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STUDYING AND IMPROVING BLAST FURNACE CAST IRON QUALITY

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In the article there are presented the results of studies to improve the quality of blast furnace cast iron. It was established that using fire clay suspension for increasing the mould covering heat conductivity improves significantly pig iron salable condition and filtration refining method decreases iron contamination by nonmetallic inclusions by 50 – 70 %.

Key words: blast furnace, cast iron, fire clay, filter, filtering elements

INTRODUCTION

With the development of motor transport industry, machine-tool building and other machine building branches there increased the requirements to the quality of blast furnace cast iron. With the use in the cupola mixture of cast iron melted in large-volume furnaces with the melting progressive parameters, at machine building plants there became often defective castings with shrinkage defects, friability, cracks.

To increase the quality of blast furnace cast iron there were carried out scientific-research works. Pig cast iron, under the condition of observing the melting parameters and pouring, was obtained with high carbon content, rough surface with graphite-and-slag clusters on it. In large-crystal bright fracture of pigs there were voids, blisters filled with graphite kish.

To increase heat conductivity of mould coverings in the lime solution there were added carbon-containing additives: graphite, coal charge of coke-chemical production of 3 – 0 mm grade, coke breeze of 1 – 0 mm fraction, thin-milled coal powder of 0,2 – 0,00 mm grade after processing in the ball mill. The best results were obtained with the addition in the lime of graphite solution, but its deficit and high cost limit its use. However, hydration water and underburning of lime lumps cannot be eliminated when preserving the lime covering. For this purpose lime solution was completely replaced by the suspension of unburnt fire clay.

The fire clay suspension with density 1,13 – 1,15 g/cm^3 waters moulds well, possesses sufficient refractoriness and its protective layer on the mould does not practically contain water after mould drying with coke gas. Therefore, pig iron salable condition improves significantly.

Besides, the use of fire clay for mould coverings excludes claps in dissolution and prevents the lime solution corroding action when split on the open parts of the worker's body, increases the culture of production and decreases labor intensity when making solution, as there is excluded the waste presence up to 30 – 40 % in the form of underburning with the use of lime. The weight clay rate is 1,5 – 1,7 decreased as compared with lime.

Starting from the fact that with iron temperature decreasing the carbon solubility reduces, there were carried out experiments for artificial decreasing liquid iron temperature in ladles by the way of smelting in them unlettered iron scrape. In the iron-transporting ladle of 100 t volume there were loaded 5 t of preliminarily heated scrape, then the ladle was filled with iron.

At present alongside with the abovementioned methods for the product quality improving there is more widely used the filtration method of refining alloys, mainly based on iron and aluminum. Its essence is in passing metallic melt through a special device (filter) where as a result of physical-chemical, adsorption, mechanical phenomena there takes place the melt purification from harmful impurities, inter-metallic compounds, nonmetallic and gas inclusions.

Filters used in metallurgy can be structurally divided into two groups: two-dimensional and depth filters.

A two-dimensional filter is a grid (a plate) of ceramics or glass fiber. At present ceramic grids present a widely used type of filters and are manufactured in a wide range of shapes and sizes. Such filters with the openings diameter ≥ 2 mm purify the metal from large inclusions of exogenous character, but they do not permit to decrease the content of fine, thin-dispersed inclusions whose size is significantly smaller than the openings in the grid.

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Figure 1 Filtering section components appearance

More efficient and reliable are depth filters (Figure 1). The characteristic feature of such filters (grain, lump) is their large contact surface with metal in the course of filtering and presence of long and thin inter-grain channels of variable section, which causes removing from the melt of both large and fine inclusions [1].

A depth filter presents a layer of filtering material grains of certain size and thickness located in a crucible or a funnel with openings in the bottom part, or a whole block of ceramics. Depending on the ratio of the densities of the filtering material and the melt, the grain (lump) filter is either laid in the funnel [2] or located between two crucibles [3, 4], grids [5, 6] in the funnel for preventing their floating.

EXPERIMENTAL STUDIES

The results of the experiments for changing liquid iron temperature (Table 1) and its chemical composition (Table 2) are shown below (iron temperature was measured with optical pyrometer). The keeping from the beginning of the ladle filling to the beginning of pouring was in the usual range of 40 – 50 minutes.

Blast furnace cast iron filtering was carried out in the industrial conditions of JSC "ArcelorMittal Temirtau". It was performed by the way of passing the melt through a filtering nozzle (Figure 2a) that was assembled in a standard funnel (1) by means of fixing in it two ceramic grids (2 and 4), between which there were located filtering adsorbents (3) in the form of granules with diameter 14 – 16 mm. As the material for making granules there was used silica, magnesite and yttrium oxide. In one mould there were obtained two castings with mass of 12 kg for each variant of filtering (Figure 2b).

