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SOME RESEARCH REGARDING THE 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 basic 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 material is used, the electric arc furnace oven with basic 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 sulphur 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 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 presented in Table 1.

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 sulphur percentage from the resulting cast irons as well as the parameters of the modifying process. The relationship is the following:

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

where:
Q_{mod} – 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
$Mg_{prealloy}$ – the quantity of magnesium in prealloy,
T – modification temperature, °C
G – the quantity of modified iron, kg

The used prealloy had the chemical composition, which is presented in Table 2. The limits of molted irons chemical composition, before modification, were presented in Table 3. The residual elements in ductile iron are presented in Table 4.

Table 1. Chemical composition of the resulting cast irons

Chemical composition. %							S_C	η_{Mg} %
C	Si	Mn	P	S_i	S_f	Mg_{rez}		
3.68	1.56	0.66	0.110	0.030	0.004	0.048	0.98	25
3.72	1.73	0.70	0.110	0.022	0.002	0.043	1.01	12
3.60	1.92	0.68	0.110	0.020	0.013	0.005	0.98	-
3.64	1.87	0.92	0.127	0.021	0.019	-	0.99	-
3.80	2.03	0.79	0.120	0.025	0.008	0.063	1.05	38
3.70	1.34	0.76	0.095	0.021	0.011	0.059	0.96	28
3.72	1.80	0.75	0.130	0.033	0.010	0.037	1.01	23
3.60	1.94	0.79	0.150	0.030	0.010	0.080	0.99	40
3.66	1.66	0.78	0.140	0.023	0.009	0.031	0.98	21
3.73	1.95	0.68	0.113	0.022	0.011	0.048	1.02	28

Table 2. The chemical composition of used prealloy

Mg, %	Si	Ca	Fe
10.0...15.0	40.0...45.0	max 1.0	remainder

Table 3. The limits of molted irons chemical composition

Limits of chemical composition, %					S_C
C	Si	Mn	P	S	
3.15	1.34	0.68	0.095	0.020	0.98
3.70	1.92	0.80	0.110	0.030	1.05

Table 4. Residual elements in cast irons

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

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

- 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;
- In the modification area the molted iron was cleaned of the formed slag and the temperature was measured;
- 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;
- 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 5). The microstructures are shown in Table 6. The cast pieces out of the modified irons (ingots respectively) were exposed to a heat treatment for detention (see Table 7), according to the following pattern:

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

Table 5. The parametres of the modification process

No	Temperatures, °C		Durations, min			
	Modifing	Casting	modif	stay	cast	total
1	1370	1300	3	7	2	12
2	1300	1250	2	8	1	11
3	1260	1200	2	6	1	9
4	1270	1190	2	7	1	10
5	1300	1240	3	7	2	12
6	1340	1280	2	8	1	11
7	1330	1260	2	6	2	10
8	1350	1260	2	6	2	10
9	1360	1310	3	7	1	11
10	1350	1280	3	7	1	11

No	Prealloy		Q_{iron}, to
	Type	Quantity	
1	Fe-Si-Ca-Mg	100	5.0
2	Fe-Si-Ca-Mg	100	5.0
3	Fe-Si-Ca-Mg	75	4.8
4	Fe-Si-Ca-Mg	85	5.0
5	Fe-Si-Ca-Mg	80	5.0
6	Fe-Si-Ca-Mg	85	4.5
7	Fe-Si-Ca-Mg	75	5.2
8	Fe-Si-Ca-Mg	80	5.0
9	Fe-Si-Ca-Mg	80	4.9
10	Fe-Si-Ca-Mg	75	45.0

Table 6. Microstructure of the ductile irons

No	Microstructure			
	Graphite	Surface occupied, %	Graphite diameter, μm	Matrix
1	Nodular + vermicular	10.91	75	Ferrite
2	Nodular	9.52	60	Ferrite
3	Flake	14.50	-	Ferrite
4	Flake	11.91	-	Ferrite
5	Nodular	7.71	70	Ferrite
6	Nodular	10.09	75	Ferrite + pearlite
7	Nodular	13.02	90	Ferrite + pearlite
8	Nodular + vermicular	11.44	62	Ferrite + pearlite
9	Nodular + flake	6.52	70	Ferrite + pearlite
10	Nodular, vermicular + flake	11.84	70	Ferrite + pearlite

Table 7. Heat treating

No	Mg_{rez} %	Heat treating
1	0,049	Detension
2	0,043	Detension
3	0,005	Detension
4	-	-
5	0,063	Detension
6	0,059	Detension
7	0,037	Detension
8	0,080	Detension
9	0,031	Detension
10	0,048	Detension

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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