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THE OBTAINING OF DUCTILE IRONS ELABORATED IN ELECTRIC ARC FURNACES

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ABSTRACT

The present paper presents a series of experiments concerning the concocting of irons destined to the modification in electric arc furnaces, with bazic wall lining. The chosen modifier is a classical one, based on Fe, Si, and Mg.

It will be presented the chemical compositions of irons that are subject to modification, the parameters of the modification process, and also the results (the final composition of ductile irons, the characteristics of the graphite and of the matrix, gases contents).

The conclusions can be used for the making up of a modifying technology, on an industrial scale. This is similar with the experimenting technology.

Keywords
Modification, ductile iron, graphite, magnesium.

1. FOREWORD

It is known that at the concocting of ductile irons, the electric arc furnaces are being used only at the making up of superior quality irons. When a low quality raw materials is used, the electric arc furnace oven with bazic wall lining is the only aggregate that allows the de-sulfuration and de-phosphoration processes.

The following experiments were made in an electric arc furnace with bazic wall lining, with a 5 tones capacity, which was set on a steel casting platform. The resulting irons are destined to the nodulizing modification of the graphite.

2. EXPERIMENTS

The materials from the oven were chosen so that they would satisfy low percentage of sulphurus and other anti-modifier elements and in the same time high percentage of carbon in order to limit the carburating process.

The weighted 4700-5500 kg, and the was made from 85-90 % new and old cast iron and from 10-15 % old iron.

Depending on the ingredients of the raw materials, the chemical composition of the resulting cast irons was the following (table 1)

Table 1. *Chemical composition of the resulting cast irons*

Nr. crt.	Chemical composition, %							S_C	η_{Mg}, %
	C	Si	Mn	P	S_i	S_f	Mg_{rez}		
1	3,68	1,56	0,66	0,110	0,030	0,004	0,048	0,98	25
2	3,72	1,73	0,70	0,110	0,022	0,002	0,043	1,01	12
3	3,60	1,92	0,68	0,110	0,020	0,013	0,005	0,98	-
4	3,64	1,87	0,92	0,127	0,021	0,019	-	0,99	-
5	3,80	2,03	0,79	0,120	0,025	0,008	0,063	1,05	38
6	3,70	1,34	0,76	0,095	0,021	0,011	0,059	0,96	28
7	3,72	1,80	0,75	0,130	0,033	0,010	0,037	1,01	23
8	3,60	1,94	0,79	0,150	0,030	0,010	0,080	0,99	40
9	3,66	1,66	0,78	0,140	0,023	0,009	0,031	0,98	21
10	3,73	1,95	0,68	0,113	0,022	0,011	0,048	1,02	28

For the modification it was chosen the pot modifying technology together with the help of the modifying bell. The modifier quantity was calculated taking into account the sulphurus percentage from the resulting cast irons as well as the parameters of the modifying process. The relationship is the following:

$$Q_{mod} = \frac{0{,}76(S - 0{,}10) + Mg_{rez} + t.10^{-3}}{\eta.\frac{Mg_{prealiaj}}{100}} . \left(\frac{T}{1450}\right)^2 .G \qquad (1)$$

where: Qmod – the alloy quantity needed for modification;

S – the sulphurus percentage in iron exposed to the modification, %

Mg_{rez} – the proposed magnesium in iron, %

t – the time required to maintain iron in, after modification, min

η– the assimilation efficiency of the magnesium

$Mg_{prealiaj}$ – the quantity of magnesium in prealloy,

T – modification temperature, ^{o}C

G- the quantity of modified iron, kg

The prealloy used had the following chemical composition:

Mg = 10-15 %; Si = 40-45%; Ca=max 1%, Fe= rest

The chemical composition of molted irons before modification was:

C = 3,15 – 3,70%; Si = 1,34 – 1,92 %; Mn = 0,68 – 0,80 %; P = 0,095 – 0,110 %; S = 0,020 – 0,030 %; S_c = 0,98 – 1,05.

