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Quality of the reclamation sand and the casting surface structure

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Abstract

The article is discussing the issue of the graphite degradation emission in the surface layer of a nodular iron casting. A diffusion of sulphur from moulding sand to the surface of the casting is a cause of this occurrence. Examinations present the influence of the quality of the reclamation sand of furan no-bake sand to the arrangement and the size of the degenerate graphite zone.

Keywords: Moulding sand; Sulphur; Nodular cast iron

1. Introduction

The type of mould influences casting surface layer, through the ability to accompany the heat of molten metal, but can also interact with his microstructure as a result of processes of diffusion elements of moulding sand. At the production of nodular iron castings in no-bake moulds with furfuryl resin (in so-called furan mould), it is possible sometimes to observe the decline of spheroid graphite and passing him into the lamellar form on outside surfaces of casting. Changes of this kind are being attributed to the diffusion of sulphur of moulding sand to the surface of solidifying casting [1-7]. Spheroidal elements entered into the molten iron can react with sulphur. It is a continuous operation, all the way to the moment of solidification of metal. The area of the casting skin enriched into sulphur coming from moulding sand contains the insufficient amount of spheroidal element, what is watching in relation to graphite degradation emission in this part of the casting. The sulphur source in no-bake sand with furfuryl resin are sour hardeners, produced on the basis of sulphonic acids or sulphuric acid. Under the influence of the high temperature the disintegration of the hardener proceed, product of which are sulphur compounds diffusing to molten metal and intensifying in used moulding sand and get from it mechanic reclamation sand. Compounds of sulphur are a product of the disintegration of the hardener, mainly sulphur dioxide and hydrogen sulphide. Below an example of the disintegration for the sulphonic acid was presented:

$$C_7H_7SO_3H \rightarrow C_7H_7OH + SO_2$$

The flake graphite by the surface in a nodular iron casting is an one of anomalies of spheroid graphite turning up at the production of this alloy at furan no-bake moulds. The recalled anomaly affects for lowering mechanical properties of the casting. Reducing a limit of the material fatigue is being watched of about 15 % whether it causes stresses which can sometimes appearance of the crack. Moreover small petals of graphite in surface layer are supporting oxidizing and the sensitivity to decarburising of the subjected casting for heat treatment. Analysis of the diffusion process of sulphur of moulding sand to outside layer of steel

casting is discussed in the separate publication [8]. Changes of the chemical composition (S content) were meant on areas about millimetre distances from the surface of the casting. Measurements were being conducted to the depth of 10 mm, by means of EDS techniques – of microanalyser LINK AN 10/85S coupled with the electron microscope JSM 840. Simultaneously on mill areas in the distance as 1 mm from the surface of the casting, content of coal and sulphur were being determined with the help of the spectrometer. Results of conducted analyses were placed on Figure 1.

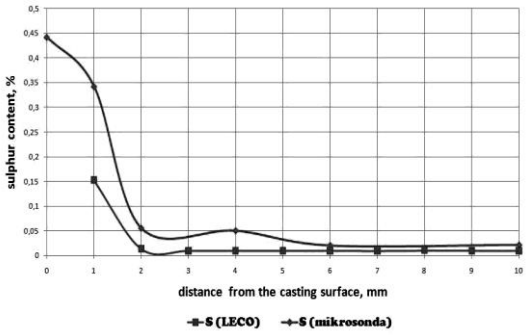

Fig. 1. Change of the chemical composition of steel (C and S content) depending on the distance from the surface of the casting [8]

As can be seen, by such a massy steel casting, the diffusion of sulphur is deep and considerable. Additionally these examinations confirmed the ineffectiveness of the analysis of the appearance with the help of the method of the microprobe.

In the separate publication of authors [1], a diffusion process of sulphur going from the mould carried out of no-bake sand with furfuryl resin for the iron casting with spheroid graphite was discussed. All experimental moulds were carried out of sand with Kaltharz furfuryl resin made out on the basis of fresh quartz sand, by the same contents of resin and different types of the hardener. The difference consisted in the different content of derivative sulphur acids in the given hardener what it was possible to observe in Leco analysis results of the content of sulphur in individual sand (from 0.045 % to 0.08 % sulphur). In experimental castings in principle a change of spheroid graphite in the area of the casting skin wasn't observed. One should however remember that diffusion transformations are being stimulated with the massivness of castings, the wall thickness and the solidification time what isn't making impossible coming into existence lamellar layer in an massy nodular iron castings, drawn up also in moulds on the basis of fresh sand.

