ANALELE UNIVERSITĂȚII
"EFTIMIE MURGU" REȘIȚA
ANUL XIV, NR. 1, 2007, ISSN 1453 - 7397

Cincă - Ionel Lupinca

Study on the Solidification of Grey Irons, by the Drawing of the Cooling and of the Contraction Curves

This paper presents the study of the solidification of hypoeutectic grey irons using a computer registration system for the setting of the cooling and of the contraction curves and for the determining of the parameters of the two curves and their secondaries.
This study focuses on the obtaining of the solidification results for grey irons produced in induction electric furnaces using different types of metallic charges.

1. Introduction

The germination and the growing mechanisms of the crystalline grains in alloys suppose structural chemical procedures for the transformation from the liquid state, characterized by a close order, to the solid state, characterized by an atomic order at high distances.

This phenomenon determines, in grey irons, in which the carbon is found in a free state as graphite, the appearance of the initial dilatation. The simultaneous study of the contraction curve and of the cooling one, drawn for these cast irons during solidification, using a computer registration system, highlights the role of the eutectic crystallization. The separation of the graphite in the eutectic crystallization represents the main reason for the production of the initial dilation in grey irons and exercises a certain pressure between the grains of the metallic matrix "the pressure of the graphite".

The subcooling phenomenon characterizes all transformation produced during the cooling of the metals, respectively the solidification and the transformation in the solid state. In this paper, we have proposed ourselves to present the study made on the solidification of unalloyed grey irons unmodified and modified. We have analyzed the influences induced by the metallic charge and the influences of the inoculation on the progress of the solidification process and of the cooling process, of the grey irons samples.

An induction electric furnace, of medium frequency (8000Hz), with an acid lining and with a capacity of 10 kilos has been used for the producing of grey irons. The obtaining of the cooling curves and of the solidification has been made with the help of a simultaneous computer registration mechanism, with which a termo-differenciated analysis of the mechanism of the solidification process and of cooling process of the grey irons has been made (Fig. 1).

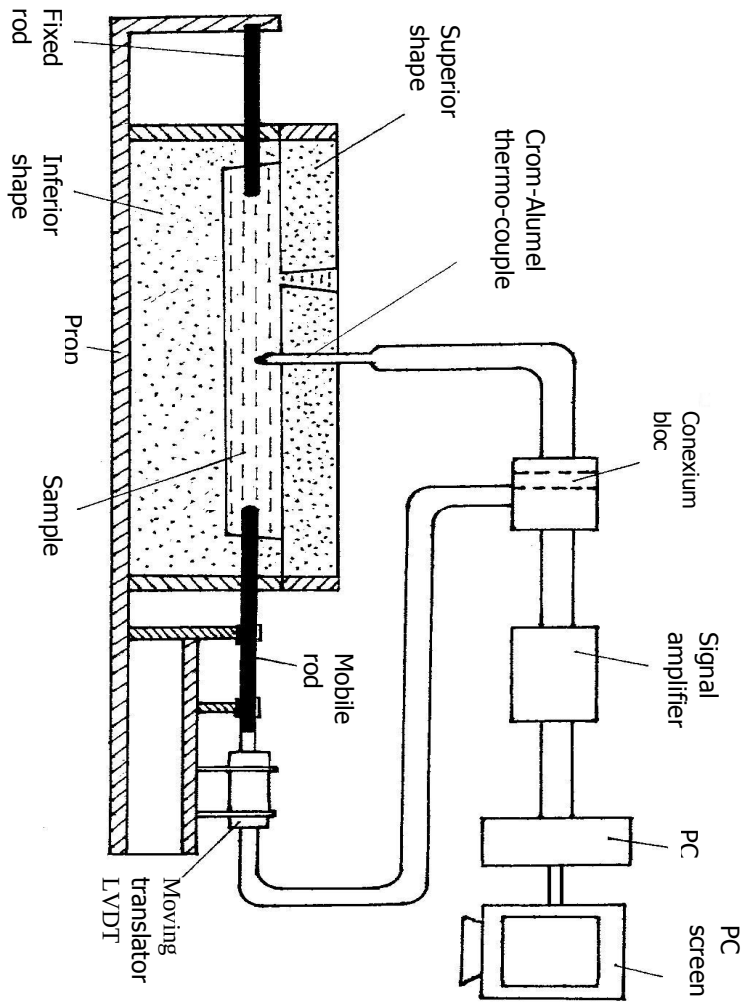

Figure 1. Simultaneous registration system of the cooling and of the contraction curves in the solidification of grey irons.

