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Influence of the charge materials on the quality of cast wheel rims made from AK7 alloy

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Abstract. The widespread use of aluminum and alloys based on it in mechanical engineering is determined by high values of specific strength, increased corrosion resistance, as well as the ability to damp vibrations and high energy absorption. These indicators are especially important in the production of cars, as these alloys can reduce product weight and, as a result, the amount of fuel consumed. Reduced weight of cars can reduce harmful emissions into the environment and reduce the pressure on the road surface. Currently, AK7 cast aluminum alloy is the standard alloy for making rims. To obtain an alloy with the necessary properties, it is necessary to take into account the quality of the used charge materials. First of all, this applies to foundry alloys, which are used for alloying and alloy modification. In the study, we studied AlSi10 pig foundry alloy and AlTi5B1 foundry alloy rod.

1. Introduction

The desire to significantly lighten weight, reduce fuel consumption and increase the speed and maneuverability of cars has led to the fact that more and more parts of ferrous alloys began to be replaced by analogs of aluminum alloys. This also affected the wheels of automobile wheels [1]. For their production, a variety of charge materials are used, the influence of the structure of which on the properties of cast products is not always taken into account.

Used for smelting alloys, pig silumins, aluminum alloys, such as AlSi10, are made taking into account the requirements for compliance with the chemical composition and purity of alloys regulated in GOST 1583 and GOST 53777-2010 according to non-metallic inclusions and appearance. They do not allow shrinkage shells, cracks (on ingots weighing more than 200 kg), traces of stripping and cutting, and in the fracture of ingots weighing up to 20 kg there are no slag and other foreign inclusions visible to the naked eye. The total surface area occupied by oxide films and films on ingots of aluminum-silicon alloys should not exceed 5% of the entire surface of ingots. However, the quality control of the surface and kink of ingots is regulated by consumers only visually, without the use of magnifying devices.

The foundry alloy A1Ti5B1 used for the modification is the most famous and popular among manufacturers of ingots and shaped castings [2]. As a rule, it is supplied in the form of rods and must comply with the following requirements:

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- There should be no oxide inclusions in the metal, and the surface without coarse oxide captures and traces visible to the naked eye.
- Have a constant diameter along the entire length of the bar.
- Guarantee the constancy of the chemical composition and uniform distribution of phases in volume.

The surface quality of products is regulated by inspection without the use of magnifying devices.

2. Problem statement

The production of rims by casting wheels allows you to organize production with large volumes of products. High dimensional accuracy when using metal casting, the possibility of obtaining a different design and the introduction of automation determine the advantage of this process [3, 4]. High thermal conductivity of the alloy provides better cooling of the brake mechanisms. In addition, a strong protective, oxide film that forms on the surface of the disk helps protect it from corrosion, and therefore destruction.

The following requirements apply to wheel materials:

- Foundry alloy must have good casting properties: flawless filling of the mold, no metal sticking to the mold, minimal tendency to hot cracking and shrinkage.
- The material must have a high ability to withstand mechanical shocks (ductility, impact strength).
- The material of the rim should have high corrosion resistance, both in normal and in saline atmosphere.
- The disk material must have high fatigue strength.
- Wheel rims for tubeless tires must be airtight.
- The macrostructure of the workpieces should be dense, without cracks, foreign inclusions and mechanical damage [5].
- Shells and other defects exceeding the permissible values established in the design documentation are not allowed inside the workpieces.
- On wheel blanks to be machined, surface blowholes with an area of more than 2.5 mm2 and a depth of more than 0.7 mm are not allowed.
- On the rim surfaces adjacent to the tire, porosity over an area of more than 1 cm^2 is not allowed. By agreement with the consumer, it is allowed to eliminate this defect by surface hardening treatment.

In accordance with these requirements, pre-eutectic aluminum-silicon alloys with a silicon content of 7 to 12% are used for the manufacture of rims [6].

