

## ABSTRACT

The evolution of reduction of the self-reducing pellets of chromite for obtaining ferro-chromium high carbon (FeCrHC) was analyzed. The influences of Fe-75%Si additions, addition of fluxing agents, temperature and time of reduction were studied.

The materials (chromite, ferro-silicon, petroleum coke, dolomite lime, silica and cement Portland), were characterized by chemical and particle size analysis. After characterization, the materials were agglomerated in the form of pellets (P1, P2, P3 and P4), with additions of 0, 1, 2 and 4% Fe-75%Si, respectively, and P5 with additions of 2% Fe-75%Si and fluxing agents (3.83% dolomite lime and 2.88% silica).

The reduction of pellets was made using induction furnace with capability to reach temperatures up to 1973K (1700°C). The experiments were performed at temperatures of 1773K (1500°C), 1823K (1550°C) and 1873K (1600°C), using graphite crucibles.

After the reduction the products (slag and metal) were analyzed by optical microscopy, scanning electronic microscopy (MEV) and energy dispersion spectrum analysis (EDS).

The reduction process in pellets 1, 2, 3 and 4 followed phenomena as: i) gaseous reduction (CO/chromite) produces metallic globules on the surface of chromite particles, initially rich in iron; ii) these globules grow continuing the reduction at the periphery of chromite particles, leaving refractory oxides at this area of the original chromite particle; iii) an incipient slag is formed with the components of the pellet (inorganic binders, ash of reducer and fluxing agents) and with the dissolution of gangue from small particles of the reduced chromite; iv) the incipient slag dissolves refractory oxides remaining at the periphery of the chromite particles, liberating the metallic phase and the slag becomes more refractory; v) the metallic phase grows and becomes richer in chromium by reducing chromium oxides and eventually of iron dissolved in the incipient slag; vi) the coalescence of the metallic phase is favored by the slag formation and dissolution of refractory gangue of the chromite.

The reduction process of pellet 5 follows as: i) indirect and direct reactions reduce fine particles of chromite, with formation of metallic nodules and slag phase at the beginning of reduction; ii) the metallic nodules are formed by the reduction of fine particles of chromite. Large chromite particles are reduced at the peripheral

surfaces and are embedded by the slag and remain dispersed in it; iii) the slag formed is harmful for the gaseous reduction and the time for completing the reduction is increased, but facilitates the coalescence of the metallic phase; iv) the metallic nodule follows growing and becomes richer in chromium.

The carbothermic self-reduction pellets of the chromite at the temperature range of 1773K (1500°C)-1873K (1600°C), presents great influence of the temperature, either, with or without addition of Fe-75%Si. The increase of the temperature from 1773K (1500°C) to 1873K (1600°C) decreases the time for completing the reduction as: i) 8 times for pellet without Fe-75%Si; ii) 4 times for pellet with 1% of Fe-75%Si; and iii) 3 times for pellet with 2% of Fe-75%Si.

A significant effect of additions of Fe-75%Si in self-reducing pellets of chromite in the reduction time was observed. The best addition was with 2% and its contribution was approximately 9% of necessary heat for complete the reduction, for the temperatures of 1873K (1600°C), 1823K (1550°C) and 1773K (1500°C).

The evolution of reduction is highly sensitive (it decreases) with addition of fluxing agents which form the slag with *liquidus* temperature below 1500°C. The evolution of reduction for the indirect reaction (CO/chromites) is remarkably faster than that of the reduction by the direct reaction (C/chromite and C dissolved in the metallic phase/chromium oxide in the slag). At the beginning the gaseous reduction is predominant but it becomes less important with formation of larger amount of slag.

The pellets (1, 2, 3 and 4) without addition of fluxing agents (silica and dolomite lime), after reduced, are highly porous and have small formation of slag phase than pellet 5 with addition of fluxing agents.

Pellet 3 with 2% of Fe-75%Si presented the best results with relation to time for completing the reduction of chromite.

The pellet with addition of 4% Fe-75%Si (pellet 4) did not present advantage with relation to that of 2% addition due to larger volume of slag formation. The micrograph analysis showed that the reductions of chromite particles practically were complete when the reaction fractions approach to the unit, confirming the confidence of the methodology used for determining the reaction fraction.

The reduction of the self-reducing pellet, regardless its composition, happens by not isothermal way although it is submitted at isothermal temperature. The temperature gradient between surface and the core of the pellet is larger at the

beginning but it disappears as the reaction progresses, becoming uniform with time. The heat transfer showed to be the slowest step of the process due to, the endothermic reactions of reduction, the size of the pellets, the high temperatures and porous nature and refractory material.

The compression strength of the pellets (1, 2, 3, 4 and 5), after 28 days of curing, before of the reduction was ~4kgf/pellet but it increased up to 150 - 400 kgf/pellet; which are acceptable for charging the melting furnace for metal/slag separation.

These results were confirmed by using laboratory rotating furnace, with pellet 2 (2% of Fe-75%Si), as: i) the reductions of Cr and Fe were practically complete (fraction of reaction 0,99) after 30 minutes of experiment at 1500°C; ii) the coalescence of metallic particles, depends the capability of the slag to dissolve remaining oxides in the reduced chromite particle; iii) incipient not-continuous slag phase forms, at 5 minutes of experiment, from the gangue of the chromite and from the components of binders and/or fluxing agents; iv) the yield of metallic recovery is high (99%), after 30 minutes of experiment at 1500° C.

The results show that the self-reduction process presents a great potential for the ferro-chromium high carbon production (FeCrHC).