Nanostructural Mechanically Alloyed Powdersf Gasometrical Spraying Method and Coatings of Them

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Classical powders for thermal spraying are multicomponent systems, complicated in their chemical composition, containing, in most cases, a significant amount of scarce elements. Industrial production technologies require sophisticated and expensive equipment, and the organization of their production demands significant capital investments, chemical methods, besides, are environmentally hazardous.

A progressive way of producing powder materials that provide acquisition of protective coatings with highly operating properties, is the reactionary mechanical alloying; when the basic burden manufactured, there appears interaction between basic substances in mechanoreactor (mechanochemical synthesis). This technology, which is easy and universal, can produce nanostructured, dispersion-strengthened powders for gasometrical coatings of various functional purposes ,and it creates a considerable basis for making economically alloyed category of materials as well.

The authors of this work have developed a wide nomenclatorial range of powder materials, used for obtainment of gasometrical coatings of various purposes and possessing a unique structure and properties. The created materials make it possible to get a wide range of economically alloyed cheap powders for gasometrical anti-wear, heat-resistant and temperature-resistant coatings for various applications: for hardening of tools and constructive items that operate at high loads in heavy wear – X, X3, X6, X9, X3-DS ; corrosion-resistant – 12X18H10, 15X18H10T, 15X18H10T-DS; for renovation of the structural items for general purpose – 15X2H4 . The field of application of the developed nickel powders resembles the counterparts , they are promising for high-temperature corrosion-resistant refractory coatings , whose operating temperature may exceed 0.7 mp. Iron-aluminum alloys are promising materials , which coatings possess high hardness, wear resistance, good workability at higher temperatures in various aggressive gas environments. The basis of mechanically plated composite ceramic powder is a classical batch consisting of aluminum and titanium oxides, alloying components such as nickel and aluminum.

It was found during treatment in mechanoreactor that when processed in powder compositions containing oxygen, carbon, on the one hand, and metals that have high affinity to these elements, on the other, there occur mechanically activated phase transformations that lead to the formation of solid solutions of oxides and carbides, or intermediates of their bonds, and providing a dispersive and dispersed hardening that is preserved when heated to temperatures up to 1000 °C.

Formation of the matrix structure when the batch on the basis of metals being worked , has the same mechanism and occurs as a result of dynamic recrystallization process. The product of mechanical alloying is a granular composition with an average particle size of 30-60 microns. The mechanically alloyed powders are characterized by a homogeneous elements’ distribution , nanocrystalline structure with a grain size of its basis less than 100 nm consisting of sub-grains of less than 50 nm, stabilized by nano-sized inclusions of hardening phases ; they are unbalanced systems, in which, together with the balanced phases, there exist intermediate bonds and basic alloying components .

The product of mechanical batch alloying based on oxide ceramic containing up to 15 % of metal constituent (Ni and/or Al), is metallized metal ceramics with an average size of its powder particles of 3-5 microns. In the processing of handling there flow phase and structural transformation which cause the formation of a complex oxide - Al2TiO5 and intermetallic Ni3 (Al, Ti), that reduces the amount of the basic components - nickel and titanium oxide in 2 times . There is also a change in the lattice parameters of the phase α-Al2O3. Manufacturing the batch in mechanoreactor causes the increase in density dislocation approximately in 5 times and the decrease of CSR in 2.5 times.

The studies showed that the steel powders of pearlite , pearlite- martensite and martensite classes as a result of multiple shock actions working bodies on the particles that cause plastic deformation, the heating of microvolumes with their forthcoming cooling, experiences the phase of framework transformation $Fe_{\alpha} + Fe_3C \rightarrow Fe_{\gamma}(C) \rightarrow Fe_{\alpha}(C)$, the final product of which is the unbalanced phase , similar to martensite with a thickness of the plates of a few atomic parameters . The hardening caused by martensitic transformation, is removed when heated to of 500-600 °C .

The annealing of mechanically alloyed compositions leads to transformations approximating phase composition to its the equilibrium, but not reaching it. The presence of the majority of the equilibrium phases is detected during thermal exposure above 700 °C. After annealing, the composite powders retain the nanodimensional type of structure, they become heat-resistant and in their hardness in the temperature range of 20-1000 °C they significantly exceed the counterparts , due to the complex nature of their hardening , combining solid solution , dispersion , grain boundary and dispersed with the decisive role of the latter two . This allows one to make scientifically substantiated conclusions on the prospects of the reaction of mechanical alloying technology of obtaining powders for gasometrical wear-and- heat-resistant coatings that operatie in harsh temperature and force conditions.

The optimal values of the mechanical alloying process factors in a vibratory mill that provide maximum hardness of the composite powders based on iron , nickel and metal for gasometrical coatings , regardless of their composition, are practically the same and are found in the following range: the acceleration of working bodies – 135-145 м·sec^{-2}, working media and the feedstock – 10-12, the degree of filling the milling cell with working bodies – 70-80 %, the processing time in mechanoreactor – 8-10 hours.

According to the results of experimental research the meaning of the factors of the plasma spraying mechanically alloyed powders based on iron and nickel that provide maximum wear resistance of the coatings are: current strength – 240-250 A, voltage – 190-200 V, power – 45-49 kW, spraying range – 250-300 mm, tube’s diameter – 2.0-2.6 mm, the distance from the nozzle to the outlet – 4.5 mm. Optimal conditions for obtaining composite powder coatings based on aluminum oxide are in the following range: spraying distance – 100-150 mm diameter tubes – 1,4-2,0 mm, the distance from the nozzle to the outlet – 6-7 mm.

The results of the study have become the scientific basis for the development of mechanically alloyed nanostructured composite powders’ manufacturing processes and the production from them the coatings using plasma spraying. Besides, these results have become the bases for design and creation of the production area for their implementation ,where there have been made 12 business bargains ordered by Russian and Belarusian enterprises during the years of 2006-2010.The optimal wear-resistant composition of the coating is 1.3-2.1 times higher than that of the counterparts.