At one of the enterprises manufacturing wheel disks for cars from AK7 alloy, the number of defective products increased periodically. Checking the manufacturing technology of the discs did not reveal violations of compliance with applicable regulations. It was found that the cause of the defect is the quality of the resulting alloy for castings. Specialists of Siberian Federal University set the task of checking the quality of the used charge materials.

3. Results

Initially, studies were conducted of AlSi10 foundry alloy, which was acquired in the form of ingots. Visual inspection revealed coarse loosening, inclusions of dark gray and yellow on the upper surface (Figure 1a), and the presence of a large amount of cold laps and inversion of oxide films on the lower surface (Figure 1b).

In the macrostructure of the prepared sample (Figure 2a), a porous structure was discovered to a depth of 25 mm, in which a large number of oxide and slag films were observed. At the kink of the ingot there are pores up to 2 mm in size, slag inclusions and oxide films 0.1–5 mm in size (Figure 2b).

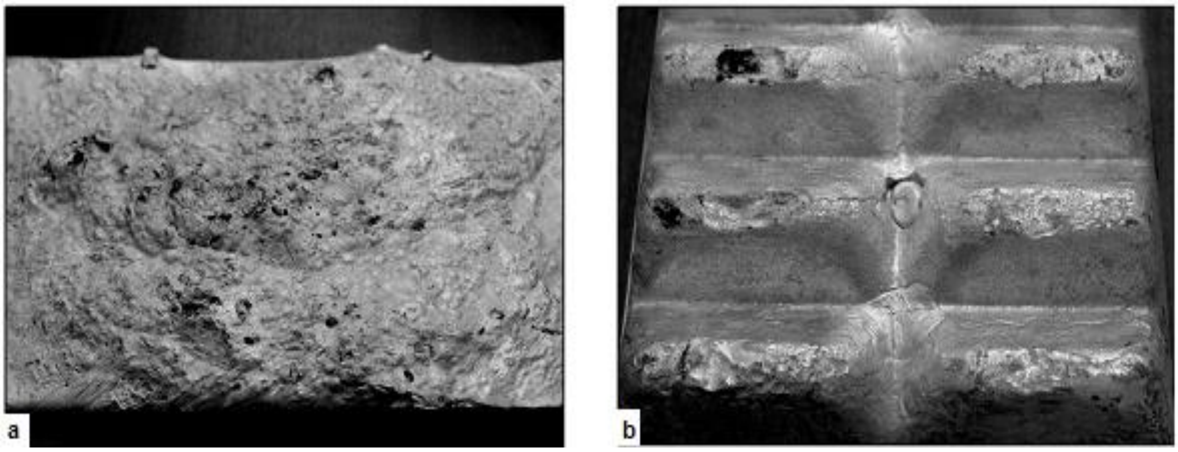

Figure 1. Appearance of the surface of the ingot of AlSi10 foundry alloy:
a - upper surface, b - lower surface.

