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DEPENDENCE OF CAST IRON QUALITY FOR CASTINGS ON THE SMELTING METHOD

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Annotation. The article provides materials on the study of the influence of melting processes in coke oven, gas cupola furnaces and after electroslag treatment on the mechanical properties of cast irons. Smelting was carried out under identical conditions, and charge materials having the same values of the carbon equivalent. It has been established that treatment with various fluxes improves mechanical strength and improves the properties of cast iron for castings.

Key words: Cupola, electric furnace, charge, carbon equivalent, fluxes, mechanical properties, slags, structure, charge materials, electroslag treatment.

In the foundry laboratory of the Tashkent Technical University named after Islam Karimov and on the production of cast iron smelting units of various enterprises of the Republic of Uzbekistan, the mechanical properties of cast iron from coke oven, gas cupola and electric furnaces were studied.

Data on a gas cupola with a refractory blank spike was determined on a gas cupola in the Penza construction [1], which was most widely used. The results of experiments on coke cupola were determined on 3 tons of cupola of a repair-mechanical plant (Tashkent), data on smelting in induction furnaces from the Technologmash plant and electroslag treatment of cast iron from the repair-mechanical plant of the Mining plant.

Smelted gray cast iron grade 150 (EN-GJL-150) of the following chemical composition: C - (3,5 – 3,7 %); Si - (2,0 – 2,4 %); Mn - (0,5 – 0,8 %); P - 0,3 %; S - 0,15 %;

The chemical composition of cast irons was determined using spectral analysis instruments, the temperature of the cast iron during the tests was approximately 1450 °C for all compared melting units and was measured with a single thermocouple and an optical pyrometer.

Samples for determining the mechanical properties were cut from standard samples, for mechanical bending tests Ø30 mm and 1 = 300 mm. Samples for the study of wear were cut from plates 300 X 200 X 70 mm.

During the experimental melting, identical conditions were observed. Smelting was carried out on the same type of charge materials, with the same technology for pouring samples, etc.

The results of determining the chemical composition and mechanical properties of cast irons smelted during experimental production smelting show that gas cupola allows smelting of various grades of gray cast irons with ferrite-pearlite graphite and that the mechanical properties of these cast irons are not lower compared to cast irons having the same value carbon equivalent, but smelted in a coke cupola.

To compare the same grade of cast iron smelted in coke and gas cupolas, for the carbon equivalent of 3.61 - 3.62 the following values are accepted:

$$\sum \Pi^{CC}_{М.Е.} = 3{,}18 \qquad \sum \Pi^{GC}_{М.Е.} = 3{,}44$$

It was also established that cast iron from gas cupola has a higher $\sum \Pi_{Л.С.}$ value:

$$\sum \Pi^{CC}_{Л.С.} = 2{,}62 \qquad \sum \Pi^{GC}_{Л.С.} = 3{,}21$$

The excess of the tensile strength of cast iron smelted in a gas cupola over the tensile strength of coke melting cast iron increases with increasing carbon equivalent. On average, the specified excess is 20%. For a gas cupola with a refractory blank spike - about 15%. [2]

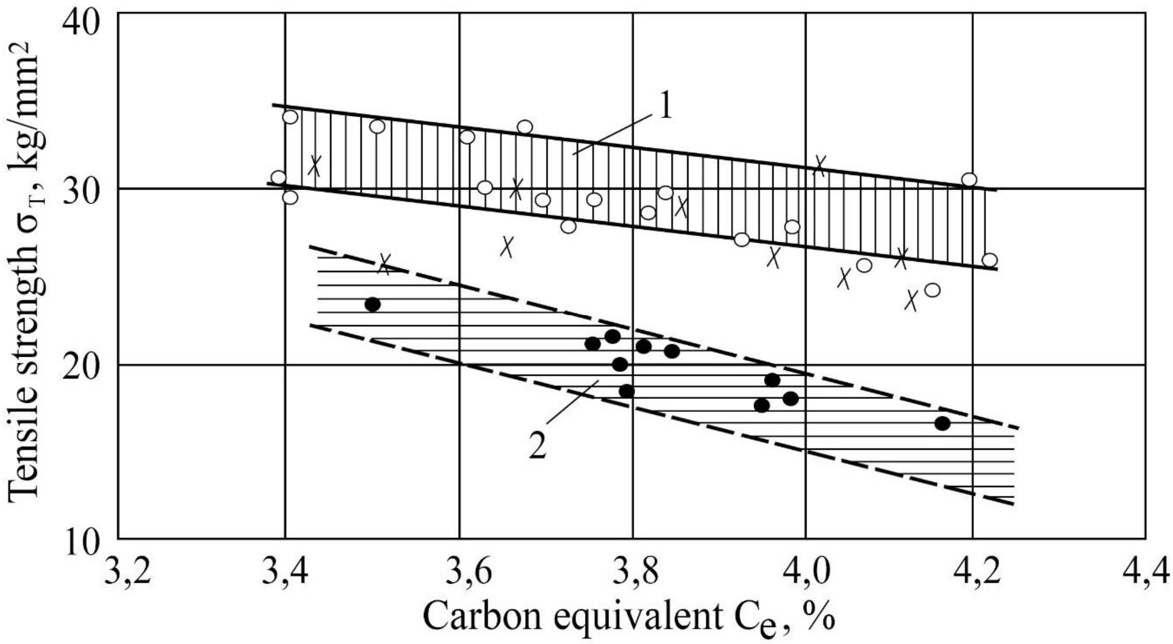
The microstructures of cast irons were studied using microscopes of the foundry department of the Technical university (TSTU).

