www.czasopisma.pan.pl PAN www.journals.pan.pl

ARCHIVES of FOUNDRY ENGINEERING

DOI: 10.1515/afe-2016-0083

Published quarterly as the organ of the Foundry Commission of the Polish Academy of Sciences

DE GRUYTER OPEN

ISSN (2299-2944)
Volume 16
Issue 4/2016

57 – 60

Elimination of Chunky Graphite in Castings with Large Thermal Points

P. Futas
Institute of Metallurgy, Faculty of Metallurgy, Technical University of Košice,
Letná 9, 004001 Košice, Slovakia
Corresponding author. E-mail address: peter.futas@tuke.sk

Received 01.07.2016; accepted in revised form 31.08.2016

Abstract

The presence of the chunky graphite is unwanted in the cast iron with the spheroidal graphite for this significantly lowers the properties of the ductile iron. This shape of the graphite is formed as the result of the slow cooling rate of the castings with large thermal point and also due to the presence of the elements which suppress the formation of the spheroidal graphite and support formation of the chunky graphite. The spheroidal graphite present in the ductile iron assures the excellent mechanical properties, while the chunky graphite significantly reduces those properties of the ductile iron. Therefore it is of importance to assume conditions under which prevented is the formation of the chunky graphite. The casts were carried out under the conditions of the regular operation of the foundry and tested were various types of modifiers and inoculators and also pre-inoculators containing the elements suppressing the formation of the chunky graphite (Al, Sb a Ba). Applied were also the chromium breaker core to suppress the formation chunky graphite which was present in the structure in the places after the feeders elimination. As whole, executed were eight casts with various types of the modifiers and inoculators.

Keywords: Ductile iron, Chunky graphite, Cooling rate, Casting, Thermal point

1. Introduction

Disintegrated and exploded graphite may be present in the casts from the above-eutectic cast iron, in particular if CE > 4,5%, or in very slowly cooled cross-sections, where spheres of the graphite float and are disintegrated. The degraded form of the graphite – chunky graphite – may be formed in the casts made of ductile iron with large thermal point due to the different solidification rate. The spheroidal form of the graphite in the structure of the ductile iron assumes its excellent mechanical properties, mainly the tensile strength and ductility, for the chunky graphite significantly reduces these properties its presence in the structure of the ductile iron is not allowed. Chunky graphite is formed inside the cells, while the cell boundaries may also contain the well formed spheres – it is a case of the thicker walls of the cast. Metallurgical flaws may exist not only in the casts but also in the welded joints [1-3].

Chunky graphite (Fig.1) may be eliminated and obtained may be the structure with fully spheroidal graphite when added are the elements supporting the formation of the inter-cell lamellar graphite.

From the point of the support for the inter-cell lamellar graphite formation and therefore prevention of the chunky graphite formation, these elements are classified in two groups. The elements supporting the chunky graphite formation are Ce, Ca, Si, Ni and the elements supporting the formation of the lamellar inter-cell graphite formation are Bi, Pb, Sb, Al, As, Cd, Cu, Sn [4,5].

With regard to the fact that the chunky graphite is the most frequently formed in such parts of the casts which solidify as the last and where the magnesium content is low. Due to the above it is suitable to increase the magnesium content in the casts with the objective to prevent the formation of some forms of the graphite. One of the possibilities is the application of the addition of 0.001% antimony or 0.02% tin, which prevent the chunky graphite formation [6].

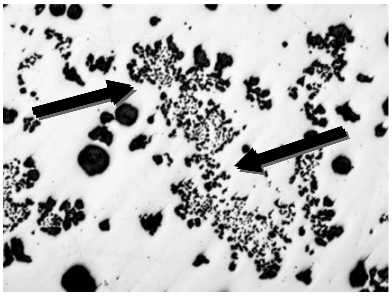

Fig. 1. Chunky graphite

2. Methodology of experiments

Experiments were performed under the conditions of the regular operation of the foundry. In course of the experiments altered were the conditions of the metallurgical processing of he melt and location of the riser on the thermal points f the cast with the large thermal points. The tests were performed on the test cast, model of which was designed for this purpose (Fig. 2). Dimensions of the model were 300 x 300 x 250 cm.