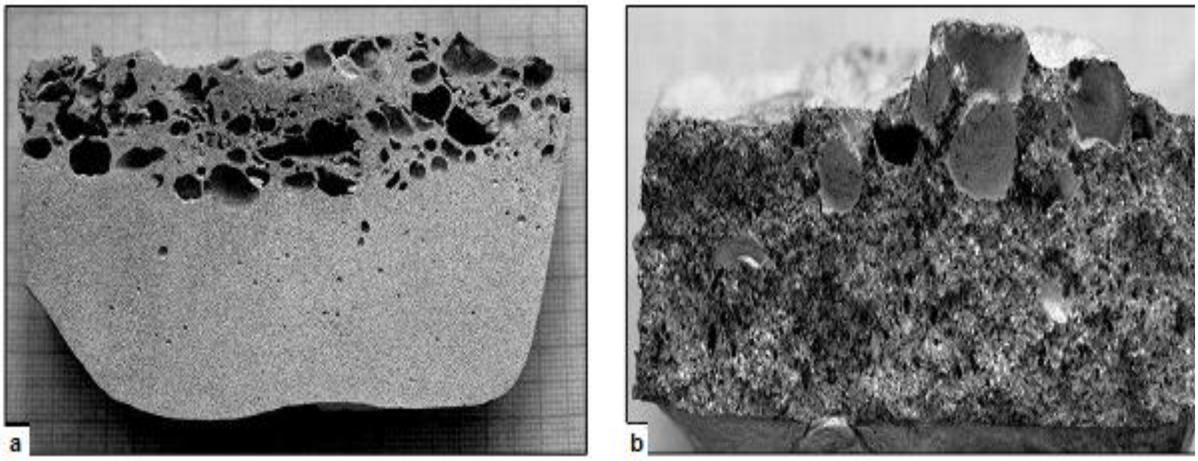

Figure 2. Samples of ingots for research: a - microstructure, b - fracture.

Then, microstructure studies were carried out in the middle part of the ingot (Figure 3a-d). Oxide films, slag inclusions, and particles of insoluble salts with a size of 10–25 μm were found over the entire cross section. The microstructure itself consists of primary Al_4Si intermetallic compounds in the form of fragmented needles and the e + Al_4Si eutectic (Figure 3f). The density of the alloy was 2.659 g / cm^3.

Then, the microstructure of the AlTi5B1 foundry alloy rod was studied on a sample made from its longitudinal section with an area of 2.5 cm. An uneven distribution of $TiAl_3$ crystals and TiB_2 particles was found in the structure (Figure 4a, b).

With a large increase (Figure 5a), it is seen that $TiAl_3$ crystals are located, scattered, in the form of clusters (agglomerates). In the study area, 7 sections of such clusters were found, the sizes of which were 440 * 200 ÷ 2700 * μm. In individual agglomerates, these crystals are interspersed with nonmetallic inclusions and accumulations of TiB_2 particles (Figure 5b).

The shape of intermetallic phases in the clusters corresponds to the shape of disparate crystals, and their color in individual agglomerates has a yellowish tint, emphasizing different phase composition (Figure 5b).

TiB_2 particles are arranged in clusters that form veins of different thicknesses and lengths, elongated along the axis of the rod (Figure 6a), and the largest particles are located in the central zone of the sample (Figure 6b).