This publication is devoted to the analysis of the effect of mechanic reclamation sand in furan no-bake mould for appearing of the flake graphite in the outer layer of a nodular iron castings.

2. Own investigations

2.1. Examination methodology

The first research stage concerned making experimental castings of the nodular cast iron, type EN-GJS 500-7. Castings had dimensions: 175 x 195 x of 120 mm and the characteristic shape "U" selected as a result of the literature data analysis [5]. Experimental castings were made in moulds of no-bake sand with furfuryl resin drawn up on reclamation sand warp (made with mechanical method) which contained different amounts of sulphur. Reclamation sand applied in 1R SAND contained 0.10 % sulphur, in SAND 2R - 0.15 % sulphur and in SAND 3R was applied reclamation sand of the content of sulphur 0.20 %.

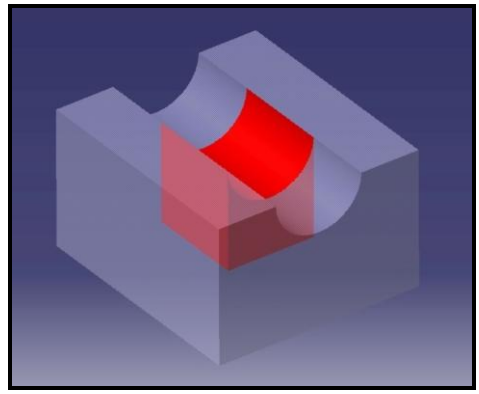

Fig. 2. Experimental casting with the marked place of the sampling for examinations

Individual moulding sand was being carried out, about the following composition:

Reclamation sand	100 p. p. w.
Fenol-furfuryl resin Kaltharz (nitrogen: 0,35-0,5%, furfuryl alcohol ~50%)	1,1 p. p. w.
Standard hardener (50-65% PTS acid, <5% sulphuric acid)	0,55 p. p. w.

Samples of sand this way prepared were taken for indication the sulphur content with thermal method with Leco CS 444 apparatus. These examinations were conducted at the Foundry Research Institute of the Founding in Cracow – Table 1.

Table 1.
Content of sulphur in reclamation sand and in individual moulding sands

Sand nr	Content of sulphur in reclamation sand, %	Content of sulphur in moulding sand, %
SAND 1R	0,10	**0,18** ± 0,018
SAND 2R	0,15	**0,22** ± 0,023
SAND 3R	0,20	**0,30** ± 0,025

The other research stage consisted in cutting samples from experimental castings with a view to carrying out metallography investigations. The research was conducted on samples cut out sheer to the surface, in the place of the greatest concentration of gasses, from every experimental casting. Their surfaces were subjected to examinations of the chemical composition and the

microstructure by means of the method of dispersion of roentgen rays EDS and analysis of optical images and scanning. These examinations were performed in Department of Materials Science and Analysis of the Faculty of Metal Engineering and Industrial Computer Science AGH. Samples were sinked in conducting bakelite, they were grinding and polishing. After polishing, samples were being etched 3 % nitalem with a view to revealing differences of the structure among the outer surface and the interior area. Examinations of the microstructure were being conducted with using the light microscope Zeiss and electron scanning Hitachi 3500 N. Moreover behind the help of the EDS microanalyser of the Noran company, examinations of the content and elements arranging in chosen areas and current phases in outer layer were executed.

2.2. Examination results

Figures 3a - 3c represent exemplary results of measurement. Metallographic images, drawn up from experimental castings, are showing very clearly lamellar surface layer of nodular interior.

