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ASSESSMENT OF THE DEGREE OF CONTAMINATION OF ALUMINUM CASTING ALLOYS

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ABSTRACT

Currently in the aluminum industry for the manufacture of disks for automobile wheel molds, due to increased requirements for the mechanical and casting properties of alloys. Obtaining a given set of physical and mechanical properties is due to both the technology of the alloy and its control for the presence of non-metallic inclusions. The quality of the obtained castings is largely determined by their homogeneity, which, in turn, depends on the amount, size and nature of non-metallic inclusions that form in the casting (ingot) during melting and subsequent crystallization. The content of non-metallic inclusions in the volume of the metal is relatively small, but their presence leads to a significant decrease in the quality of the metal and, as a consequence, the rejection of the finished product. Therefore, the development of new and improvement of existing methods for assessing the degree of contamination of a metal alloy, which makes it possible to reduce the time for conducting research, reduce labor costs and the use of expensive, difficult-to-maintain equipment is an urgent task today. The purpose of this work is to evaluate the method of conducting quantitative analysis to determine the degree of contamination of cast aluminum alloys at different stages of the technological process. Research carried out in the course of the work showed the effectiveness of its application. The use of this technique can significantly reduce the time spent on the analysis. To carry out express control of the degree of contamination of the melt at all stages of the technological process, which makes it possible to improve the quality of the metal and increase the amount of good metal due to timely refining. Investigation of the obtained K-test samples at × 10-50 magnifications allows one to determine the type of inclusion (non-metallic inclusions, oxide film, slag inclusions).

Keywords: aluminum alloy, non-metallic inclusions, refining, casting.

INTRODUCTION

In the modern aluminum industry, there are certain difficulties in the manufacture of car wheel disks due to increased requirements for the mechanical and casting properties of alloys. The formation of the required complex of physical and mechanical properties is determined both by the technology of obtaining the alloy and by its control for the presence of non-metallic inclusions. The quality of the obtained castings is largely determined by their homogeneity, which, in turn, depends on the amount, size and nature of non-metallic inclusions that form in the casting (ingot) during melting and subsequent crystallization. The content of non-metallic inclusions in the volume of the metal is relatively small, but their presence leads to a significant decrease in the quality of the metal and, as a result, to the rejection of the finished product, thereby requiring the introduction of new and improvement of existing methods and technologies for assessing the degree of contamination of the metal alloy [1-6, 8, 13, 14].

MATERIAL AND METHODS

One of the criteria for evaluating the quality of castings made of aluminum alloys is the presence of non-metallic inclusions. Ensuring high quality of the resulting casting begins with the control of the melt used at all technological stages of its production. Improving accuracy and reducing the time spent to determine the degree of contamination of the melt increases the efficiency of the production cycle by increasing the yield and improving the quality of finished products [14, 6, 7, 9, 10-12].

The main advantages of the applied method are:

- quick assessment of the degree of contamination of the melt under production conditions (no more than 10-15 minutes);
- ease of handling and sampling;
- portability.

The essence of the method is as follows. After refining, two samples are taken from the melt using a titanium spoon, the use of which excludes contamination of the aluminum melt during sampling. Samples are taken at a depth of 10-20 cm from the surface of the molten metal, below oxide films and slags, 0,4 kg each and poured into a preheated and painted mold-mold (Figure-1). After crystallization, the sample is knocked out of the chill mold and the next one is poured.

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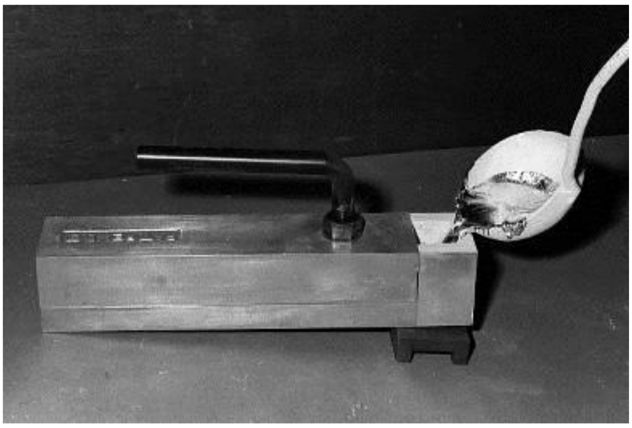

Figure-1. Mold-chill mold for pouring samples.