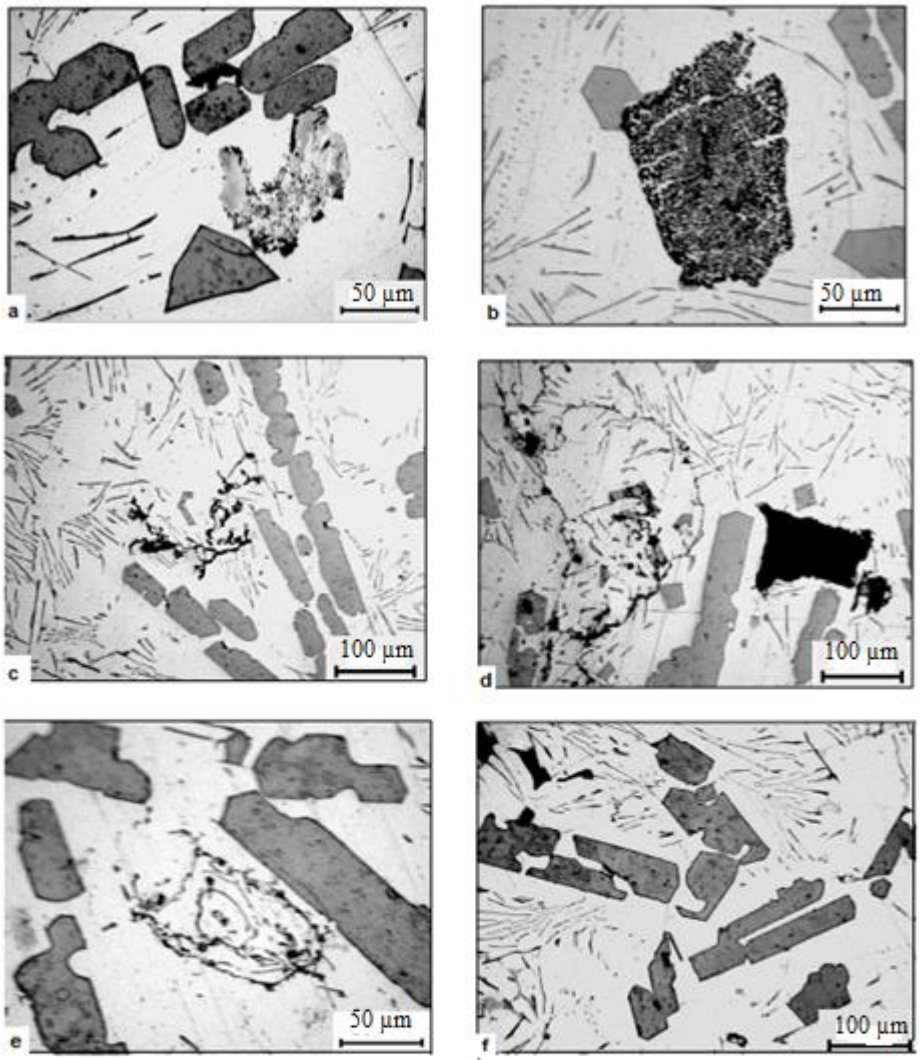

Figure 3. Microstructure of ingots from AlSi10 alloy:
a, b - insoluble salts, c - e oxide films, f - base.

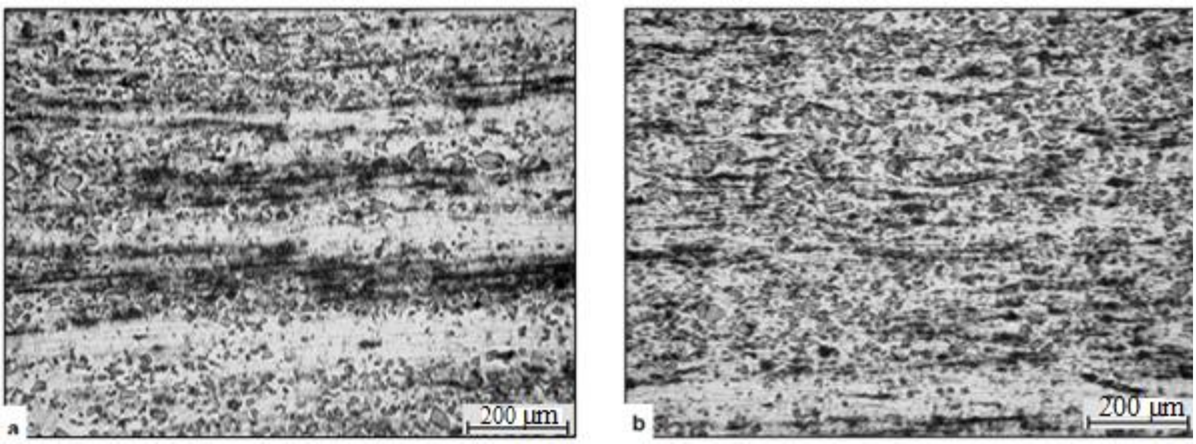

Figure 4. Microstructure of the foundry alloy rod: a - distribution pattern of $TiAl_3$,
b - distribution of TiB_2 particles.

