MATHEMATICAL MODEL OF HIGH-TEMPERATURE SYNTHESIS OF THE NI3AL INTERMETALLIC COMPOUND IN THE MODE OF THE POWDER PRESSING THERMAL EXPLOSION OF THE STEHCHIOMETRIC COMPOSITION INITIAL ELEMENTS

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The intermetallic compound Ni_3Al (γ'-phase, ordered solid solution) is the main strengthening phase of modern nickel superalloys, the behavior of which under load largely determines the service life of alloys as a whole. The efficiency effect increase of the use of the intermetallic compound Ni_3Al as the main component of high-temperature alloys is limited by its high tendency to brittle failure. Polycrystalline Ni_3Al breaks along the grain boundaries, at both low and high temperatures. Therefore, one of the topical research areas in the field of developing new and improving existing intermetallic high-temperature alloys is to investigate the possibilities of increasing the strength and ductility of the Ni_3Al compound. Increasing the strength and, accordingly, the plasticity of the intermetallic compound is possible by improving existing or applying new technological processes for its production. The high-temperature synthesis method of intermetallide in a powder mixture of initial elements of a given composition in the regime of a powder billet thermal explosion is the one of the latter. The thermophysical conditions of the synthesis bulk reaction of an intermetallic compound in a powder mixture of pure elements provide the synchronism of the phase transformations course in the entire volume of the powder perform. A unique feature of the thermal explosion process is the ability to consolidate individual structural fragments of the synthesis reaction products when the homogeneous structural-phase state reaches the thermoreacting system by applying an external pressure and forming a homogeneous structural phase state in the final product.

To initiate a bulk exothermic reaction (thermal explosion) in a powder blank, various methods of heating the preform are used. The general principle of heating the preform before autoignition is to minimize the temperature gradients in the volume of the preform under controlled heating conditions. To the fullest extent, the latter is achieved by heating the compact from the original powder mixture in a steel mold-reactor with high-frequency currents. The heating of the mold-reactor walls under controlled conditions to heat the powder compact before self-ignition, followed by a power seal of the high-temperature synthesis product.

The mathematical model of high-temperature synthesis of intermetallic in the thermal explosion regime of a powder compact is proposed. The model takes into account all stages of heating the mixture in a steel cylindrical mold.

The model consists of two parts. It’s electromagnetic and thermal.

From the solution of the electromagnetic problem, the dependence of the heater temperature on the strength of the magnetic field was obtained. With a body with this temperature, the heat transfer of the reagent is carried out by thermal radiation, for which the following part of the problem is needed. Using this dependence, we solve the thermal problem of initiating the reaction in a powder mixture in a cylindrical mold. The problem includes the equation of thermal conductivity for a mixture of powders and a steel cylindrical mold, takes into account the heating due to thermal radiation from the inductor and the chemical reaction of formation of the final product of Ni_3Al.

The problem was solved numerically. The model makes it possible to study not only temperature changes in space and time, but also to investigate in dynamics the influence of the heating conditions and the properties of the powder mixture on the thermal explosion modes in this technological process. The model allows for taking into account the dependence of thermophysical properties on temperature and composition.