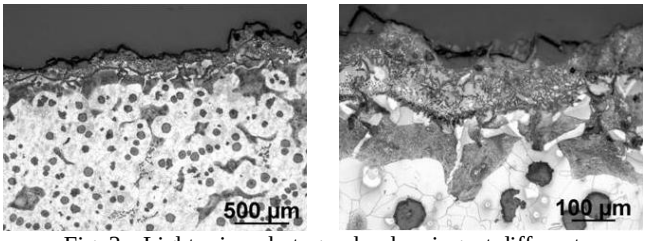

Fig. 3a. Light microphotographs showing, at different magnification, structure of the section of the outer layer of the experimental casting in 1R SAND (nital)

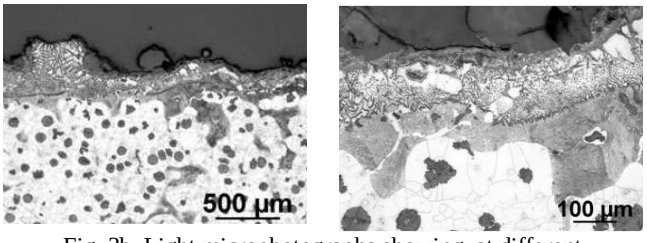

Fig. 3b. Light microphotographs showing, at different magnification, structure of the section of the outer layer of the experimental casting in 2 R sand (nital)

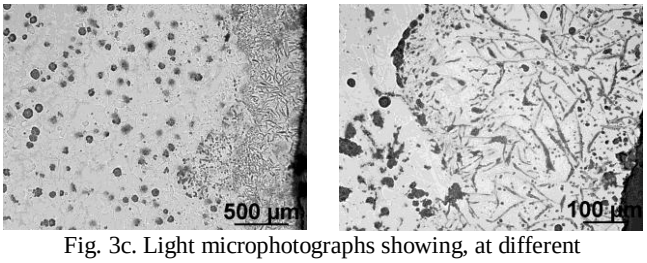

Fig. 3c. Light microphotographs showing, at different magnification, structure of the section of the outer layer of the experimental casting in 3 R sand (not etched)

In case of castings drawn up in SAND 1R and 2R was being observed great coarseness of the surface area. Thickness of outer layer with the changed structure, with flake graphite in ferrite matrix, in comparing to the interior, in which graphite was found in a spheroid form in ferrite-pearlite matrix, was irregular on the entire surface of the casting (Figure 3a and 3b). On the border of outer layer was being observed, in some areas, emissions of fat, extended graphite, which are well visible in Figure 3a and 3b at bigger magnification. It was already stated that the layer of degenerate graphite is uneven, and its thickness for castings drawn up in SAND 1R and 2R is changing from 200 to 600 µm. However for the casting carried out in SAND 3R the area of the lamellar graphite was characterized by even thickness which took out about 600 µm (Figure 3c). In outer layer, apart from the flake graphite in the ferrite matrix, it was observed spheroid graphite in different size, and the irregular shape grey oxides and sulphides emission. A fact that these sulphides have always been on end of petals of graphite is interesting.

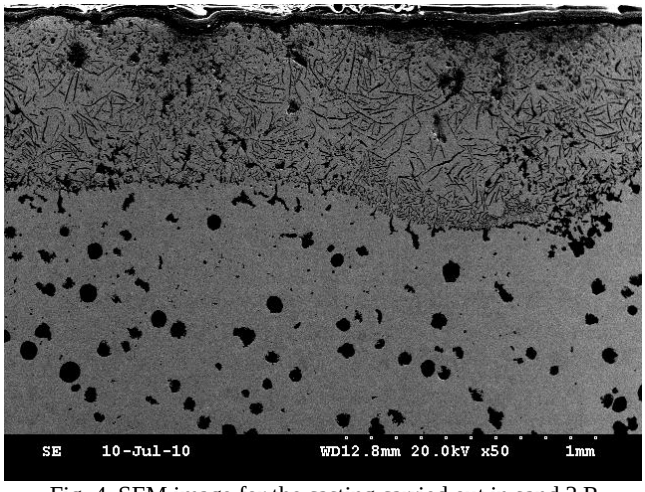

Fig. 4. SEM image for the casting carried out in sand 3 R describing the structure of the section of the outer layer

On the basis of an analysis of metallographic images it is possible to state that as higher content of sulphur in sand the greater and more regular layer of degenerate graphite (Figure 4).