The study of microstructures shows that with the same carbon equivalent and, moreover, with almost the same carbon and silicon contents in cast iron smelted on natural gas, graphite inclusions are slightly shorter than cast iron smelted on coke. With increasing carbon equivalents with increasing carbon content in cast iron in both cases of melting, the length of graphite inclusions proportionally increases, remaining nevertheless smaller for cast iron melted in a gas cupola. In samples filled with cast iron from a gas cupola, the structure of the metal matrix is pearlitic, with a dispersion of D 0.3 - D 0.5. The structure of the matrix of cast iron with the same carbon equivalent, but filled with cast iron from coke cupola, is pearlite and pearlite-ferrite, while the dispersion of perlite is D 0.5 - D 1.6. [ПВ]

It was also established that in cast iron of gas cupola, the eutectic grain is 20-30% smaller than the eutectic grain of cast iron smelted on coke.

Thus, an increase in the mechanical properties of cast iron melted in a gas cupola compared with coke cupola cast iron at the same carbon equivalent value and almost the same carbon and silicon contents is explained by a decrease in the size of graphite inclusions, pearlite, with a higher dispersion structure of the metal matrix and grinding eutectic grain.

Figure 1 shows the combined effect of carbon and silicon on the tensile and bending strengths of cast iron smelted in gas (1) and coke (2) cupolas.



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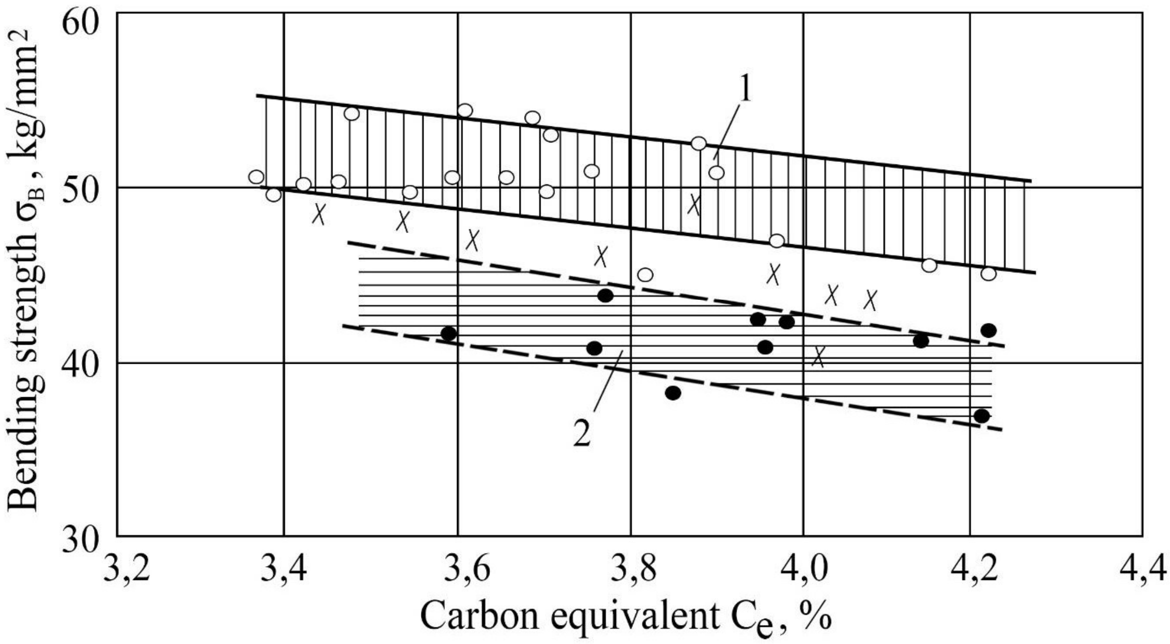

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Figure 1. **The effect of the carbon equivalent on σ_T (a) and σ_B (b) for gas (1), coke (2) cupolas, gas cupola with blank spike (x)**

An analysis of the data presented shows that in cast iron smelted on natural gas, there is a known pattern of decrease in strength properties with an increase in carbon equivalent, but the intensity of this decrease is less in comparison with cast iron smelted in coke cupola, which is especially noticeable at high values of carbon equivalent. [1]

It can also be seen from the above data that the smelting of cast iron in a gas cupola with a refractory blank spike occupies a middle position, that is, the properties of cast iron ($σ_T$ и $σ_B$) are slightly lower than in a cupola with ledges, but higher than in a coke cupola.

The results of determining the properties of cast iron smelted in a gas cupola with a refractory nozzle, in an electroslag furnace with various fluxes, in a gas cupola with an electroslag treatment of cast iron, showed that as a result of electroslag treatment, the mechanical properties increase.