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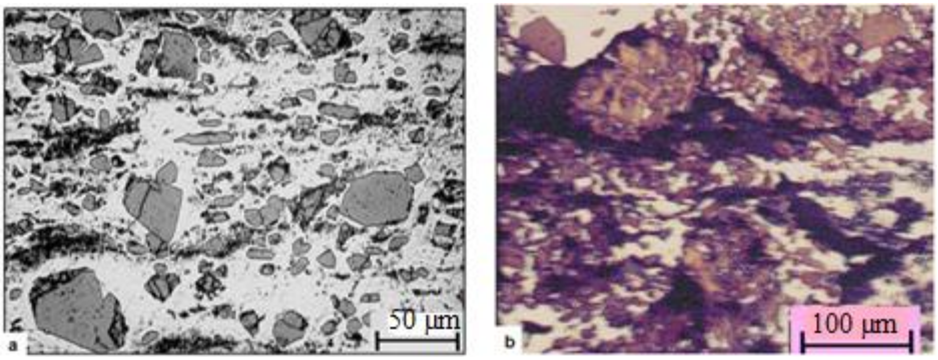

Figure 5. Microstructure sections with clusters of $TiAl_3$ and TiB_2 formations: a - $TiAl_3$ agglomerates, b - $TiAl_3$ agglomerates with TiB_2 particles.

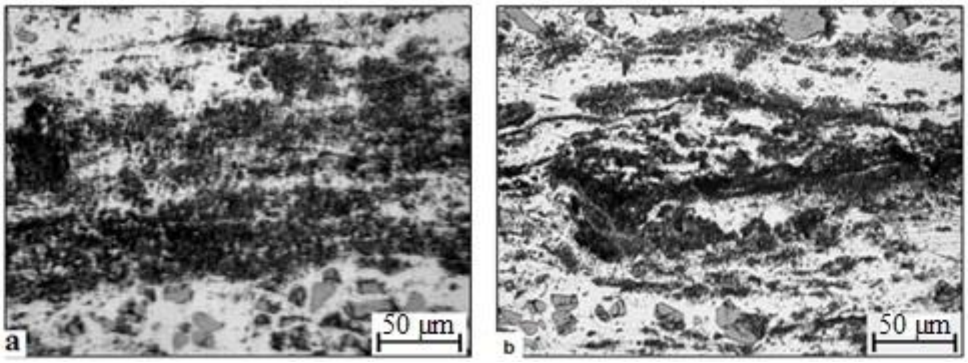

Figure 6. The shape and arrangement of TiB_2 particles: a - TiB_2 in the form of veins, b - coarse clusters of TiB_2.

In addition, unreacted salts and nonmetallic inclusions with sizes of 145 ÷ 250 * 100 μm were found (Figure 7).

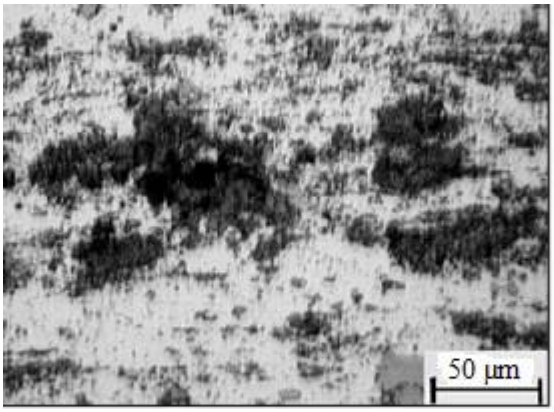

Figure 7. Plot of unreacted salts and non-metallic inclusions.

4. Conclusion

As a result of the studies, it was found that the samples of AlSi10 cast alloy and AlTi5B1 foundry alloys taken from different batches of the same supplier do not provide the necessary quality of castings. This is due to the fact that the presence of a detected number of films, slag and other foreign inclusions located on the surface and in the base metal, cast alloy and foundry alloys, leads to an increase in the number of pores, gas and slag shells. Control methods reveal an increase in the number of rejected castings, which impairs production efficiency due to an increase in material and labor costs.

The company was advised to change the supplier of AlSi10 cast alloy and AlTi5B1 foundry alloys.

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