For the inoculation of grey irons a modified substance has been used, from the FeSiSr category (46.5%Si; 0.77%Sr; 0.037%Ca; 0.25%Al; 0.94%Mn; 0.47%Cr and Fe) with a quantity of 0.3% in the charge.

The thermo-technological parameters of the produced of grey irons are:
- overheat temperature: 1450^0C;
- cast temperature: 1320^0C.

Table 1.

The content of metallic charge of the induction electric furnace

No. charge	Charge variant	Inoculation	Metallic charge
1.	I	Neinoc. (i)	Blast pig iron
2.		Inoc. (f)	Grey cast iron offals Scrap iron (steel) offals
3.	II	Neinoc. (i)	Grey cast irons offals
4.		Inoc. (f)	Scrap iron (steel) offals
5.	III	Neinoc. (i)	Synthetic pig iron
6.		Inoc. (f)	Grey cast iron offals Scrap iron (steel) offals

2. Experimental results

In Figure 2 are represented the position of the cooling curves parameters and of their first order secondaries and in Figure 3, the position of the contraction curves parameters and their first order secondaries for grey irons.

In the Figures 4, 5 and 6 are represented the cooling curves, the contraction curves and their first order secondaries for the six charges of grey irons already studied.

Table 2.

The chemical composition of the hypoeutectic grey irons [%]

Ch. var.	Ch. no.	C	Si	Mn	P	S	C_e	S_C
I	1	3.32	1.44	0.98	0.060	0.022	3.77	0.87
	2	3.25	1.58	0.96	0.059	0.021	3.74	0.86
II	3	3.52	1.24	0.78	0.070	0.021	3.91	0.91
	4	3.50	1.39	0.77	0.070	0.022	3.93	0.92
III	5	3.23	1.68	0.72	0.040	0.025	3.74	0.85
	6	3.17	1.79	0.71	0.040	0.023	3.71	0.86

Obs. Trace elements: Cu = 0.12,,,0.21%; Ni = 0.007,,,0.15%; Cr = 0.10,,,0.14%; Mo = 0.01,,,0.02%.

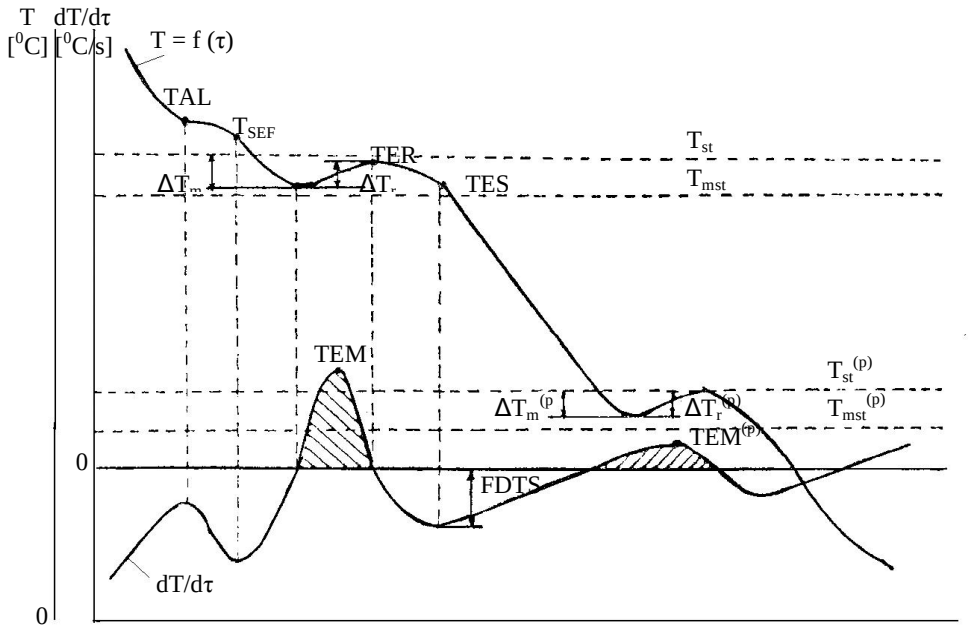

Figure 2. The appearance of the cooling curves and their first secondaries. The position of the parameters of the curves.

