APPLICATION OF SHS AUXILIARY REACTION OF TITANIUM CARBIDE FOR INTRODUCTION OF AlN NANOPARTICLES INTO ALUMINUM MELT[1]

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Due to a low weight, excellent mechanical properties, thermodynamic and dimensional stability at high temperatures, aluminum matrix composites reinforced with AlN nanoparticles are promising for use in aerospace, automotive and defense technology [1]. However, due to a high cost of AlN nanopowder, as well as a high cost and other disadvantages of existing solid-phase and liquid-phase methods of manufacturing Al-AlN nanocomposites, there is currently no industrial production of these nanocomposites [1].

In this regard, the study of the possibility of using the achievements of a simple energy-saving powder technology based on the process of self-propagating high-temperature synthesis (SHS) is of great interest for manufacturing Al-AlN nanocomposites [2]. Firstly, the cost of nitride nanopowders, obtained by SHS azide technology (SHS-Az), is about 2-3 times lower than the cost of similar nanopowders obtained by plasma chemical synthesis. Secondly, the SHS process creates a high temperature and thus contributes to wetting of ceramic nanoparticles and their insertion into the matrix. Thirdly, the synthesis of inexpensive reinforcing ceramic nanoparticles can be carried out directly in the matrix, ensuring their good adhesion to the matrix.

The papers [2-4] present the results of our previous studies on the ex-situ fabrication of Al-AlN nanocomposites using different methods of introduction into the melt of aluminum (or its alloys) a nanopowder of SHS-Az brand of composition (AlN-35wt.%Na_3AlF_6), where a by-product Na_3AlF_6 (kryolite) played the role of flux. Direct mixing of AlN nanopowder in a bulk form in the aluminium melt did not lead to success due to the poor wettability of aluminium nanopowder with liquid Al and clumping the nanoparticles in the agglomerates. The use of pressed briquettes of nanopowdery master alloy of Cu-4%(AlN-35%Na_3AlF_6) composition allowed us to obtain a cast composite of the calculated composition of Al-1.2% Cu-0.035%AlN. Composite master alloy, obtained by melting the flux carnallite $KCl \cdot MgCl_2$ with nanopowder (AlN-35%Na_3AlF_6), allowed us to introduce a maximum of 1%AlN into the matrix of alloy Al6%Mg. Nanocomposite with content up to 4%AlN was able to be obtained by mixing nanopowder (Al-35%Na_3AlF_6) in Al5%Cu alloy in the solid-liquid state (semi-solid process).

In the present work, an attempt was made to increase the content of AlN reinforcing phase in aluminum matrix nanocomposite. The auxiliary reaction of SHS of titanium carbide Ti+C=TiC with adiabatic temperature of 3017°C was used for this purpose. Charge (Ti+C) with addition of different content of nanopowder (Al-35% Na_3AlF_6) was mixed, pressed into briquettes and injected into the melt of aluminum with a temperature of 900°C. It was determined whether the SHS reaction was initiated or not, how fully it proceeded, whether the inclusions of the unreacted charge remained, how evenly the reinforcing phases of AlN and TiC were distributed in the solidified aluminum matrix, what were the sizes and morphology of the particles AlN and TiC. As a result, it was possible to obtain a hybrid nanocomposite of the calculated composition of Al-7.7%AlN-19%TiC. The resulting nanocomposite sample had a fine-grained uniform dense structure, there were no shells, nonmetallic inclusions, pores and cracks, and its hardness was 64 HB.

Thus, using a combination of ex-situ approach (introduction of pre-synthesized AlN nanopowder into the matrix melt) and in-situ approach (combustion synthesis of TiC particles in the matrix melt during composite fabrication), it was possible to increase the content of AlN nanoparticles to 7.7% and to obtain a cast hybrid aluminum matrix nanocomposite with two reinforcing phases (AlN and TiC). It should be noted that the hybrid reinforcement of aluminum alloys with mixtures of ceramic particles of different types has been successfully used and allows using the advantages of different particles [2, 5].

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