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STUDIES ON THE INFLUENCE OF METHANE GAS BUBBLING OF METAL ALLOYS ON THE CASTING PROPERTIES

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Abstract: *The purpose of using bubbling in the case of metal alloys was to increase the mechanical resistance, to improve the casting properties as well as to observe the changes brought by gases on the structure. During bubbling, especially hydrogen and oxygen are removed, which obviously leads to the improvement of metal alloys. The influence of bubbling on the casting properties is explained by the structural changes that occur in the cast alloys. Therefore, bubbling with methane gas is a safe means of improving the quality of cast parts, ensuring at the same time the increase of casting properties of alloys.*

Key words*:* *Cast iron, mechanical properties, bubbling, methane gas*

1. INTRODUCTION

It is known from the literature that the bubbling of liquid metal alloys with gases before their casting leads to a change in the structure and thus in the mechanical properties, and in some cases also to a change in the casting properties. Most experiences show that by bubbling liquid cast iron with argon, nitrogen, carbon dioxide, hydrogen, etc. , there is an increase in the degree of graphitization of cast iron, an improvement in the shape and distribution of graphite separations, a decrease in gas content and the amount of non-metallic inclusions. For this reason, the quality of cast iron improves, and in some cases, an increase in fluidity is also observed. It was found that the bubbling of liquid cast irons with gases can replace the modification process, thereby the modifying effect having a much longer duration, than in the case of using ordinary modifiers such as (FeSi and SiCa).[1-7]

The presented method is by bubbling the cast iron developed in a tilting furnace with a crucible with a capacity of 150 kg.

In one form or another, the process of bubbling the liquid alloy with gases has been known for a long time in metallurgical practice (the perusing operation of copper melts with birch wood; the very process of making steel in the converter, the boiling period in the Martin process ; bubbling of non-ferrous alloys with chlorine, etc.). [5-9]In the case of cast iron, bubbling was used in order to increase mechanical resistance and quasi-isotropy.

In general, until now, the influence of gas bubbling of cast iron on the structure and mechanical properties has been investigated, without considering the casting properties.

The bubbling of liquid cast iron with methane gas, acetylene and other hydrocarbons leads to the improvement of the shape of the graphite, namely to its nodularization. This increases the degree of graphitization of cast iron.

According to literature, by bubbling liquid cast iron with methane gas, the process of dissociation of the latter takes place with the formation of solid carbon which is deposited in the form of soot and hydrogen.[7-11]

$$CH_4 = C_{solid} + 2H_2 - 22\,200 \text{ [cal/mol]}.$$

At the same time, part of the methane gas, without dissociating, passes through the bath of liquid cast iron, bubbling it, producing a refining effect (degasification and reduction of the proportion of non-metallic inclusions) just as in the case of bubbling cast iron with other gases (argon, CO_2, N_2 etc).[9-11]

The hydrogen that separates as a result of the dissociation reaction of methane gas occupies the space of the remaining undecomposed methane gas bubbles, and the carbon is adsorbed on the surface of the bubbles. In this way, in the presence of gas bubbles and native carbon, favorable conditions are created for the formation of graphitization centers corresponding to the nodular form of graphite. In other words, a process similar to that in the case of treating cast iron with magnesium takes place. [9-15]

However, when bubbling cast iron with methane gas, as opposed to treating cast iron with magnesium, it is difficult to obtain 100% nodular graphite, because even before it penetrates the cast iron, the methane gas partially decomposes in the tube through which it is blown, since its temperature of decomposition is approximately 600 0C. The carbon obtained in this way (in the form of soot) is drawn into the cast iron by hydrogen, the second product of the methane decomposition reaction. Thus, germs are introduced into the cast iron to separate the graphite in lamellar form.

The problem of bubbling cast iron with methane gas is particularly important, given its modifying effect. The consumption of methane gas for the bubbling of cast iron is very small and will cost tens of times less than the modifiers normally used. [13-18]

2. PROBLEM SOLUTION

Methane gas was taken from the network, the pressure being measured with a manometer. The introduction of methane gas into the liquid cast iron in the casting pot was carried out with the help of a graphite tube with an inner diameter of 10 mm and an outer diameter of 30 mm. The graphite tube was inserted almost to the bottom of the pot with liquid cast iron. In order to avoid possible splashes of cast iron from the pot, the latter was covered with a lid made for this purpose.