3. Conclusion

The study of the cooling curves, of the contraction curves and their first secondaries in grey irons has emphasized the semnificative influence of the charging network of the production furnace of grey irons on the process of solidification, the concordance between the parameters of the curves studied, but also, the graphitization potential and the modification potential of the grey irons studied. There have been presented some specific states of the graphitization potential ad of the different durations of solidification and the existence of a lot of components of the initial dilatation. From all the parameters studied in this paper we may give as example the following ones:

* The study of the cooling curves shows that the unmodified grey irons, obtained from the third variant of charge, present a high value of the lichidus temperature of the austenite (TAL); on the other hand, the modified grey iron, obtained from the first variant of charge has a lower value of the lichidus temperature of the austenite (Figure 7);

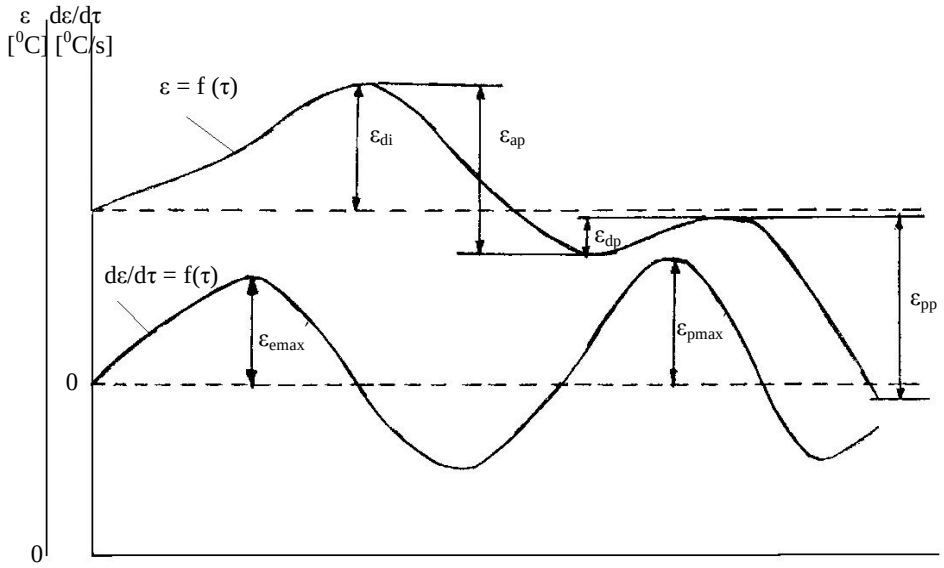

Figure 3. The appearance of the contraction curves and their first order secondaries. The position of the parameters of the curves.

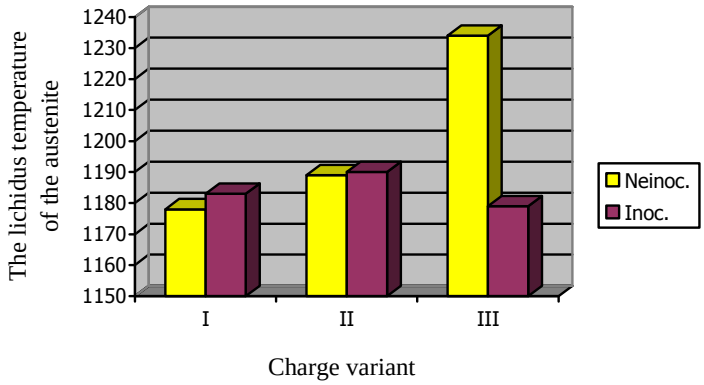

Figure 7. The representation of the lichidus temperature of the austenite (TAL), in ^{0}C, for the grey irons.

