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ВЛИЯНИЕ НАГРЕВА АЛЮМИНИЕВОЙ ПРУТКОВОЙ ЛИГАТУРЫ НА ВЕЛИЧИНУ ЧАСТИЦ АЛЮМИНИДА ТИТАНА

Г. Г. Крушенко

Институт вычислительного моделирования СО РАН
Россия, 660036, Красноярск, Академгородок, 50, стр. 44. E-mail: genry@icm.krasn.ru

Металлоизделия машиностроительного профиля, изготовляемые из заготовок, прошедших цикл плавление-кристаллизация, обладающие мелкокристаллической структурой, обладают и более высокими физико-механическими свойствами и эксплуатационными характеристиками по сравнению с изделиями с крупнокристаллической структурой. С целью измельчения структуры в процессе плавки в жидкий металл с помощью лигатур вводят добавки, которые измельчают структуру. К таким лигатурам, в частности, относится и прутковая алюминиево-титановая лигатура, содержащая частицы алюминида титана, являющиеся центрами кристаллизации. Установлено, что нагрев прутка в процессе его введения в жидкий металл приводит к укрупнению частиц алюминида титана, что снижает эффективность измельчения структуры. Поэтому в каждом отдельном случае необходимо оптимизировать скорость введения прутка в расплав.

Ключевые слова: алюминиево-титановая лигатура, частицы алюминида титана, отливки из алюминиевых сплавов.

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THE EFFECT OF THE ALUMINUM MASTER ALLOY HEATING ON THE SIZE OF TITANIUM ALUMINIDE PARTICLES

G. G. Krushenko

Institute of Computational Modeling of the SB RAS
50, building 44 Academgorodok, Krasnoyarsk, 660036, Russia. E-mail: genry@icm.krasn.ru

The metal products of machine-building profile manufactured of billets passed through the cycle of melting-crystallization and having microcrystalline structure, demonstrate higher physical-mechanical properties and exploitation characteristics in comparison with the metal products of macro crystalline structure. During the process of melting the refining structure additives are introduced into liquid metal using master alloys for the aim of the structure refinement. In particular, the similar master alloy is the rod aluminum-titanium master alloy containing titanium aluminide particles which are the crystallization centers. It is determined, that the rod heating in the process of its introducing into the liquid metal leads to enlargement of the titanium aluminide particles, that decreases the efficiency of structure refinement. Therefore, in every particular case, it is necessary to optimize the velocity of rod introducing into liquid metal.

Keywords: aluminum-titanium master alloy, titanium aluminide particles, foundry goods of aluminum alloys

Using as an example information about known Al-Ti- and Al-Ti-B-containing aluminum master alloys [1] it has been shown that their quality has a strong influence on the quality of cast parts of aluminum alloys inoculated with these master alloys. One of the basic quality indices of master alloys is the size and distribution of the particles of inoculating compound.

It is well known that, the addition of a master alloy to molten aluminum results in fine equiaxed structure [2]. So it is known that fine equiaxed structure results in improving the mechanical properties. In addition, the grain size decreases due to the addition of grain refiner and the distribution of secondary phases and porosity is on finer scale and machinability is improved. The improved machinability of the material results in less machining time, longer tool life, lower maintenance costs and reduced machine tool.

In case of aluminum alloys, though there exists many new techniques of grain refinement still addition of grain refiners as nucleant (or inoculant) is the most common and preferred method for refining the grain structure [3]. Melt inoculation with titanium and or boron is the method predominantly used for refining the grain structure.

The inoculants Ti and or B are usually introduced in the form of an aluminum master alloy [4]. The morphological characteristics of titanium aluminide $TiAl_3$ particles in several Al-5Ti-1B (wt- %) master alloys in the form of rods have been investigated using a wide range of microscopical techniques. It has been found that both rough blocky and faceted blocky aluminides are present in such materials and that hexagonal platelets are entrained within these blocky aluminides. Auger spectroscopy and transmission electron diffraction have confirmed that the platelets are diborides. In previous work, it has been suggested that duplex aluminides are particularly effective in promoting grain refinement during solidification. To investigate this, a master alloy containing duplex blocky aluminides was briefly remelted and recast from a range of temperatures. This resulted in the formation of significantly different aluminide types. When the original and remelted alloys were tested in commercial purity aluminum, using standard procedures, it was found that the presence of duplex aluminides does not, in itself, seem to be of great importance in influencing grain refiner efficiency.