The gas pressure and flow was chosen according to the height of the cast iron column in the pot, so that the cast iron bath gives the impression of slow boiling.

The duration of the bubbling varied between 6-120 seconds.

During bubbling with methane gas, there is a drop in the temperature of the cast iron, which depends on the amount of cast iron, the flow rate of methane gas and the duration of bubbling. Practically, the temperature drop was between 30-60^{0}C. The temperature was determined using the Pt-PtRh immersion thermocouple and the optical pyrometer.

The free linear contraction was determined with the help of the devices described previously, and the volume of retouches, based on the specific weight. The fluidity was measured using the spiral with a section of 0.52 cm^2.

The volume of gases released during the cooling and solidification of the cast iron was determined. Through this, it was possible to appreciate the influence of bubbling on the release of gases during the solidification and cooling period, that is, during the formation of retches.

3. RESULTS AND DISCUSSION

Both cast iron bubbled with methane gas and non-bubbled cast iron were analyzed. By bubbling liquid cast iron with methane gas, at a temperature of 1360-1370[^{0}C], for 120 seconds, it is found according to figure 1, that the initial expansion increases by 20-40%. In the case of non-bubbled cast iron with methane gas, the initial expansion is between 0.110-0.170[%], while for bubbled cast iron between 0150[%]-0.225[%].

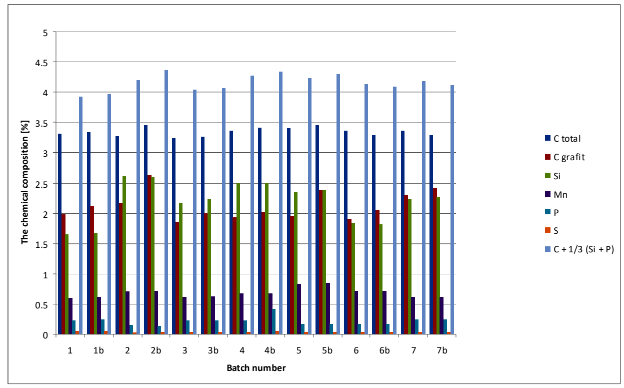

Figure 1. The variation of the chemical composition with the number of bubbled (b) and non-bubbled batches

The pearlitic expansion following the bubbling of cast iron with methane gas, decreases to a significant extent, rarely exceeding the value of 0.030[%].

In these conditions, the total free linear contraction of cast iron bubbled with methane gas decreases by more than 30-40[%].

The volume of retouches in the cast irons studied varies between 1.0-1.7[%]. Following the bubbling of cast iron with methane gas, the tendency to form cracks suddenly decreases, for the given cast irons, the volume of cracks shrinking to half and even more.

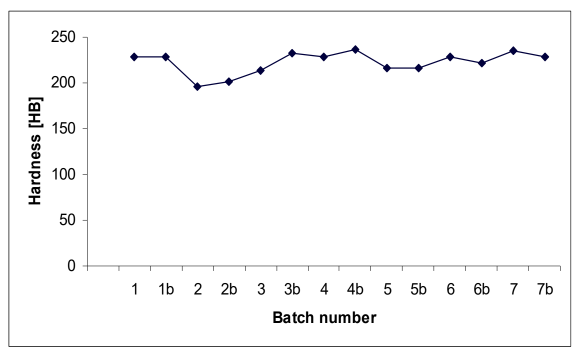

Figure 2. The hardness variation for the analyzed slats

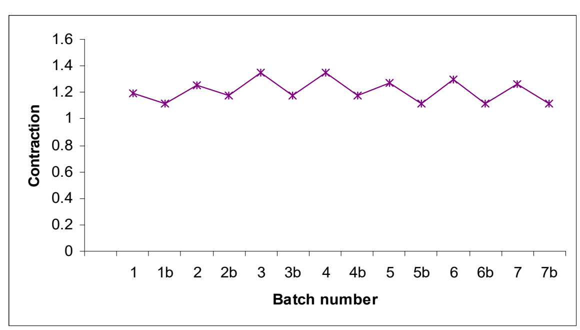

Figure 3. Contraction variation for the analyzed slats

The hardness values are increased for bubbled cast iron, so from the point of view of hardness, we find that the hardness of cast iron increases after the treatment with methane gas, according to figure 2.