* The modification of the grey iron, obtained from the first variant charge may lead to the growth of the lichidus temperature of the autenite;

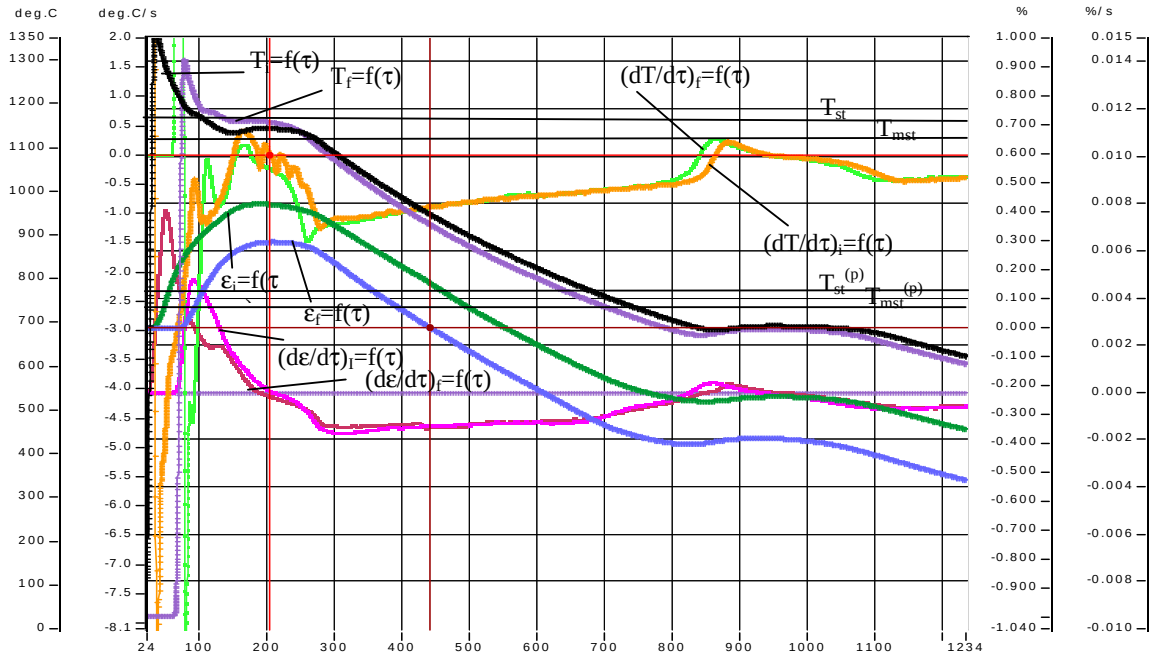

Figure 4. The appearance of the cooling curve, of the contraction curve and their first order secondaries, in grey irons obtained from first variant of charge.

