} \quad (18)$$

4. EXPERIMENTAL RESULTS

After experimental researches we arrived at the conclusion that the crucible may be repaired with a refractory mortar with the following composition: Al_3O_3 = 24-26%; Fe_2O_3 = 1,5-2%; $C_{graphite}$ = 8-10%; water = the rest.

With this lining the cupola has a durability twice greater (48 h).

The cost of this mortar 0,895 RON/kg. The cost of a repairing of the lining with this mortar is:

$$3000 \text{ x } 0{,}895 = 2055 \text{ kg/day} \quad (19)$$

It is resulting that the economy obtained by using this mortar is:

$$4740 - 2055 = 2685 \text{ RON/day} \quad (20)$$

5. CONCLUSIONS

The lining of the cupola is deteriorated by the chemical reactions produced during the melting of gray iron. The cost of repairing of the lining of the crucible with bricks is rather high.

In this paper is proposed to repair the crucible with a mortar whose the composition is: Al_3O_3 = 24-26%; Fe_2O_3 = 1,5-2%; $C_{graphite}$ = 8-10%; water = the rest

The efficiency obtained by using this mortar in place of bricks is 2685 RON/day. In the same time, the durability of the lining of the cupola is twice greater.

REFERENCES

1. Ciucescu, D., Simionescu, Gh.-*Elemente de ştiinţa materialelor*, Editura Plumb, Bacău, 2004;
2. John, V.B.-*Introduction to the Engineering of Materials*, Macmillan Publishing Company, New York, 1983;
3. Moldovan, P., Florian, E. –*Tehnologii metalurgice,* Editura Didactica si Pedagogica, Bucuresti, 1979;
4. Simionescu, Gh.-*Tehnologia materialelor*, Ed. Alma Mater, Bacău, 2001;
5. Simionescu, Gh.-*Analiza calităţii materialelor tehnologice pentru turnătorie*, Editura Plumb, Bacău, 2001.