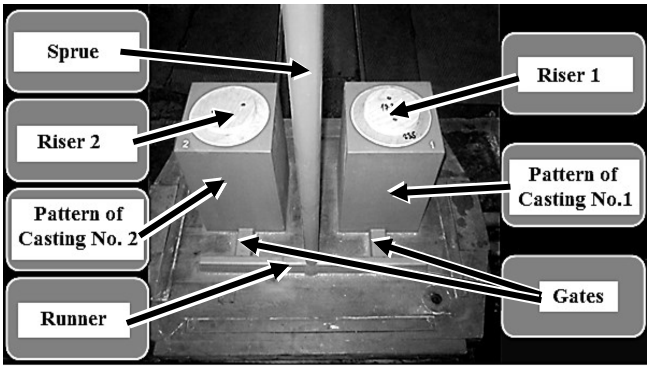

Fig. 2. Pattern of Casting

Melting was realised in the medium-frequency inductive furnace with the acidic lining with the volume of 10 ton. As the charge used was the steel scrap (SVa), pig iron and return material in various proportions. As carburizer applied was Carbolux SK. Following the last addition of the charge added was also SiC in the amount of 0,5wht %. After starting melting of the charge cast iron was heated to 1420°C, the slag was skimmed and the sample was taken for the spectral analysis.
As whole executed were eight test melts, from which cast were the test castings. The review on the metallurgical processing of the individual melts is documented in Table 1. Metallurgical processing of the melt consisted of the chemical composition modification and addition of the various types of the modifiers and inoculators with the aim to eliminate the chunky graphite.

All melts were heated to the temperature of 1535°C and the pouring temperature in all cases was 1355°C.
Modification of the melt was carried out applying the method tundish-cover and cast iron was cast to the moulds within 15 minutes after its casting from the furnace to the pouring ladle.
As the modifier applied were Elmag 5800 and Elmag 6039. As the inoculators applied were SMW 605 with the addition Bi and VP116 with the addition Al, possibly with the addition Al and Sb with the addition Ba.

Table 1.
Metallurgical treatment of the melts

Melt No.	Modifier	Inoculant	Secondary inoculant	Cr breaker core
1.	*Elmag 5800*	*SMW 605*	Germaloy (Al)	No
2.	*Elmag 5800*	*SMW 605*	SMW (Bi)	No
3.	*Elmag 6039*	VP116	Germaloy (Al)	No
4.	*Elmag 6039*	VP116	SMW (Bi)	No
5.	*Elmag 6039*	VP116	Germaloy (Al)	Yes
6.	*Elmag 6039*	Spherix	SMW (Bi)	Yes
7.	*Elmag 6039*	Sb5	Germaloy (Al)	Yes
8.	*Elmag 6039*	Sb5	SMW (Bi)	Yes

The chemical composition of modifier Elmag 5800 and modifier Elmag 6039 is documented in Table 2.

Table 2.
Chemical composition of modifiers Elmag 5800 and Elmag 6039

Element	Elmag 5800	Elmag 6039
	[%]	
Si	44-48 %	44-48 %
Al	0,4-1,0 %	0,0-0,8%
Ca	0,8-1,2 %	1,5-2,0 %
Re	0,85-1,15%	0,0-0,1%
Mg	5,55-6,15 %	5,75-6,25 %

Samples for the metallographic analysis were taken from the surface sections of the test casts under the riser. For the casts from the melts 5 through 8 applied were Cr breaker core with the thickness of 20 mm, objective of which was the prevent the possible formation of the chunky graphite in those sections of the casting. Cr breaker core was removed after the cast completion by grinding.
As the secondary inoculator applied was the inoculator Germaloy with the addition Al in melts No. 1, 3, 5 and 7 and inoculator SMW with the addition Bi in melts No. 2, 4, 6 and 8. Chemical composition of used inoculants is given in Tab.3.

Table 3.
Chemical composition of inoculants

Element	SMW 605	VP116	Spherix	Sb5
		[%]		
Fe	Rest	Rest	-	Rest
Si	67,40	69,40	70,0-75,0	66,60
Al	0,95	2,60	0,7-1,4	1,49
Ca	2,20	0,83	1,0-2,0	1,45
Se	0,92	-	-	-
Bi	1,05	-	0,8-1,3	-
rare earth metals	-	-	0,4-0,7%	-
Ba	-	-	-	2,46

3. Acquired results

Shape, size and distribution of the graphite in the casts from the surface sections from the individual melts were observed in not etched state with 100x magnification. Chunky graphite was observed in samples of melts No. 1 to No. 4. Differences among these melts were inusing of Cr breaker core. Fig. 3 shows the samples of cast iron with and without the chunky graphite.