The obtained samples must be marked, as shown in Figure-2. For this, the number of the future sample is indicated, and the arrow indicates the side of the fracture for subsequent examination. The first element from the sprue bowl, marked on the sample with the symbol "X", is not used in research.

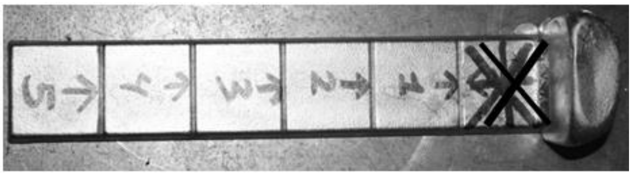

Figure-2. Appearance of the sample.

After marking, the obtained samples are destroyed into separate elements (Figure-3). It is necessary to destroy the samples with a sharp blow in order to avoid bending at the break points. The received samples are added sequentially, according to the serial number (Figure-4).

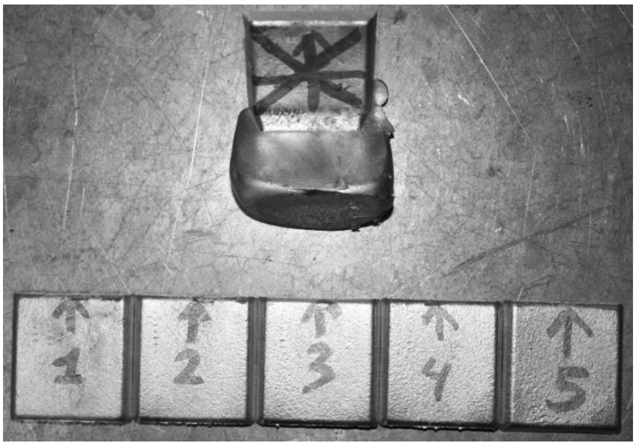

Figure-3. General view of the samples with marking.

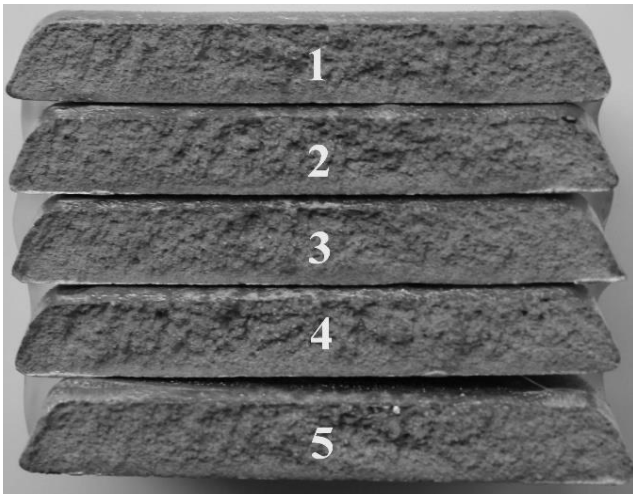

Figure-4. Samples for research in the collection.

Determination of the degree of contamination of the melt is carried out by counting the number of non-metallic inclusions on the fracture surface of the samples obtained (Figure-5). The study of the fracture of the fracture of the samples, to count the number of non-metallic inclusions, is carried out according to the standard method using a stereoscopic microscope. The microscope magnification is × 10-50.

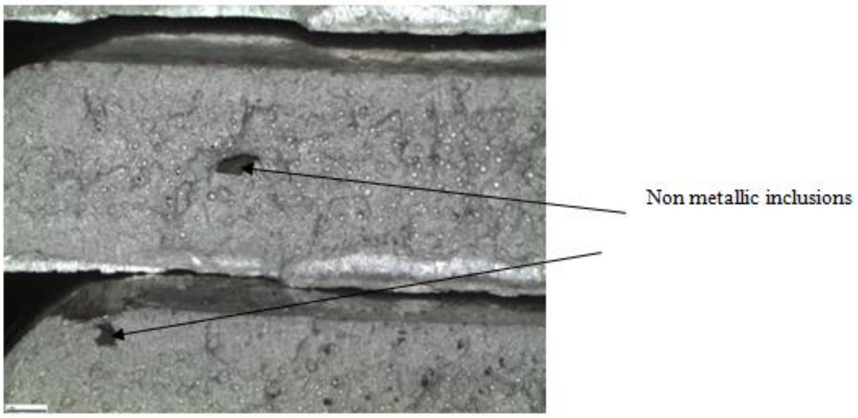

Figure-5. Non-metallic inclusions on the fracture surface, × 20.