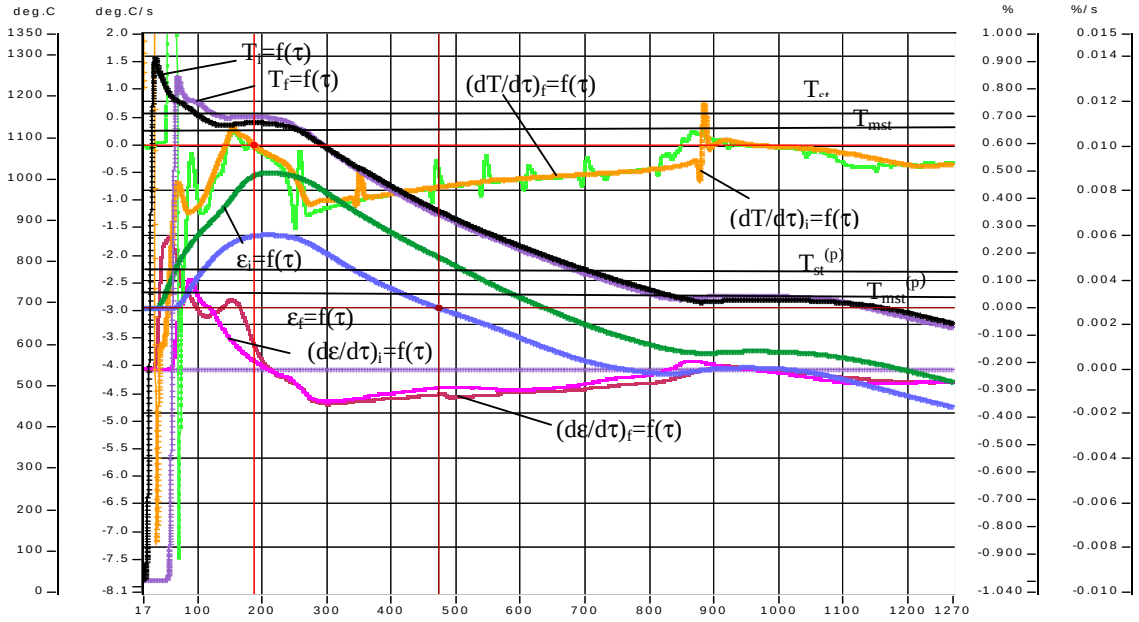

Figure 5. The appearance of the cooling curve, of the contraction curve and their first order secondaries, in grey irons obtained from the second variant of charge.

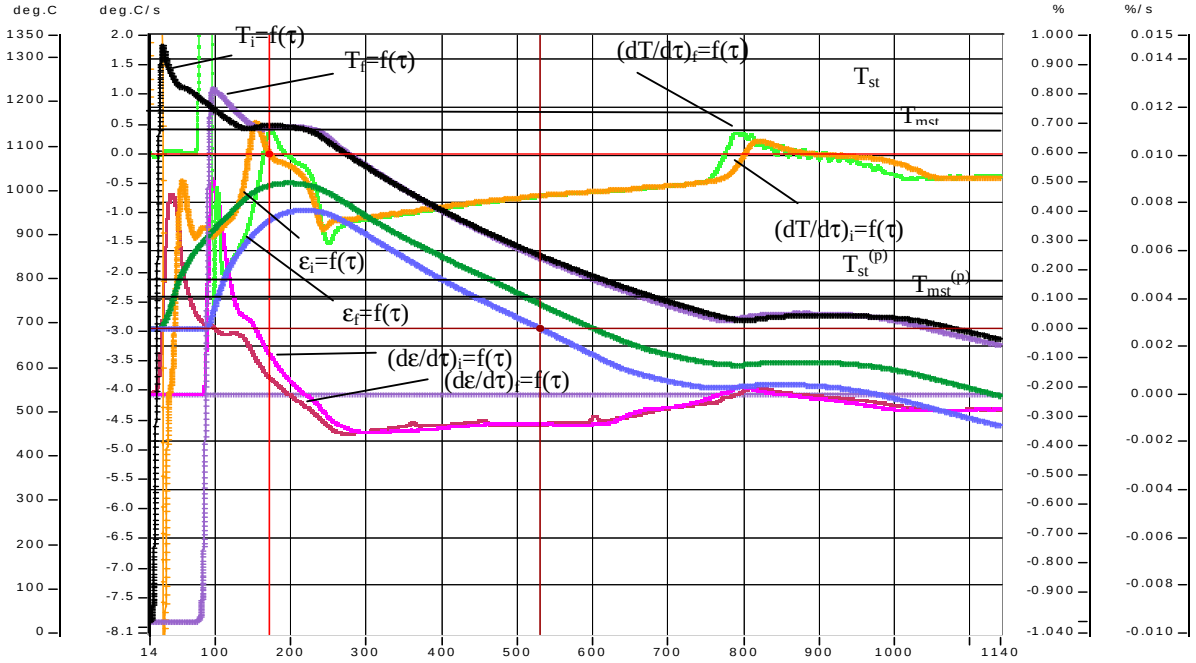

Figure 6. The appearance of the cooling curve, of the contraction curve and their first order secondaries, in grey irons obtained from the third variant of charge.