The rezidual elements in ductile iron are presented in table 2:

***Table 2**. Rezidual elements in cast irons*

Nr. crt.	Chemical composition, ppm								
	Cr	Ni	Mo	Co	Ti	V	Cu	Pb	As
1	11	414	163	113	443	81	164	183	108
2	88	310	17	113	198	26	178	45	44
3	58	484	29	123	221	29	219	8	71
4	9	251	76	76	139	37	125	63	52
5	125	461	96	188	215	79	77	194	113
6	96	284	22	104	147	24	163	44	40
7	100	293	8	105	152	25	168	36	42
8	98	288	-	55	157	25	166	31	41
9	12	440	189	112	299	90	201	210	119

The sequence of the modification operations of cast iron was the following:

1. Molted iron, elaborated in the 5 tone furnace was melted in the 8 tone modification pot, after which the transportation of this on the casting platform was executed;
2. In the modification area the molted iron was cleaned of the formed slag and the temperature was measured;
3. After closing the modification pot-bell, the actual modification was undertaken. The reaction during modification was strong due to the high temperature of the iron. The modification time was 3-4 minutes;
4. After cleaning the pot of the slag formed during the modification, the casting was executed. The stop time between modification and casting process was 6-8 minutes and the duration of modification was 1-2 minutes.

The total duration to maintain the molted status did not go over 12 minutes (see table 3). The cast pieces out of the modified irons (ingots respectively) were exposed to a heat treatment for detention, according to the following pattern:

- heating from 150 to 650 ^oC with a speed of 100^oC/h, for 5 hours
- maintain at 650 ^oC for 4 hours
- cool from 650 ^oC to 300 ^oC with a speed of 100 ^oC/h
- free cooling from 300 ^oC to the environmental temperature

The microstructures and mechanical properties are shown in tables 4 and 5.

***Table 3**. The parametres of the modification process*

Nr. crt.	Temperatures, ^oC		Durations, min				Prealloy		$Q_{iron,}$ to
	Modifing	Casting	modif	stat	cast	total	Tipe	Quantity	
1	1370	1300	3	7	2	12	FeSiCaMg	100	5,0
2	1300	1250	2	8	1	11	FeSiCaMg	100	5,0
3	1260	1200	2	6	1	9	FeSiCaMg	75	4,8
4	1270	1190	2	7	1	10	FeSiCaMg	85	5,0
5	1300	1240	3	7	2	12	FeSiCaMg	80	5,0
6	1340	1280	2	8	1	11	FeSiCaMg	85	4,5
7	1330	1260	2	6	2	10	FeSiCaMg	75	5,2
8	1350	1260	2	6	2	10	FeSiCaMg	80	5,0
9	1360	1310	3	7	1	11	FeSiCaMg	80	4,9
10	1350	1280	3	7	1	11	FeSiCaMg	75	45,0

***Table 4.** Microstructure of the ductile irons*

Nr. crt.	Mg_{rez}, %	Heat treating	Microstructure			
			Graphite	Surface ocupated by graphite, %	Diameter of graphite, μm	Matrix
1	0,049	Detension	Nodular + vermicular graphite	10,91	75	Ferrite
2	0,043	Detension	Nodular graphite	9,52	60	Ferrite
3	0,005	Detension	Flake graphite	14,50	-	Ferrite
4	-	-	Flake graphite	11,91	-	Ferrite
5	0,063	Detension	Nodular graphite	7,71	70	Ferrite
6	0,059	Detension	Nodular graphite	10,09	75	Ferrite+ pearlite
7	0,037	Detension	Nodular graphite	13,02	90	Ferrite+ pearlite
8	0,080	Detension	Nodular and vermicular graphite	11,44	62	Ferrite+ pearlite
9	0,031	Detension	Nodular and flake graphite	6,52	70	Ferrite+ pearlite
10	0,048	Detension	Nodular, vermicular and flake graphite	11,84	70	Ferrite+ pearlite

4. CONCLUSIONS:

- The elaboration of cast irons for modification in electric arc furnaces is possible especially due to the fact that the process for elaboration can be led much easier, resulting in less quantities of sulphurus, the main restrictive element in the composition of chemical composition, as well as other hampering elements (P, O, H, N).
- the temperatures at the moment of evacuation from the furnace can be more easily framed within the limits indicated by the specialized readings in modification process
- Due to the less quantities of hampering elements within the composition, the quantities of pre-alloy unmodifying required to ensure the modification effect of the graphite are smaller.
- The duration of the modification effect is longer and the graphite nodulizing is more secure
- The proportion of nodular graphite is bigger than in the case of ductile irons obtained in other types of furnaces, and all the characteristics of the graphite (size, distribution) are better than the previously mentioned process
- The proposed technology can be applied for the elaboration of ductile irons in electric arc furnaces of any size.

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