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The purity of the melt is expressed through the value (K), which is calculated by the formula:

$$K = \frac{S}{n},$$

where S - total number of inclusions found in all samples, pieces.; n - number of samples examined, pieces.

The obtained K value is compared with the purity levels of the melt indicated in Table-1, which also lists the actions that are recommended to be performed after determining the purity of the melt.

Table-1. Purity level and recommendations for melt use.

Cleanliness level	Value - K	Melt purity	Recommendations for using mel
A	< 0,1	clean	can be used
B	0,1-0,5	pretty clean	can be used, but additional refining of the melt is recommended
C	0,5-1,0	a little dirty	can be used after additional refining of the melt
D	1,0-10	dirty	additional refining of the melt is required, re-analysis is recommended
E	>10	very dirty	additional refining of the melt and re-analysis is required

For experimental studies, sampling was carried out from production heats of OOO LMZ Skad, Krasnoyarsk, Russia, with different charge composition (Table-2), which will allow evaluating the proposed method and determining the effect of the composition of the charge on the purity of the resulting melt.

Carried out metallographic studies (Figures 6-12) showed that the use of additional refining of primary aluminum (alloy No. 1) increases the level of purity of the melt. The value (K) in this case is K = 0.1, while the alloy without additional refining (alloy No. 2) in terms of purity refers to "fairly clean" (see Table-1), and the value of K = 0.4. The introduction of AlSi7 shavings (alloy No. 3, 4) into the composition of the charge reduces the degree of purity to the level "D". Alloy No. 3 has a smaller number of inclusions than alloy No. 4, due to the higher content of primary AlSi7. The introduction of industrial waste into the composition of the charge reduces the purity of the melt to the lowest level "E", which allows us to conclude that their purity is low. The addition of manufacturing scrap in the form of castings (alloys No. 6, 7) to the composition of the charge reduces the purity of the melt to the "C" level.

Table-2. Influence of the composition of the charge on the level of purity of the melt.

Melt number	The composition of the charge	Number of inclusions, S	Number of samples, n	Value, K	Cleanliness level
1	primary AlSi7 (1500 kg) + additional refining	1	10	0,1	A
2	primary AlSi7 (1500 kg)	4	10	0,4	B
3	primary AlSi7 (1500 kg) + AlSi7 shavings (280 kg)	26	5	5,2	D
4	primary AlSi7 (1000 kg) + AlSi7 shavings (280 kg)	45	5	9	D
5	primary AlSi7 (1100 kg) + industrial waste AlSi7 (550)	86	5	17,2	E
6	primary AlSi7 (1500 kg) + manufacturing defect AlSi7 - casting (500 kg)	7	10	0,7	C
7	primary AlSi7 (1000 kg) + manufacturing defect AlSi7 - casting (500 kg)	9	10	0,9	C

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Figure–6. Alloy № 1, ×40.

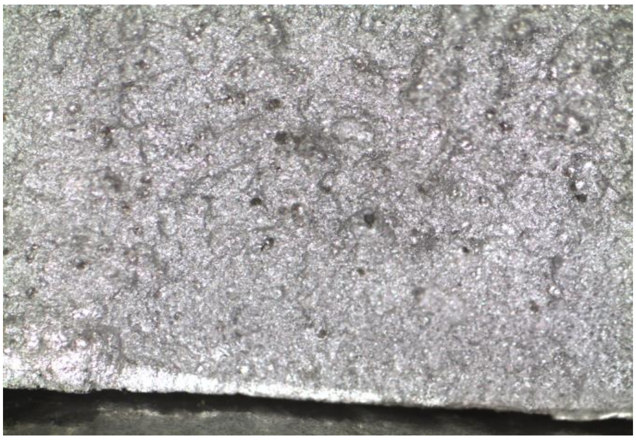

Figure-7. Alloy № 2, ×40.

