SHS OF ROUNDED NI-AL ALLOY POWDERS FOR ADDITIVE TECHNOLOGIES

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Intermetallic alloys based on NiAl, Ni_3Al are widely used in thermal power engineering and aerospace engineering due to the high strength and oxidative resistance of materials at temperatures up to 1300÷1400°C. Progressive methods for producing parts from these alloys are additive technologies (AT), based on the sequential melting of primary powder material layer by layer according to a given digital model using a high-energy source - selective laser melting, electron beam melting, direct metal deposition [1]. Primary materials for AT are subject to special requirements: spherical/near-spherical shape of granules, narrow particle fractions (usually less than 100μm), high bulk density and fluidity of the powder, minimal oxygen impurities [2]. SHS is one of the most energy-efficient methods for the synthesis of intermetallic compounds of various compositions. However, in most cases, when grinding the resulting products, powders with irregular angular particle shapes are formed, which for use in AT require an additional spheroidization procedure in a gas plasma flow [3].

In this work, the possibilities of direct spheroidization of synthesized Ni-Al alloys in an SHS wave are studied using the influence of fluid-forming chemical active additives $CaCO_3$, $Ca(OH)_2$ in Ni+(16÷20wt.%)Al reaction mixtures. The alloys were prepared using sequential procedures: SHS – grinding of the product – washing in a 10% HCl solution and distilled water. At an additive concentration β>7÷10%, the formation of predominantly round granules with a size of less than 100μm and a sphericity of ~0.7 is observed. They consist of a composition of aluminides: $L1_2Ni_3Al$, B2NiAl, $L1_0Ni$. With increasing dispersion of the components and porosity of the reaction mixtures, the mass fraction of round microgranules increases, reaching a value of 93%. In terms of fluidity characteristics and oxygen impurity content, the synthesized alloys (24÷26s/50g; 0.07÷0.12wt.%O) are close to spherical Ni-Al-Cr-Co-Hf alloys (20s/50g; 0.13wt.%O), which were previously obtained using the following procedures: SHS – grinding – plasma spheroization – washing [3]. The probable mechanism of structuring of Ni-Al alloys in a combustion wave includes successive stages: (1) synthesis and sintering of primary grains of intermetallic compounds in places of short-term outbreaks of local reaction sites (~10ms); (2) maximum heating of primary grains with subsequent merging of melts into isolated droplets under the action of surface forces; (3) agglomeration of droplets in the phase of thermal relaxation of the foci. Round alloy particles are formed under the influence of the following factors: (*) – simultaneous reactions of synthesis of intermetallic compounds and partial oxidation of aluminum by thermolysis products $CaCO_3/Ca(OH)_2$ – CO_2/H_2O at stage (2) and (**) – low rate of droplet agglomeration, limited by layers of oxide phases and the pressure of exhaust gases between the droplets at stage (3).

A test SLM process of surfacing a synthesized alloy with a granule size of 40÷63μm and an average composition of Ni+14.3wt.%Al was carried out in an Ar atmosphere. An almost pore-free material sample 8x8x2mm was obtained, with an average composition of Ni+13.6wt.%Al, close to the original alloy.

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