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Metallurgy

Universal Closed Arc Furnace of Periodical Functioning for Producing Steel Direct from Briquettes of Iron Ore Monocharge

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ABSTRACT. For the first time in the practice of steel production, universal arc furnace of periodical functioning for producing steel by direct reducing is proposed. This unique furnace permits to use ore monocharge briquettes for steel making. *© 2008 Bull. Georg. Natl. Acad. Sci.*

Key words: *arc furnace, briquettes, direct reducing.*

A universal closed arc furnace of periodical functioning for producing steel by the method of direct reduction at single-stage cycle has been elaborated at the Georgian Technical University (GTU).

Taking into consideration the experience of GTU specialists in the development of a unique method for preparation of briquettes of monocharge for ferroalloys [1], a new method in steel-making industry for the iron-ore monocharge becomes very actual. However, this method is not used in steel-making industry for iron ore monocharge, because an appropriate steel-melting electrical furnace does not exist so far.

Pilot experimental melting in a 3-ton steel-making arc furnace at the Rustavi metallurgical plant (Georgia) was realized. By means of ore-thermal reduction briquettes of monocharge (composition of monocharge - iron ore and coke) the following results were obtained: efficiency degree of iron yield 90-93 %; presence of sulphur in steel not more than 0.03 %.

Mechanical characteristics of melted steel meets the demands for responsible brands of steel.

Work has shown that fitting preparation of monocharge even from low grade ingredients permits to obtain desirable steel by means of direct reduction. But it should be underlined that use of the existing arc steel-making furnaces for these purposes was not expedient, which is accounted for by the high expenses of electrical energy and long duration of melting process, because the geometrical and energetic parameters of the furnace are not in proper relation with the regime of melting.

In the proposed universal closed arc furnace of periodical functioning reduction occurs at the beginning of the melting process, the electrodes being in the charge during this period. After the melting of the charge and removing the slag through the upper tap hole (the lower part of the pouring aperture of this tap hole is on the level of metal surface), the electrodes are lifted and the transformer switched, the electrical regime for refining and alloying processes is established. Upon completion of these processes steel is poured out from the lower outlet aperture.

At the transition to open arc regime the lower grade of voltage, used during the refining and alloying, should be equal to 230-240V, with the linear current 8000A.

According to the calculations of the authors, the average specific expenditure of electrical energy during the steel making process equals 2500 kWt·H/t. To watch the melting process and give slag-forming and alloying additives the furnace has a working hatch-window.

Calculation of a round three-electrode furnace with definite capacity at the ore-reducing process may be carried out in the following way:

At first the useful capacity is determined according to the formula:

$$P = S \cdot \eta \cdot \cos\varphi,$$

where S is the full capacity of the furnace transformer, kVA, η - electrical efficiency, $\cos\varphi$ - coefficient of furnace transformer's capacity.

The useful working voltage is obtained as

$$U = C\sqrt[4]{P}\ .$$

Study of the electrical resistance of the briquettes of iron ore monocharge, which is fulfilled by means of a similarity method, permits to find the coefficient C=6.3.

Linear voltage is determined by the formula:

$$U_{lin} = \frac{\sqrt{3}\cdot U}{\eta\cos\varphi},$$

but linear current in the electrode equals:

$$J_{lin} = \frac{P}{\sqrt{3}\cdot U}.$$

The diameter of the graphitized electrode, which is selected depending on the linear current (the main criterion is the possible density of current in the cross-section of electrode, which is usually regulated by the provider of electrodes) is determined by means of the formula:

$$d_{el} = \sqrt{4J_{lin}/\pi\cdot j}\ ,$$

where j is the density of current in the electrode.

Proceeding from the diameter of the electrode, the principal parameters of the furnace bath may be selected:

$D_b = 6d_{el}$ - diameter of furnace

$D_c = 3d_{el}$ - electrodes circle diameter

The thickness of furnace lining is determined by thermal calculation, taking the temperature on the furnace cover not more than 150°C. Then the cover diameter equals:

$$D_{eov} = D_b + 2\delta, mm.$$

On the basis of the above calculation method, a universal closed arc furnace with productivity about 41 tons/day has been designed by us. The furnace was built and now it is exploited in Rustavi (Georgia).

