Influence of carbon forms on the synthesis of highly dispersed titanium carbide by combustion in aluminum melt

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Cast aluminum-matrix composite materials reinforced with a dispersed phase of titanium carbide have considerable strength with a small mass and a high value of the elastic modulus and therefore belong to the group of the most promising materials. Traditionally, they are manufactured according to the ex-situ methods, when the carbide phase particles are manufactured separately and only then introduced into the aluminum melt. However, in the case of highly dispersed (less than 1 μm) ceramic particles, this is difficult to do because of their tendency to agglomeration and poor wetting by melt, as well as contamination with impurities. More promising are the in-situ methods, which implie the formation of a carbide phase directly in the matrix. For this purpose, the use of a simple resource-saving method of self-propagating high-temperature synthesis (SHS), which is based on an exothermic combustion reaction between titanium and carbon powders Ti+C=TiC, is of undoubted interest and, as shown in numerous studies [1,2], can be successfully implemented in a matrix aluminum melt. However, most studies using SHS are carried out using traditional forms of carbon: carbon black and, in some cases, graphite and charcoal [3]. At the same time, new polymorphic modifications of carbon materials, including nanostructured ones, have been discovered in recent years. In this regard, the purpose of this work was to compare the effect of various types of carbon forms on the formation of highly dispersed titanium carbide during the implementation of SHS in Al and Al-5%Cu melts. In the course of the study, the following carbon forms were studied: activated carbon of BAU and AG-2 grades, colloidal graphite of C-1grade, carbon black of T-900 and P-701 grades, carbon multilayer nanotubes (CNTs) of "Taunit" grade.

Experimental studies have shown that all the considered forms of carbon are reactive and, when a mixture of Ti+C powders is introduced into an aluminum melt at a temperature of 900 ° C, they lead to a combustion reaction that can result in the formation of particles of both the target phase TiC and the side phases Al_3Ti and Al_4C_3. However, a full-fledged SHS reaction with the formation of highly dispersed particles of one target phase of block-shaped titanium carbide without impurities of side phases was recorded only in cases of the use of P-701 carbon black in the Al melt and the use of P-701 and CNT "Taunit" in the melt of the Al-5%Cu alloy. In general, the results of experimental studies show that the use of carbon forms such as activated carbon, colloidal graphite and carbon nanotubes does not give advantages over the use of carbon black for SHS of titanium carbide in the melt of aluminum and its alloys, therefore, for practical use in the production of aluminum matrix composites of the Al-TiC system by the SHS method, the use of carbon black is recommended.

References

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