MODIFICATION OF ALUMINUM WITH AlTi5C0,1

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ABSTRACT

In the paper the modification of aluminium with the use of AlTi5C0,1 primary alloys of varying concentrations from 0,1% to 0,4% wt has been presented. The modified metal was melted in a chamber resistance furnace inside graphite-chamotte crucibles and the effects of modification were evaluated in the investigations of macro- and microstructure and by scanning microscopy (EDX-analysis). The results of these examinations showed the advantageous grain refinement of aluminium and the change of its pillar grains into the structure with equiaxed grains. As it was revealed titanium and carbon were concentrated in the heterogeneous crystallization centra where the particles defined as TiC/Al3Ti were localizied. The trace amounts of the mentioned elements: titanium and carbon in the metal matrix confirm that the effect of grain refinement is due to the modifying influence of titanium and carbon on aluminium during its modification process.

Key words: aluminium, modification.

1. INTRODUCTION

The process of aluminum grain refinement has been widely applied in the processing industry of this metal. It has a very favorable effect on the increase of ingot flexibility to plastic working which contributes to lowering of production costs and improvement of production efficiency.

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In the process of aluminum grain refinement first alloys Al-Ti-B are used, however, their modifying effect has not been explained explicitly. Some authors (1) claim that as the result of TiB₂ interaction a metastable compound (Al, Ti)B₂ forms from the master alloy of B and liquid aluminum. The released titanium forms the Al₃Ti phase with aluminum which covers boride (Al, Ti)B₂ and causes nucleation of aluminum crystals. M.M. Guzowski and co-authors (2) state that the boride TiB₂ that is present in the master alloy Al-Ti-B brings about nucleation of Al₃Ti phase, which then causes nucleation of aluminum. L. Backerund (3,4) is of a similar opinion, but on the other hand claims, that atoms of titanium on the surface of TiB₂ particles are replaced with atoms of aluminum, whereas the released titanium forms on the surface of boride particles a phase stratum of Al₃Ti, which performs nucleation of aluminum crystals.

Carbide theory is valid at least if TiC particles are already present in the melt (via Al-Ti-C master alloy addition) before the melt begins to solidify (5). The new Al-Ti-C master alloys score over the commercial Al-Ti-B master alloy due to the much smaller size of TiC- agglomerations in the former, than the TiB₂- agglomerations in commercial Al-Ti-B master alloys. Thus, the Al-Ti-C master alloys seem to have a good future for application in the industry for producing high quality products like foils, lithographic sheets and aircraft plates (5).

2. DESCRIPTION OF THE TESTS

2.1. Modification

Technical aluminum A1 in pig sows of the chemical constitution of: according to PN-(Polish Standards) 79/H-82160 was used in the tests. Melting of the metal was done in electric chamber resistance furnace with the use of graphite-chamotte crucibles. Slag protective coating was not used in the melting process.

Modification treatments were performed after metal melt had been overheated up to the temperature of 993K (720°C). As a modifying additive first alloy A1Ti₅C₀.₁ was used in the quantity of: 0,1%; 0,2%; 0,3% in relation to the metallic charge mass (sand).

In order to evaluate effects of aluminum modification the workers cast samples of rolls in metal mould. The samples had the diameter of 35 mm and the height of 60 mm, which were designed for testing metal structure in the initial state as well as in the state under modification.

2.2. Examinations of structure

Samples of aluminum designed for macrostructure evaluation were etched (digested) with Tucker reagent. The time of etching (digestion) was 20s. The macrostructure of the aluminum samples under examination is illustrated in diagrams 1 to 4. Aluminum in a non-modified state (fig. 1) shows structure of columnar (pillar) crystals in the outer sphere of the sample. The internal sphere of the sample
shows equiaxial grains of the diameter of 1,2 mm. The modification treatment caused change of the aluminum structure into equiaxial grains (fig. 2-4). The average grain size with addition of 0,1% modifier was 0,65 mm (fig. 2), whereas with the 0,2% modifier it decreased to 0,45 mm (fig. 3). Increase of the amount of modifier to 0,3% and 0,4% caused further change in aluminum grain refinement to 0,2 mm (fig. 4).

2.3. Examination of heterogeneous nuclei of crystallization

Examination of heterogeneous nuclei of crystallization in the aluminum under crystallization was done in the Institute of Physical Metallurgy at the Technical University of Berlin. The research workers used scanning electron microscope with energy-dispersion X-ray spectrometer type DSM950 “Zeiss”, complete with the QX200 “Link” analyzer. The methodology of the examinations is discussed in detail in the paper (6).

The results of the tests performed are illustrated in figures 5-7. The figure 5 presents nucleus of crystallization in the nucleus of aluminum grain. Figure 6 shows appearance of the nucleus of crystallization of a complex constitution. Figure 7 presents energy spectra of matrix (fig. 7c) as well as particular parts of the crystallization nucleus under analysis (fig. 7a and b). As the figures show, titanium and boron concentrate in particles forming heterogeneous nucleus of crystallization with a vestigial fraction of those elements in the metal matrix (fig. 7a,b). Aluminum, titanium and boron present in the nucleus of crystallization prove that the heterogeneous aluminum crystallization is generated by double particles TiC/Al3Ti. In some zones of those particles there are also vestigial quantities of other elements.

3. Conclusions

Examinations of aluminum modification with variable additions of first alloy AlTi5C0.1 proved that a good modification effect is ensured by addition of the modifier in the quantity of 0,3%. As the result of modification treatment a total change of columnar (pillar) structure into tiny equiaxial grains occurred in the samples of the aluminum under examination. The examinations performed with the scanning microscope equipped with energy-dispersion X-ray attachment proved that heterogeneous nuclei of crystallization in the aluminum undergoing modification were compound (complex) particles TiC/Al3Ti.
Fig. 1. Aluminum macrostructure without modification

Fig. 2. Macrostructure of aluminum modified with addition of 0.1% AlTi₆C₀.₁

Fig. 3. Macrostructure of aluminum modified with 0.2% AlTi₅C₀.₁

Fig. 4. Macrostructure of aluminum modified with 0.3% AlTi₅C₀.₁
Fig. 5 Aluminum grain modified with 0.4% AlTi5C0.1

Fig. 6 Crystallization nucleus in aluminum modified with 0.4% AlTi5C0.1
Probe 13, AITi5C0,1
EDX-Analyse Kornzentrum

Probe 13, AITi5C0,1
EDX-Analyse Teilchen rechts neben Kornzentrum
Fig. 7 Characteristic spectrum of matrix and the nucleus of crystallization in aluminum modified with addition of 0.4% AlTi5C0.1: a) position 1  b) position 2  c) matrix.
MODYFIKACJA ALUMINIUM DODATKIEM AlTi5C0,1

STRESZCZENIE

W pracy przedstawiono wyniki badań nad modyfikacją technicznego aluminium dodatkiem AlTi5C0,1 w ilości 0,1–0,4%. Badania wykazały, że zadowalający efekt rozdrobnienia ziarn aluminium zapewnia dodatek AlTi5C0,1 w ilości 0,2–0,3% przy którym średnia średnica ziarna zmniejsza się do 0,2 mm. Metodą enero-dyspersyjnej analizy rentgenowskiej stwierdzono, że heterogeniczne zarodkowanie w modyfikowanym aluminium wywołują cząstki faz TiC oraz Al3Ti.

Recenzował: prof. zw. dr hab. inż. Stanisław Pietrowski