Electrical supply of the furnace with capacity 4.5 MV A is realized from the furnace transformer.

Calculation of furnace parameters was carried out at the value of quantity $\eta\cos\varphi = 0{,}8$ [2]. At that the useful capacity of the furnace equals 3600 KWt; worked useful voltage - 50V; linear voltage - 108V.

The value of worked current in the electrode is taken at 20 kA. The diameter of the graphitized electrode equals 400 mm and density of current approaches 15.9 A/cm^2.

Proceeding from the diameter of electrode 400 mm, the main dimensions of the furnace bath were determined:

D_b =2400 mm - internal diameter of bath;

D_c =1200 mm - electrodes circle diameter;

H_B =1200 mm - altitude of bath.

The scheme of a universal closed arc furnace with capacity 4.5MV A is given in the Figure.

The foundation of the furnace hearth is made from fire clay brickwork, above which is a layer of chromatic concrete, then follows brickwork of magnesitic brick and dolomite printed clothing. The brickwork of the mine wall consists of magnesitic bricks. From the internal side the brick-work of the wall has a sloping rammed layer of carbonaceous mass (which is made with slope).

The water-cooling cap of the furnaces stands on the sandy lock of the furnace chamber. On the internal surface of cap is a drifted layer of heat-proof concrete, the thickness of which equals 30mm. The lateral wall of the cap has three windows, the dimensions of which equal 450x1000mm. These windows are needed for throat watching, but in case of need by means of these windows the charge may be approached by electrodes.

The roofing of the cap is divided into three sectors. Each sector has canals for the circulation of cooling water. The cap has three apertures, in which peaking inserts from basaltic fiber are placed and also seven apertures, in which pipes for supplying charge are inserted.

The upper ends of these pipes are connected with loading bunkers. The pipes are isolated from the cap and bunkers in order to avoid contact between them. The pipes are supplied with valves, which stop sending charged material at the moment the bath is filled . It should be noted that the furnace works in regime, which is characterized by saving part of the liquid metal on the hearth. The cap has also an aperture, in which a manifold is placed for connection with the gas outlet tube for gas cleaning.

In order to decrease electrical losses the furnace cap is usually made of non-magnetic corrosion-resistant steel. In order to economise expensive material in the