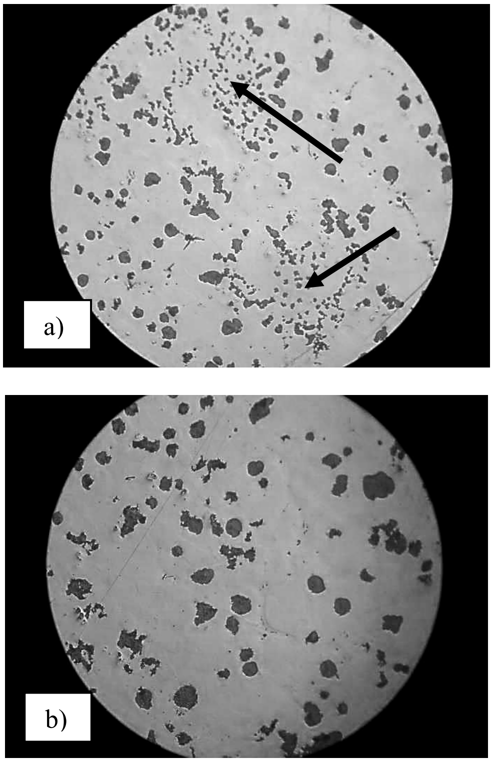

Fig. 3. Metallografical structures of sample from melts
a) melts No. 3 – with the chunky graphite
b) melts No. 7 – without the chunky graphite

In case of the samples from the melts No. 1 through 4 was observed in the structure of the cast iron the presence of the degraded shape of the graphite and on the surface layer of the cast were observed the circular imprints after the riser removal. The circular imprint after the riser removal in case of the sample from the melt No. č. 1 is provided in Fig. 4. Right in these sections presence of chunky graphite was more frequent. In case of the samples from the melts No. 5 through 8, where applied was also the Cr breaker core, the circular imprint was not present after the head removal, Fig. 4. No chunky graphite was observed in the structure in case of the above melts.

Fig. 4. Circular imprint on the cast

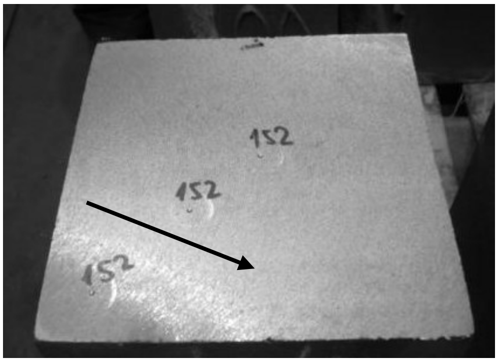

Fig. 5. Cast without the circular

4. Conclusion

The formation of the chunky graphite as one of the degraded shapes of the graphite, arising in cast iron production with the spheroidal graphite is the reason for the castings mechanical properties reduction. Therefore its presence in the structure is unwanted. The objective of the experiments was the proposal of the metallurgical interventions with the aim of the chunky graphite elimination in the castings with the large thermal point. Right the rate of the solidification is one of the decisive factors affecting the presence of this unwanted form of the graphite. Produced were eight experimental melts where altered were the modification additives and inoculators of different base with the addition of the certain elements (Al, Sb a Ba), which suppress the chunky graphite formation. Based on the carried out experiments it followed out that plain metallurgical modification does not provide the complete elimination of the chunky graphite in the structure of the ductile iron. Executed were the technological adjustments, consisting in the application of the Cr breaker core with thickness of 20 mm under the riser. In such way the solidification in this part of the casting was speeded up and the formation of the chunky graphite was prevented.

From point of the process economy the most advantageous is the melt variant and technological modification No. 7, i.e. the application of the modifier Elmag 6039, inoculator SB5, and secondary inoculators Germaloy (Al) with the use of the Cr breaker core.

Acknowledgements

This work was supported by the Scientific Grant Agency of the Ministry of Education of the Slovak Republic No.VEGA 1/0703/16

References

[1] Zhe, L., Weiping, Ch. & Yu, D. (2012). Influence of cooling rate and antimony addition content on graphite morphology and mechanical properties of a ductile iron. *China Foundry*. 9(2), 114-118.

[2] Falat, L., Čiripová, L., Kepič, J., Buršík, J. & Podstranská, I. (2014). Correlation between microstructure and creep performance of artensitic/austenitic transition weldment in dependence of its post-weld heat treatment. *Engineering Failure Analysis*. 40, 141-152.

[3] Falat, L., Kepič, J., Čiripová, L., Ševc, P., & Dlouhý, I. (2016). The effects of postweld heat treatment and isothermal aging on T92 steel heat-affected zone mechanical properties of T92/TP316H dissimilar weldments. *Journal of Materials Research*. 31, 1532-1543.

[4] Karsay, S.I. (1992). *Gusseisen mit Kugelgraphit I*., QIT-FER ET TITANE INC.

[5] Nakae, H., Jung, S. & Shin, H.C. (2008). Formation mechanism of chunky graphite and its preventive measure. *J. Mater. Sci. Tech.* 24, 289-295.

[6] Basutkar, P.K., Loper, C. R. (1971). *Predicting graphite nodularity in heavy section ductile iron by thermal analysis*. AFS report of research project. pp. 1-17.