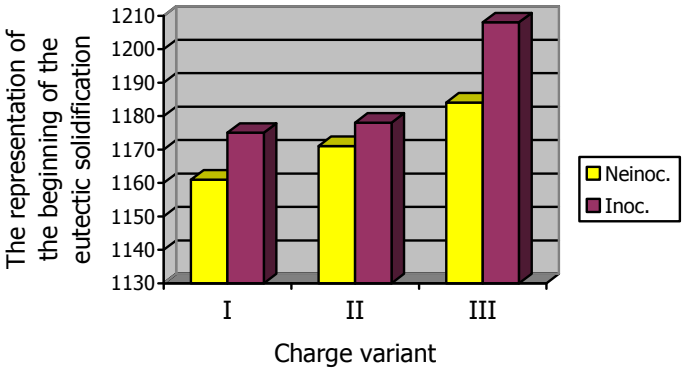

Figure 8. The representation of the beginning of the eutectic solidification (T_{SEF}), in ^0C, for the grey irons.

* The beginning of the eutectic solidification (T_{SEF}), in modified grey irons, obtained from the third variant of charge, is produced at a high temperature and in unmodified grey irons, obtained from the first variant of charge, at a lower temperature (Figure 8);

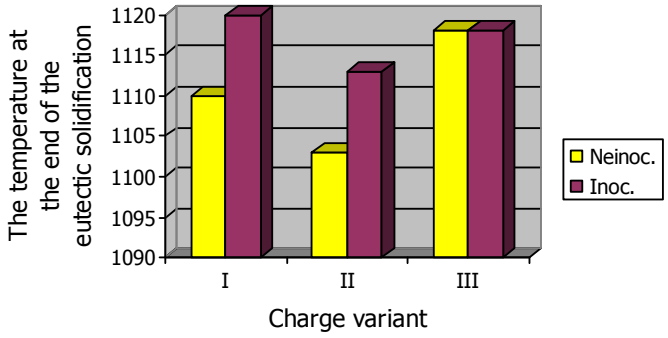

Figure 9. The representation of the end of the eutectic solidification (TES), in ^0C, for grey irons.

* The end of the eutectic solidification (TES) is produced at a lower temperature, in the case of the unmodified grey irons, obtained from the second variant of

charge and at a higher temperature, in the case of the modified grey irons obtained from the first variant of charge (Figure 9);
* The modification determines, in general, a growth of the temperature at the beginning of the eutectic solidification and, also, of the temperature at end of the eutectic solidification. The exception is represented by the grey irons obtained from the third charge that present a reduction of the solidification domain;

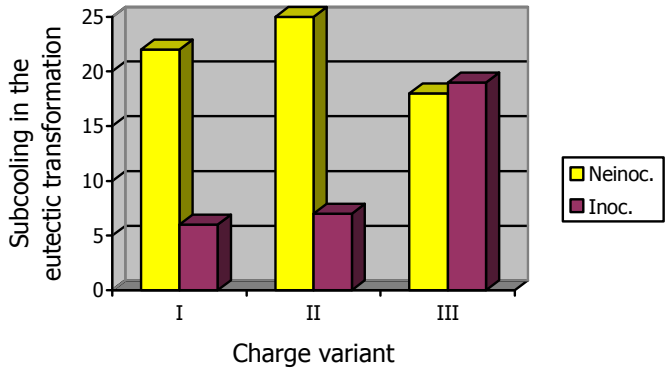

Figure 10. The representation of the subcooling in the eutectic transformation (ΔT_m), in ^0C, for grey irons.

* In the eutectic transformation, the unmodified grey irons obtained from the second variant of charge, presents a higher subcooling (ΔT_m), and the modified grey irons obtained from the first variant of charge, presents a less pronounced subcooling (Figure 10);
* The modification of grey irons obtained from the subcooling during the eutectic transformation;
* The subcooling of the modified grey irons, during the eutectic transformation, obtained from the third variant of charge has a much more higher value than of the grey irons obtained from the first and from the second variant of charge;
* During the eutectoid transformation a lower value of the subcooling is obtained from the second variant of charge, but, also, in the case of the modified grey iron which presents a value of subcooling close to that of the unmodified grey iron; a high value of the subcooling is observed in the modified grey iron, obtained from the first variant of charge (Figure 11);
* In the eutectic transformation, the modified grey iron, obtained from the second variant of charge, presents a low value of the maximum dilatation and the unmodified grey iron presents high values of maximum dilatation (Figure 12);
* In the eutectic transformation, during the cooling in the casting shapes, we can observe that the modified grey irons, obtained from the second variant of charge,