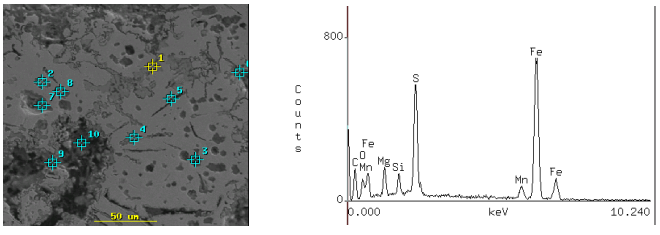

Fig. 5. Exemplary SEM image of the casting carried out in SAND 3R with marked points and EDS spectrogram for point 9

Next analysis of the chemical composition of the degenerate graphite layer was made (Figure 5) in individual experimental castings. A detailed analysis showed, apart from the content of main elements: iron, coal and silicon, that in the experimental

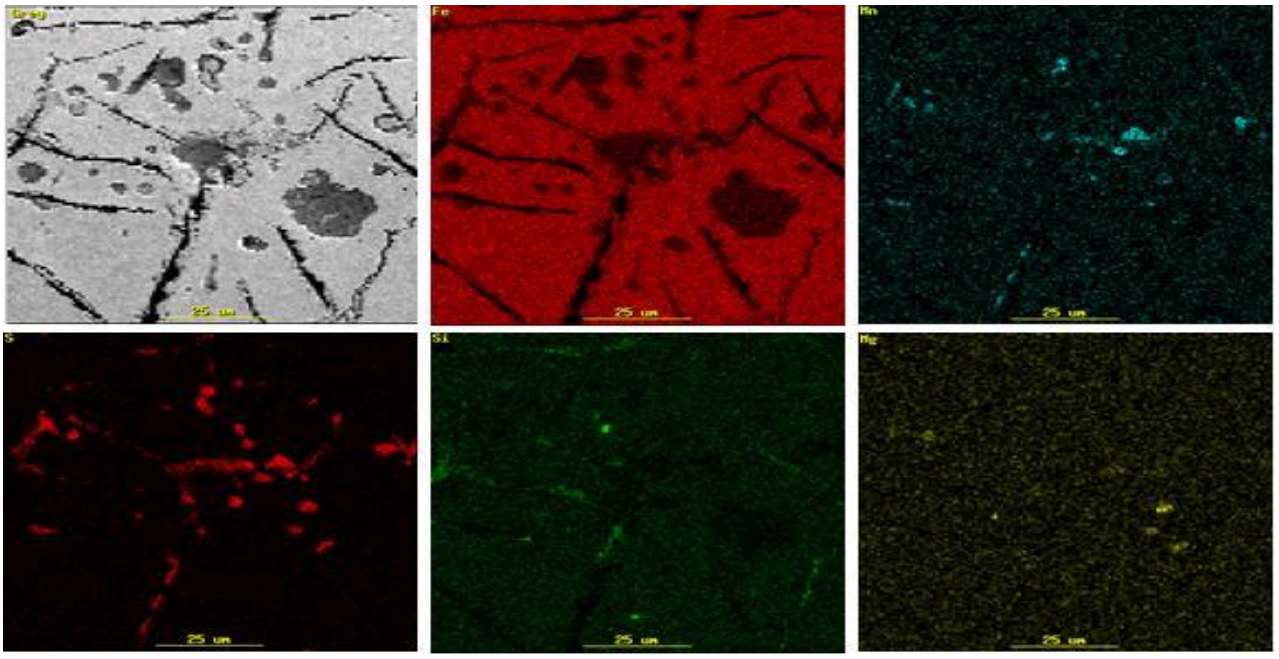

Fig. 6. SEM image of the topography of the area and images of the distribution for Fe, Mn, S, Si and Mg of analysed area enriched into sulphur

casting drawn up in 1R SAND mainly iron sulphides are appearing, sometimes sulphides of magnesium, and by SAND 2R apart from iron sulphides also sulphides of the manganese appear. Interesting conclusions stem from observation of the way of arranging of individual elements. In Figure 6 there is a SEM image describing the topography of the area and images of the distribution of Fe, Mn, S, Si oraz Mg of analysed area enriched into sulphur. The outer layer of the casting carried out in SAND 3R consists of different kind of oxides and sulphides. Manganese sulphides are prevailing, but sometimes also compounds of sulphur with iron or magnesium appear.

3. Conclusions

Conducted examinations showed that applying no-bake sand with furfuryl resin on reclamation sand warp, in which the content of sulphur is intensifying, is leading to the degradation of graphite in the surface layer of the nodular cast iron. The size and the evenness of this zone will depend on the content of sulphur in reclamation sand.

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