According to figure 3, we find that pearlitic contraction values (1.115-1.305) are increased for non-bubbled cast iron. So the bubbling of methane gas does not influence the anti-pearlitic contraction.

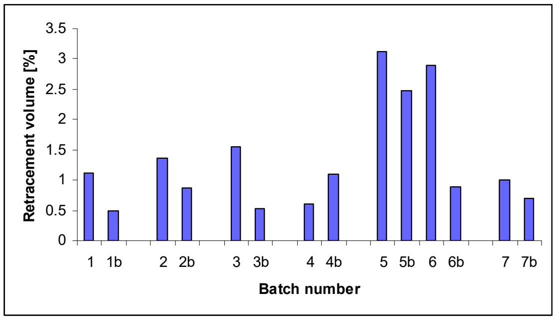

Figure 4. The variation of the retreading volume of the analyzed slats

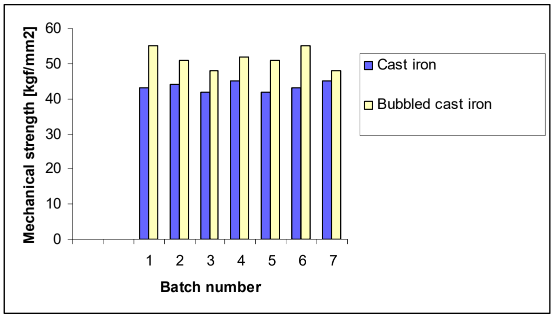

Figure 5. The variation of the mechanical resistance for the analyzed slats

According to figures 2-5, the bubbling of cast iron with methane gas leads to an important improvement of the casting properties, especially reducing the tendency to form streaks. This has a particularly great practical importance, since using methane gas bubbling of liquid cast iron, it is possible to reduce or even avoid the possibility of the formation of porosity (micro-nets), in different parts, without making changes in the forming technology.

The experiments carried out in the factories showed that by bubbling cast iron with methane gas, the quality of the cast parts was significantly improved, almost completely eliminating a series of scraps such as: micro meshes, concentrated meshes or hot cracks in a series of high-responsibility parts.

During the bubbling of cast iron with methane gas, the elimination of gases dissolved in liquid cast iron is done according to a rather complex mechanism. Thus, several actions can overlap, such as the diffusion of gas ions in the non-dissociated methane gas bubbles, which wash the liquid cast iron, rising to the surface, the diffusion of gas ions and especially hydrogen in the hydrogen bubbles.

During bubbling, especially hydrogen and oxygen are removed, which obviously leads to the improvement of cast iron.

4. CONCLUSIONS

We conclude that the bubbling of cast iron with methane gas is a safe means of improving the quality of the cast parts, ensuring at the same time both the increase of the mechanical properties of the cast iron and the increase of the compactness of the cast parts, the reduction of the tendency to form cracks and internal stresses, the formation of hot and cold cracks, keeping a good fluidity of the cast iron.

In these conditions, the total free linear contraction of cast iron bubbled with methane gas decreases by more than 30-40[%].

The volume of retouches in the cast irons studied varies between 1.0-1.7%. Following the bubbling of cast iron with methane gas, the tendency to form retches drops suddenly, for the given cast irons, the volume of retches decreasing to half.

From the point of view of hardness, we find that the hardness of cast iron increases after the treatment with methane gas, which is in accordance with the specialized literature.

Bubbling with methane gas leads to a sudden decrease in the tendency to form retches.

Increasing the initial expansion and reducing the contraction by bubbling the cast iron with methane gas, leads to the reduction of the tendency to form hot cracks in the cast parts.

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