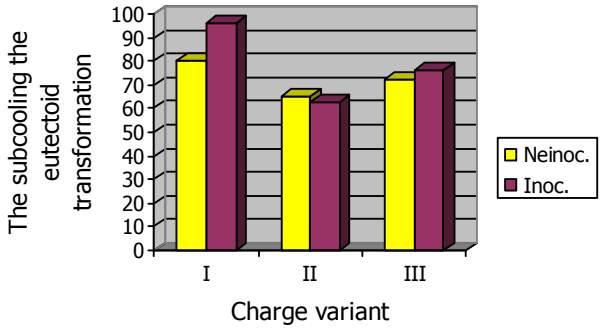

Figure 11. The representation of the subcooling in the eutectoid transformation ($\Delta T_m^{(p)}$), in ^0C, for the grey irons.

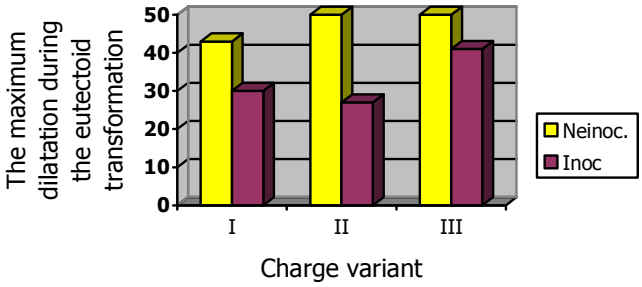

Figure 12. The representation of the maximum dilatation in the eutectoid transformation $x10^{-2}$ ($\varepsilon_{di\ max}$ $x10^{-2}$), in %, for the grey irons.

presents a high value of the pearlite contraction (ε_{dp}) and the modified grey iron, obtained from the same variant of metallic charge, presents a low value of the pearlite contraction (Figure 13);

* We can, also, observe that the modification applied to the studied grey irons determines the obtaining of different values of the pearlite contraction;

* The grey iron obtained from the third variant of charge presents equal values of the pearlite contraction for the unmodified grey irons and for the modified ones; these results regarding the pearlite contraction show that this one is not influenced by the modification in the case of the grey irons obtained from the third variant of charge.

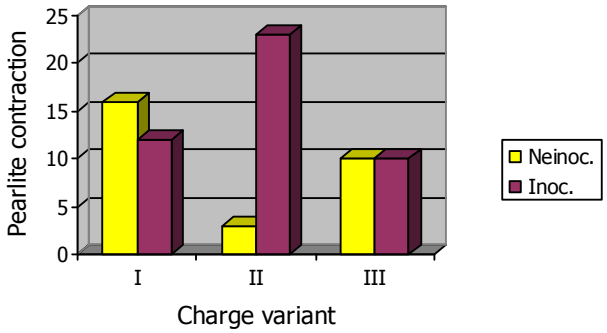

Figure 13. The representation of the pearlite contraction of the subcooling x 10^{-3} (ε_{dp} x10^{-3}), in %, for the grey irons.

By analyzing the parameters obtained through computer assisted tracing of the cooling and of the contraction curves, for the modified and unmodified grey irons obtained from 3 variants of metallic charge, is highlighted the fact that, in most cases, the forming of the primary structures of the grey irons is determined mainly by the composition of the metallic charge through their original characteristics. Of course, the obtaining of precise results concerning the solidification and the contraction of grey irons may be done by the completion of these results with the results obtained after the application of solidification stimulating software.

4. References

[1] Lupinca, C. I. - Theoretical and Experimental Studies Regarding the Improvement of Properties of High quality Hypoeutectic Cast Irons melted in Electrical Furnaces (primary and secondary), The Doctoral Thesis, Bucharest, 2002.
[2] Lupinca, C. I. - Studies about the solidification of the hypoeutectic grey irons, in „Eftimie Murgu" University of Reşiţa Annals, 2002, p. 173-177.

Addresses:

• Lect.dr.eng. Cincă - Ionel Lupinca – „Eftimie Murgu" University of Resita, Traian Vuia Square, No. 1-4, 320085, Caras-Severin Country, Romania, c.lupinca@uem.ro