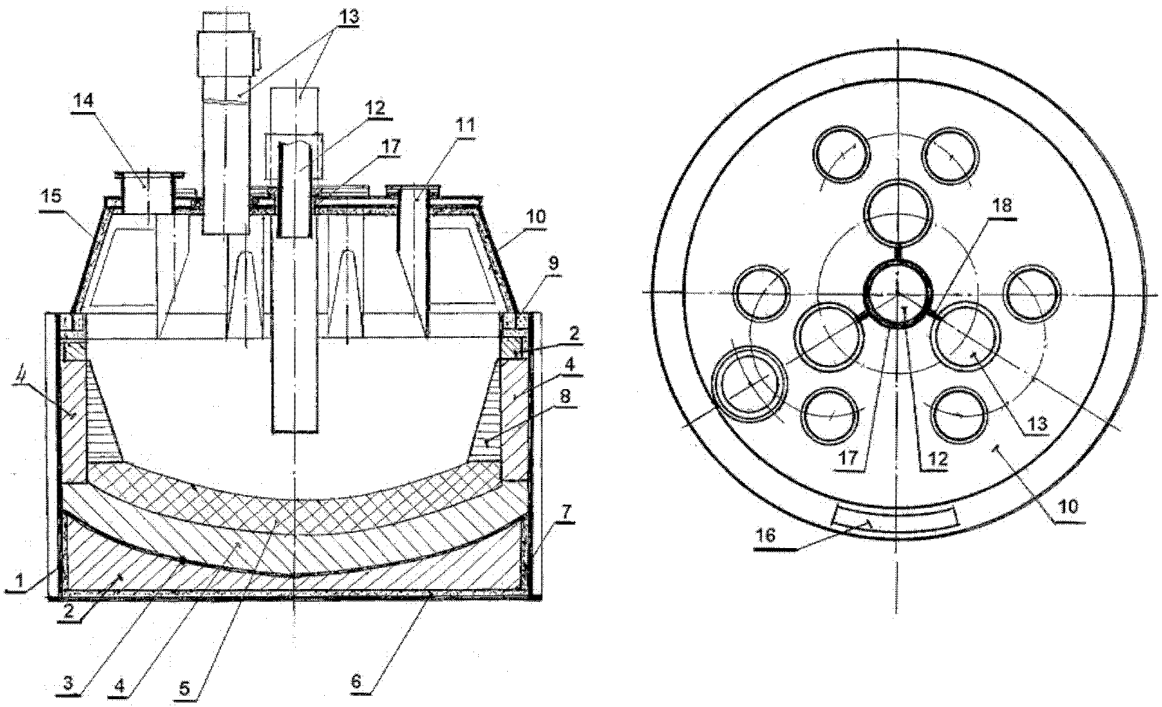

Figure. Universal closed arc furnace.
1. Casing, 2. Fireclay brick; 3. Chromitic concrete; 4. Magnesitic brick; 5. Dolomitic layer; 6,7. Fireclay gravel; 8. Packing from carbon mass; 9. Sandy gate; 10. Water cooling cap; 11. Outlying pipe line; 12. Central pipe line; 13.Electrodes; 14. Manifold for connection with gas outlet tube; 15. Coating from heat resistance concrete; 16.Working hatch window; 17. Concrete box of central pipe line; 18. Cross piece from heat resistance concrete.

given design of the cap ordinary carbon (magnetic) steel is used.

For that purpose radial slits are made in the central part of the cap, which ensures break of circular magnetic force lines, locking around electrodes. These slits are filled with heat-proof concrete, which has great magnetic resistance.

Replacement of expensive non-magnetic stainless steel with ordinary carbon steel gives a significant economic effect.

In the proposed furnace cantilever type electrodes are used with automatic regulation.

To intensify the reduction process in the furnace vertical line metallic tubes are provided. The tubes are intended to supply natural gas. These tubes are placed between the electrodes.

After removing slag and beginning refining and alloying processes for intensification of carbon's oxidation in melted metal instead of natural gas, oxygen is supplied by means of those tubes.

Conclusion

In the present article, an absolutely new type of closed arc furnace of periodical functioning is considered, which represents a combination of ore reducing and steel melting furnaces.

In the aforesaid furnace obtaining of desirable brand of steel is possible by means of direct reduction of iron ore briquettes.

For all that, the prime cost of obtaining 1 ton of steel, as compared to steel produced by traditional methods, is 25-30 % lower.

მეტალურგია

პერიოდული ქმედების უნივერსალური დახურული რკალური ღუმელი ფოლადის პირდაპირი მიღებისათვის რკინის მადნის მონოკაზმის ბრიკეტებისაგან

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ნაშრომში პირველად ფოლადის წარმოების პრაქტიკაში, შემოთავაზებულია პერიოდული ქმედების უნივერსალური დახურული რკალური ღუმელი ფოლადის პირდაპირი მიღებისათვის რკინის მადნის მონოკაზმის ბრიკეტებისაგან, მოყვანილია ღუმელის ძირითადი ელექტრული და გეომეტრიული პარამეტრების საანგარიშო ფორმულები.

წარმოდგენილია ღუმელის წყლით საცივებელი სახურავის ახალი კონსტრუქცია, რომელიც უზრუნველყოფს მინიმალურ ელექტრულ დანაკარგებს და საშუალებას გვაძლევს გამოვიყენოთ მის დასამზადებლად იაფი დაბალნახშირბადიანი მარკის ფოლადი, რაც საგრძნობლად ზრდის ღუმელის ეკონომიურობას და მინიმუმამდე დაჰყავს ღუმელის ასაგებად საჭირო კაპიტალური დაბანდებები.

REFERENCES

1. *И.М. Твалавадзе, Г.А. Ломтатидзе, Г.И. Ломтатидзе* (1987), Труды ГПИ, №3 (414), стр. 417-423.
2. *В..И. Клдиашвили. Г.Б. Кашакашвили, С.А. Мебония* (2001), Металлург, №11, стр. 47-48.

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