This article presents an evaluation of the size and quantity of the particles of titanium aluminide $TiAl_3$ in rod inoculating alloying composition (master alloy) used in continuous casting of ingots of aluminum and aluminum-base alloys. These intermetallic particles in the aluminum master alloy are believed to act as heterogeneous nucleating sites during solidification aluminum and aluminum alloys resulting in grain refinement [5]

The master alloys containing 5,0 % and 3,5 % Ti (rods with a diameter of 9,5 and 8,0 mm, respectively) were investigated. The area titanium aluminide particles was determined by the method random intercepts [6] on specimens of cross sections of the rods (at 200 x) both in the original condition and after immersion of them and holding for 60 sec in molten aluminum (700 ^{0}C) with subsequent hardening in water with ice (0 ^{0}C). The rods were held in molten aluminum for the purpose of establishing the influence of thermal action on the size of the $TiAl_3$ particles in inoculation of the master alloy in the aluminum during casting of ingots. In this case the specimens were prepared on cross sections of the rods at a minimum distance from the boundary of fusion of them.

The analysis of the measurement results shows that in the original rod containing 5,0 % Ti the quantity of titanium aluminide particles with the smallest area (0 – 100 μm^2) is 20,43 %. Heating of the rod causes an increase in the quantity of particles of this size group by 3,6 times (to 74,19 %). A larger quantity of particles (29,04 %) corresponds to this range of sizes in the original rod of the master alloy with 3,5 % Ti than in the first master alloy but heating causes an increase in the quantity of them to a lesser degree (to 46,25 %). In this case it may be seen that the quantity of the finest aluminide particles in the master alloy with 5,0 % Ti is 1,6 times greater than with 3,5 % Ti. It was also established that heating of the rods leads to solution of the coarsest particles. For example, while in the alloy with 5,0 % Ti the largest area of a particle in original rod is 1285,92 μm^2, heating causes a degrease in it by 3,1 times (to 411,84 μm^2) and in the rod of alloy with 3,5 % Ti by 1,3 times (from 1152,00 to 881,28 μm^2).The particles of titanium aluminide are less elongated in the alloy with 5,0 % Ti, which may be seen from an analysis of the ratios of their length to width of their cross sections l/h. For example, while for the alloy with 5,0 % Ti after heating og the rod l/h = 1:5, for the alloy with 3,5 % Ti l/h = 1:25.

The difference in the dimensions of the titanium aluminide particles influenced the degree of refinement of the structure of 70 x 430 mm cross section ingot case by the semicontinuous aluminum casting with a withdrawal rate of 95…100 mm/min. The rods were immersed in the molten metal during flow of it along the runner from the mixer to the mold at a rate providing a titanium content 0,056…0,060 %. In rating the grain structure to GOST 210-73.4.275 on transverse templates of the ingots it was established that without inoculation the number of grains per mm^2 of specimen area is 4,4 in the peripheral zone, 28,1 in the intermediate, and 13,1 in the center. With inoculation of the molten material by master alloy with 5,0 % Ti the number of grains in these zones increases to 47,7; 74,9 and 51,6 per mm^2 respectively, while addition of the master alloy with 3,5 % Ti causes less of an effect of grain refinement, to 38,5; 73,9 and 35,5 per mm^2.

Conclusions.

1. In heating of titanium-containing inoculating rods to the operating temperature by immersion of them in molten aluminum the size of titanium aluminide $TiAl_3$ particles increases, which decreases the inoculation effect.

2. The effect of refinement of the structure of the aluminum in casting of ingots is greater with the use of a rod master alloy with finer and less elongated compact titanium aluminide particles.

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