RESULTS AND DISCUSSION

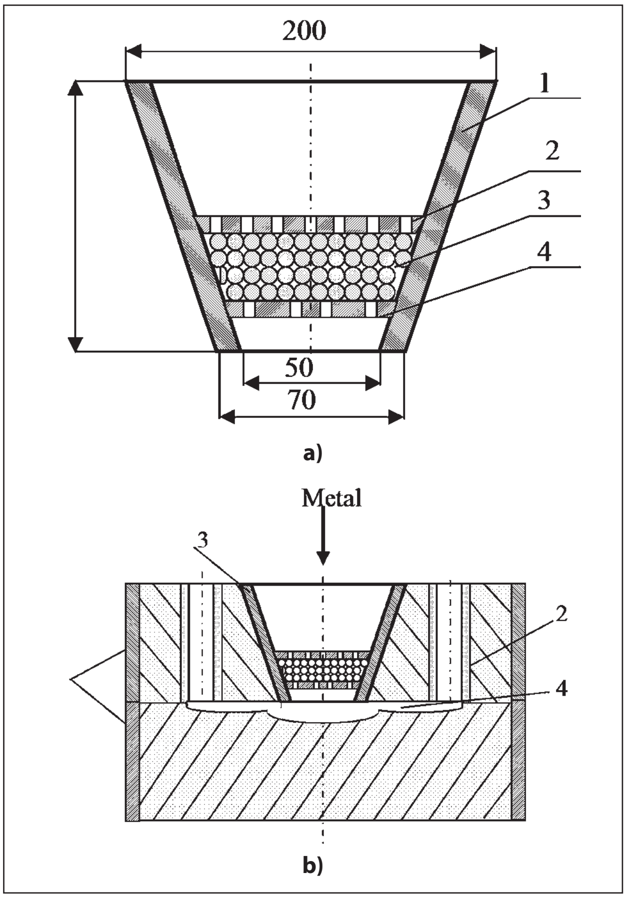
The fracture of cooled iron by the way of scape additive does not differ from uncooled iron with an insignificant increase of the pig density. However, due to the fact that in scrape melting in iron transporting ladles there takes place graphite additional emission, the surface of pig iron was respectively obtained more contaminated with the graphite kish.

Table 1 **Changing iron temperature when melting scrape in iron transporting ladles**

Method of carrying out experiment	Iron temperature at discharge / °C	Iron temperature in pouring / °C	Iron temperature changing / °C
With scrape melting	1 430	1 302	128
Without scrape melting	1 415	1 322	93
With scrape melting	1 400	1 230	160
Without scrape melting	1 400	1 330	70

Table 2 **Changing iron chemical composition when melting scrape in iron transporting ladles**

Method of carrying out experiment	Iron chemical composition / %				
	C	Si	Mn	P	S
With scrape melting	4,05	2,71	0,46	0,16	0,03
Without scrape melting	4,02	2,47	0,42	0,15	0,03
With scrape melting	3,80	2,78	0,45	0,13	0,04
Without scrape melting	3,94	2,85	0,45	0,16	0,03



1 – moulding boxes; 2 – ceramic moulds; 3 – funnel with filter; 4 – feeder

Figure 2 Diagram of assembled filter (*a*) and blast furnace iron filtering (*b*)

The most suitable there appeared the method of detaining graphite, slag and other inclusions in the iron transporting ladle when pouring cast iron on the pouring machine. There was developed and introduced a structure of a siphon opening made of refractory brick in the pouring lip of the ladle.

When pouring iron from the ladles there was detained the emitted graphite, for this a part of iron in the amount of 3 t was necessary to be left in the ladle, as at the full discharging with the last portions of iron there is discharged the arrested graphite.

The working practice showed reliability of operation of ladles with siphon devices. Besides, the introduction of ladles with such devices permitted to melt iron scrape from the pouring machines and casting bed chutes that usually contains foreign impurities and not to be afraid of graphite emission with increasing the time of keeping iron in the ladles.

As a result of filtering refining of blast furnace cast iron the efficiency of filtering was evaluated by the changing of iron chemical composition, mechanical properties and content of nonmetallic inclusions. The results of the chemical analysis show that the extent of sulfur removal depends significantly on the filter material nature. For example, in iron filtered through *silica* granules the sulfur content does not practically change as the iron limit tensile strength, and Brinnel's hardness increases by 20 – 30 %. When filtering the melt through the *magnesite* filter the sulfur content decreases by 10 – 25 %, hardness does not change. The filtered contamination with nonmetallic inclusions, according to the data of metallographic analysis, in all the variants decreases by 50 – 70 %.

CONCLUSIONS

At the considered stages of the study there were improved the appearance of pig iron quality: the pigs were obtained with clean surface, there was liquidated the pockmark affection of the pigs bottom surface, the fracture on the pig thickened part was more compact.

Thus, by implementing the considered measures it can be improved the salable condition of pig iron, to increase the product quality and the efficiency of its manufacturing.

LITERATURE

[1] Kurdjumov A. V., Inkin S. V., Chulkov V. S. i dr. Fljusovaja obrabotka i fil'-trovanie aljuminievyh rasplavov. – M.: Metallurgija, 1980. – P. 196.

[2] V. A. Kudrin. Vnepechnaja obrabotka chuguna i stali. – M.: Metallurgija, 1992. – P. 336.

[3] Kimanov B.M. Fil'tracionnoe rafinirovanie metallicheskih rasplavov. – Karaganda: CNTI. – 2007. – P. 39.

[4] B. M. Kimanov, V. A. Kim, Zh. D. Zholdubaeva. K voprosu o rafinirovanii metallurgicheskogo kremnija ot primesej // Materialy mezhdunarodnoj nauchno-prakticheskoj konferencii Metallurgicheskij kremnij-2012 »Fiziko-himicheskie processy i tehnologii poluchenija metallurgicheskogo kremnija«. – Karaganda, HMI. – 2012. – P. 137-138.

[5] Fil'trovanie metalla v litejnoj forme (Sbornik materialov po fil'tram, jeffektivnosti primenenija, opytu ispol'zovanija v otechestvennoj i zarubezhnoj praktike). – M.: ITCM Metallurg. – 2005. – P. 221.

[6] Apelian D., Mitharagan R. Filtration f met refining method // Journal of Metals. – 32 (1980) 9, 14-19.

Note: The translation of the N. M. Drag, Karaganda, Kazakhstan