Electroslag processing was carried out in the electroslag furnace of the mechanical repair plant and in the foundry laboratory of TSTU. Liquid cast iron was treated with special refining and modifying slags at a temperature of 1650 - 1700 °C.

The results of mechanical tests of cast iron samples before and after electroslag treatment show that electroslag treatment of cast iron contributes to a significant improvement in its mechanical properties. So, when cast iron is treated with flux No.1 with a practically constant carbon equivalent of cast iron, a significant improvement in mechanical properties is observed; tensile strength increases by 3.2 kg/mm^2 and bending - by 7.3 kg/mm^2, an increase in the deflection arrow and hardness is observed.

The greatest increase in strength occurs in swimming trunks under flux No.5. When using it, the improvement of mechanical properties is obviously primarily associated with deep desulfurization of cast iron, which is 97.27%, as well as some increase in the manganese content due to its burning. Analysis of the macro- and microstructures of the obtained samples showed that electroslag treatment contributes to the grinding of eutectic grain, grinding of graphite and its more uniform distribution. The phenomenon of an increase in mechanical properties is observed for all slag systems, except for the sixth, in which an increase in C and Si occurs.

Thus, on the basis of the conducted studies, it can be concluded that to obtain “hard” strong grades of cast iron from standard fluxes, flux No. 5 (60% CaO, 20% CaF_2, 10% Al_2O_3, 10% MnO) should be used, and to obtain “soft” cast irons with a high content of carbon and silicon from a cheap charge can be recommended flux No. 6, containing 10% carbon for carburization, 20% SiO_2 for silicon recovery, 10% MnO for possible recovery of manganese.

Tests of mechanical properties during smelting under industrial fluxes showed basically the same patterns. [2]

Fluxes No. 7 and 8 gave a significant improvement in mechanical properties, despite a slight increase in carbon equivalent. So, $σ_T$ from 20.1 - 21.0 increased to 26.8 - 30.5 kg/mm^2 and $σ_B$ from 41.6 - 42.0 to 45.9 - 48.0 kg/mm^2.

The change in mechanical properties under flux No. 9 is very interesting. The properties of cast iron increased significantly: $σ_T$ - by 30.4% and $σ_B$ - by 22.2%, hardness HB increased from 207 to 241. This is explained by an increase in the manganese content.

When melting under flux No. 10, the carbon equivalent increases significantly, and the properties decrease, but only slightly. This is due to the positive effect of manganese on the improvement of mechanical properties.

Flux No. 9, as we see, produces a one-sided change in the chemical composition, greatly increasing the Mn content even with a short processing time.

Flux No. 10 gives a more acceptable change in the chemical composition and allows increasing the manganese content by increasing the processing time and obtaining a pearlite structure with fine evenly distributed graphite with a significant content of carbon equivalent.

Electroslag processing of cast iron smelted on gas fuel also improves its mechanical properties. [1]

From the above data it is seen that the smelting of cast iron by the electroslag method under standard flux No.1 leads to a slight increase in mechanical properties. They are smaller than that of cast iron smelted in a purely electroslag furnace, even with a slightly reduced carbon equivalent.

The situation is somewhat corrected when melting under flux No.11. Here, the increase in mechanical properties is almost the same as in the electroslag furnace.

The test results of the samples cast iron, are given in Table 1.

Table 1

Mechanical properties of electroslag treated cast iron

Fluxing agent	Chemical composition, %					Carbon equivalent	Mechanical properties			
	C	Si	Mn	S	P		σ_C, kg/mm^2	σ_I, kg/mm^2	f	HB
12	3,43	2,17	0,42	0,06	0,20	4,15	25,9	46,2	3,1	229
13	3,39	2,28	0,44	0,065	0,21	4,15	26,4	47,1	3,1	229
14	3,24	1,12	0,53	0,027	0,05	3,61	31,2	51,4	3,2	241
15	3,12	1,57	0,54	0,023	0,05	3,64	31,0	50,6	3,2	241
Coke cupola cast iron						$\frac{4,15}{3,61}$	$\frac{16,6}{26,6}$	$\frac{36,7}{47,1}$	$\frac{2,8}{3,0}$	$\frac{179}{217}$
Gas cupola Cast Iron						$\frac{4,15}{3,61}$	$\frac{24,3}{30,0}$	$\frac{45,4}{49,5}$	$\frac{3,0}{3,2}$	$\frac{229}{229}$

For comparison, it shows the mechanical properties of cast iron smelted in coke and gas cupolas having the same carbon equivalents, and the properties of cast iron, induction melting.

From the above data it can be seen that electroslag smelting cast iron has high mechanical properties, which are significantly higher than the properties of cupola iron.

A comparison of the properties of cast iron of induction and electroslag melting shows that they are approximately the same, that is, in an electroslag furnace as well as in induction, cast iron with high mechanical properties can be obtained. [2,3]

Thus, from a gas cupola with a refractory blank spike of the city of Penza, it is possible to obtain cast irons with mechanical properties no lower than from coke cupola. Electroslag treatment of cast iron using standard and industrial fluxes increases the mechanical properties of cast iron.

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