

SHS OF POROUS NI-AL ALLOYS IN A REACTION MEDIUM WITH A FLUID-FORMING COMPONENT*

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The SHS process is one of the most economical technologies for producing porous Ni-Al alloys with a wide range of phase composition (NiAl - Ni_3Al) and transport pore size ($0.01\div 2\text{mm}$). Such materials are of great practical interest when used in corrosion-resistant filters, catalysts, solid oxide fuel cells, and heat-resistant radiation burners. The synthesis of the most coarsely porous alloys is carried out in the presence of fluid-forming components of the reaction system, such as CaCO_3 , $\text{Ca}(\text{OH})_2$. Fluid formers (F) simultaneously act as a melting point for refractory oxide impurities and as a system gas source. The detailed mechanism of action of the F-components has not been fully elucidated.

In this work, a comprehensive study of the structural-thermal dynamics of the synthesis of materials during the propagation of the SHS wave in highly porous Ni-Al powder mixtures with an F-component was carried out. A wide range of experimental methods has been applied, including high-speed video filming with laser illumination, thermocouple and pyrometric measurements, quenching of reaction processes and physicochemical analysis of synthesis products.

Using the example of the compositions $(\text{Ni}+20\text{wt\%Al})+x\text{CaCO}_3$, the main features of the reaction

* At $x = 0$, the formation of the target alloy proceeds through successive stages:

1 – nucleation of primary alloy particles ($\approx 0.1\text{ mm}$) by means of liquid-phase reaction coalescence of powder components in the fixed preheating layer of the mixture ($\approx 0.2\text{ mm}$);

2 – sintering of primary particles into a finely porous skeleton of the final product;

** At $x > 0$, the preheating layer of the powder mixture passes into a pseudo-boiling state and expands to 2 mm. Pseudo-boiling of the system is stimulated by the primary particles of the alloy, which are generated in the upper part of the layer, move deep into the mixture and cause thermal gasification of the F-component. The reason for particle motion is capillary drift associated with exothermic reactions on the particle surface. After incubation cycles lasting up to 1 s, explosive agglomeration of the mixture and primary particles periodically occurs with the formation of secondary alloy particles up to 2 mm in size. The latter are sintered into a large-pore skeleton. The internal structure of the material has characteristic cells formed by the boundaries of primary particles. In the course of explosive agglomeration, pulsed heating of particles is observed with the achievement of a temperature that can exceed the base combustion temperature by 250°C . With an increase in the concentration of the F-component and the initial porosity of the system, the amplitude of explosive heating and the size of the secondary particles of the alloy increase.

The data obtained expand the existing understanding of the mechanisms of SHS, as well as complement the ways to control and modify the properties of the synthesized alloys for practical applications.

* The work was supported by the Russian Science Foundation under grant No. 21-79-10445.