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S. Polishko, A. Davidjuk, A. Sanin, N. Kalinina, E. Dzhur

Oles Honchar Dnipro National University

ALUMINUM ALLOY MODIFIERS

В даній статті проведено аналіз виплавки алюмінієвого сплаву АК5М, встановлені причини переважного застосування багатофункціонального модифікатора алюмінієвих сплавів в порівнянні з плавленими модифікаторами. Розглянуто види модифікаторів для алюмінієвих сплавів. Також визначено вплив модифікування на підвищення рівня характеристик пластичності алюмінієвого сплаву АК5М. Доведено за допомогою багатофункціональних модифікаторів можна отримати алюмінієвий сплав АК5М з підвищенням рівня пластичності.

Ключові слова: *алюмінієвий сплав АК5М, модифікування, хімічний склад, характеристики пластичності.*

В данной статье проведен анализ выплавки колесной стали марки R7, установлены причины недолегирования колесной стали этой марки, а также рассмотрено влияние модифицирования на стабилизацию химического состава и повышение уровня механических свойств колесной стали марки R7. Доказано при помощи коэффициентов корреляции различных видов, что введение в расплав многофункциональных модификаторов способствует долегированию расплава, стабилизации химического состава и повышению уровня механических свойств колесной стали марки R7.

Ключевые слова: *колесная сталь R7, модифицирование, коэффициент корреляции, химический состав, механические свойства.*

This article dial with analysis of the R7 wheel steel smelting has been carried out, the reasons for the non-alloying of the wheel steel of this brand have been determined, and the influence of the modification on the stabilization of the chemical composition and the increase in the mechanical properties of the R7 wheel steel has been considered. It has been proved with the help of correlation coefficients of various types that the introduction of multifunctional modifiers into the melt promotes alloying of the melt, stabilization of the chemical composition and an increase in the level of mechanical characteristics of the R7 wheel steel.

Key words: *wheel steel R7, modification, coefficient of correlation, chemical composition, mechanical characteristics.*

Introduction. Aluminum is one of the main structural materials used in various industries - aerospace, shipbuilding, metallurgy, mechanical engineering, oil refining, construction, chemical, food, light, etc. This is due to the combination of its distinctive characteristics such as high specific strength for a very low specific mass (2700 kg / m3), the ability to deoxidize and refine steel due to its high affinity for oxygen, hydrogen, and nitrogen. This alloy has high technological properties - mold filling during casting, weldability, ability to deform not only at high and medium, but even at room temperatures, which is associated with a face-centered cubic aluminum lattice.

Also, the structural strength of aluminum alloys substantially depends on the presence of iron and silicon impurities, which in alloys form brittle FeAl3, α phases (α, Al, Fe, Si), β (Al, Fe, Si) and other lamellar or needle forms insoluble in solid solutions. and reduce ductility, fracture toughness, resistance to crack development and corrosion resistance; manganese doping eliminates the influence of harmful impurities due to the formation of a new phase crystallizes in a compact form [1-3].

All this causes practical interest among researchers in the field of aluminum alloys, which makes this research topic relevant.

Formulation of the problem. Determination of alloying and modification methods for aluminum alloy AK5M, as well as the effect of modifiers on the mechanical characteristics of this alloy.

Method of solution and analysis of the results. Melts of aluminum alloys are alloyed mainly with silicon, copper, manganese, magnesium, zinc, zirconium, and also lithium, beryllium, zinc, titanium, germanium, selenium, scandium, strontium. Depending on the set and concentration of alloying elements, aluminum alloys have different properties and applications. According to the manufacturing technology, aluminum alloys are classified into cast and wrought. High heat of melting and heat capacity contribute to slow cooling from the liquid state, this leads to the formation of a coarse-grained structure, but at the same time makes it possible to improve the properties of castings from aluminum and its alloys by modifying, refining and other technological operations.

For aluminum alloys, modifiers of the first kind are used; they delay the growth of grains formed due to the adsorption of surface-active compounds on the faces of the crystals that grow and of the second, providing accelerated crystallization on the ready-made embryos. They can be refractory particles (carbides, nitrides, oxides), the crystal lattice of which is well combined with the aluminum crystal lattice. In the manufacture of ingots and shaped castings from aluminum alloys, it is often used modifiers of the second kind. According to the concentration required to achieve the effect of modification, the elements can be divided into two groups. The first group includes such modifiers; the modifying actions of Ti, Nb, Zr, B, Mo, W are given in descending order. The required number is tenths and hundredths of a percent. The second group includes Mg, Cu, Zn, Fe, Ni, Cr, Mn, Si; these additives need to be introduced in a small amount.

Modifiers of the first kind for aluminum alloys can be surface-active elements with a low melting point and a weak interatomic bond in the solid and liquid states: Li, Na, Ca, Sr, Pb, Be, Zn, Ge, Sn, Se, Sc.

Modifiers of the second kind, primarily titanium, boron, rare-earth metals, zirconium, which form crystallization centers in the form of intermetallic compounds (TiAl3, ZrAl3, BAl3, etc.), carbides, nitrides, oxides were used to grind grain of both casting and deformable alloys.

Of great importance is the modification in the production of shaped castings, when the parameters of the cast structure is a factor determining the quality of the metal. In the manufacture of deformed products with an increase in the degree of deformation, its influence weakens, although it persists on highly deformed metal

(thin sheets, strips). Modification in this case improves manufacturability, dramatically reduces cracking, increases the level and stability of mechanical properties, reduces their anisotropy.

Significant changes in the structure, mechanical and technological properties during the modification, the complex nature of phenomena and processes cause considerable practical interest [4–8].

Therefore, specialists of the department of production technology developed a modifier for processing molten aluminum alloys. An experimental model and an experimental-industrial batch of titanium-based modifiers were manufactured (Fig. 1). Its specific weight is 1.7 times greater than that of aluminum and its alloys. The modifier has a strong effect of grinding the primary grains 12 times and has the ability to increase the ductility of high-strength aluminum alloys. Thus, the relative elongation of the AK5M alloy increased by ~ 17% when modifying with a new modifier. The modifier received a decision of October 23, 2008 on issuing a patent for an invention on application No. a in 2007 00849. This modifier at Hydrosila (Kirovograd) processed 0.5 tons of high-strength aluminum alloy AK5M (Fig. 2). Casting turned tight without defects. The metal structure was characterized by a very fine grain and a low content of harmful impurities, due to which the ductility of casting increased 1.7 times, which is important for high-strength products.

Fig. 1. Appearance modifier for aluminum alloy АК5М

a) **b)**

Fig. 2. Appearance of industrial casting from aluminum alloy АК5М, modified (with the letter “М”) and control serial (with the letter “К”):
a - outer side; b - the inner side

Complex modifiers used in the form of nanopowders. As a result of processing with such modifiers, the hardness, strength and ductility of the AK5M aluminum

alloy treated by them turned out to be significantly higher than the characteristics of alloys treated with fused modifiers. This direction is promising, but little studied.

Conclusions. This article dial with describes the modifiers of the first and second kind, used for aluminum alloy AK5M. It is established that these modifiers are more preferable than modifiers manufactured in a fused manner. In the modified metal using special modifiers, the relative elongation increases by about 17%. This indicates the promise of using special modifiers for the treatment of molten aluminum alloys.

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