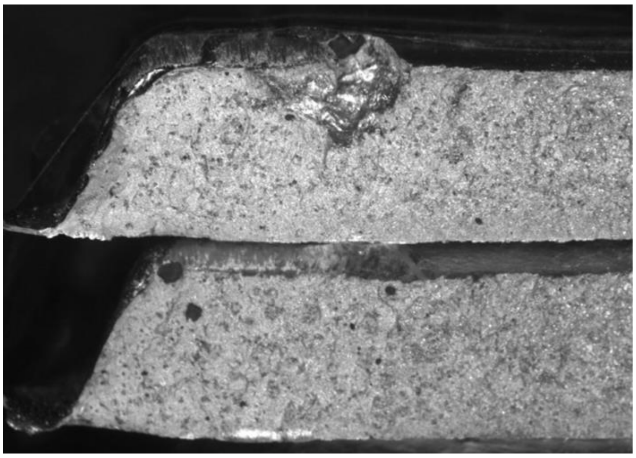

Figure-8. Alloy № 3, ×20.

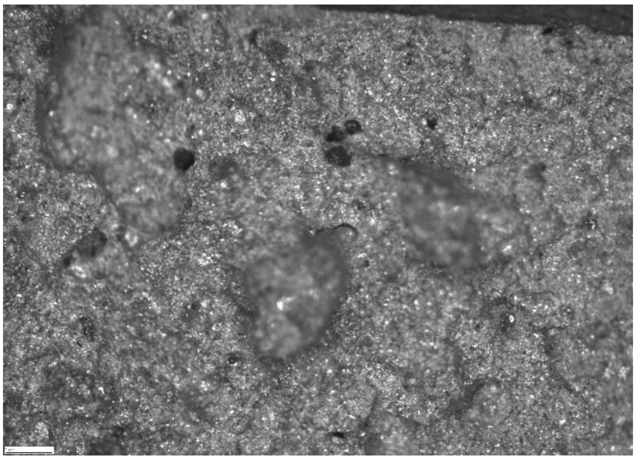

Figure-9. Alloy № 4, ×50.

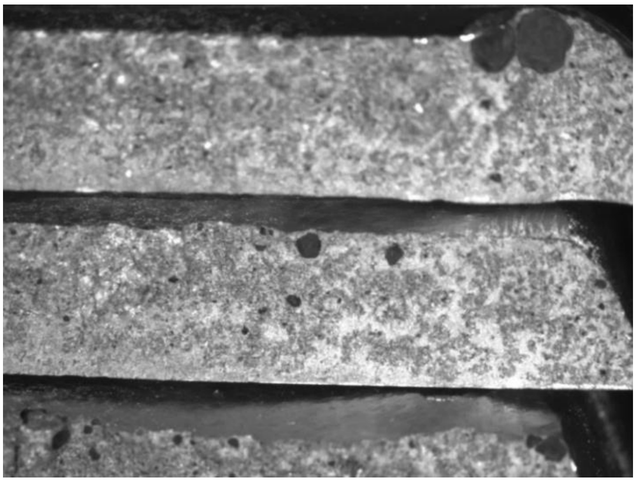

Figure-10. Alloy № 5, ×30.

Figure-11. Alloy № 7, ×40.

The results of metallographic studies have shown that the use of this technique makes it possible to detect not only non-metallic inclusions, but also the presence of an oxide film, which also refers to contamination and reduces the quality of the melt.

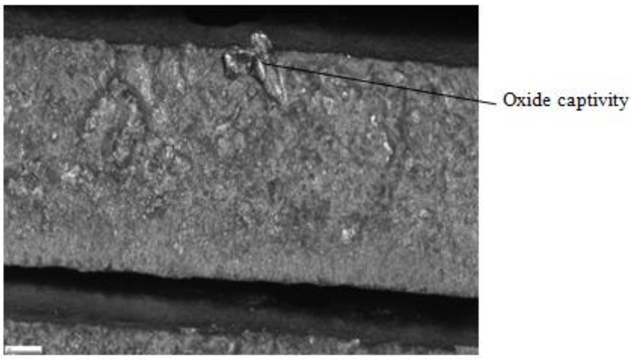

Figure-12. Oxide cap, ×40.

CONCLUSIONS

Quality control of metallurgical castings usually begins with quality control of production heats. The studies carried out show that the use of this technique makes it possible to determine the degree of contamination of the melt, regardless of its chemical composition and production technology. Investigation of samples obtained from industrial heats at magnifications of × 10-40 makes it possible to determine the type of inclusion (non-metallic inclusions, oxide film). The use of this technique allows to significantly reduce the analysis time and to control the quality of the melt at all stages of the technological process, which makes it possible to increase the amount of usable due to timely refining and improving the quality of the smelted metal.

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