TRIBOTECHNICAL POWDER BRONZES MADE BY SHS SINTERING

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An analytical survey is presented on the scope for using self-propagating high-temperature synthesis for sintering tribotechnical materials and components, particularly ones based on powder bronzes. The major macrokinetic characteristics of the burning have been established, as have the working properties of the materials.

Powder composite materials have the best antifriction characteristics [1, 2], but when they are exposed to high temperatures and gases during sintering, the functional properties of the anti-seize and lubricating components tend to be lost, and the wear resistance and self-lubrication are reduced. Also, ecologically undesirable gases and powders have to be used, which require complications in the equipment, such as sealed muffle furnaces, reliable ventilation, prevention of explosion hazards, and so on. This all increases the cost of the components.

An attempt has therefore been made to define alternative rapid and ecologically acceptable methods of making these powder composites for tribotechnical purposes. In particular, attention was given to comparatively new methods in self-propagating high-temperature synthesis SHS [3, 4], in which a blank pressed from powders on contact with a hot electric spiral ignites at a specific place and the burning front propagates throughout the volume. The local temperature before the start of burning is low, usually not more than 0.4-0.6 of the melting point of the SHS products. The maximum burning temperatures also may not exceed the melting point, as the temperature conditions in SHS are controllable and are dependent on the concentrations of the initiating components, the preheating temperature in the oven, and so on.

The physicochemical essence of SHS is based on the exothermic reactions between the components and the gas. To obtain products corresponding to a particular chemical formula (intermetallides, borides, carbides, nitrides, or chalcogenides) and combinations of them, the components are taken in strictly stoichiometric ratios in accordance with the reaction equations. The heat of formation of the products is usually low, so the reactions involve excess heat release, which is sufficient for the sintering into crystallites, conglomerates, and components of finished shape.

Most SHS products are formed in approximately this way [5]: intermetallides, carbides, nitrides, chalcogenides, and combinations of them. They are usually obtained as sinters, which are crushed and sieved as powders, which are then used for sintering the composite materials. SHS methods are used in a wide range of implantation materials for medical purposes such as the heads of hip joints, tooth prostheses, and so on [6, 7]. Unfortunately, SHS processes have hardly been used to make engineering components of ready-made shape.

If the exothermic effect from the reactions is too large, the powders melt and the SHS products crystallize as wear-resistant coatings [8], large-size blanks, cutting materials, plates for cutters, and so on [9, 10]. Some such SHS processes occur in air. In such a case, one uses a complicated mixture containing metal oxides, reducing metals and carbide-forming additives. Part of the melted slag may be difficult to remove from the coatings or blanks, which tend to lose their shape and size because of the liquid phase. This requires additional compression in the hot state and mechanical processing with considerable wastage. There are several patents on SHS sintering in air applied to metal binders for diamond tools [10-12]. During the burning, the metal powders purify themselves from oxides and other impurities by sublimation.

Can one combine operations in powder metallurgy to make components by means of fast SHS processes without protecting reducing gases in the air in an ordinary furnace? Is there any reduction in the strength and tribotechnical parameters for materials sintered in air? There are no clear-cut answers to these questions in the technical literature. We tried to answer them in the first stage of this research. The purposes were to check the suitability of SHS for sintering metal powders; to research exothermic SHS sintering of the scarcest tribotechnical materials based on copper which in composition
correspond to industrial grades of tin-free bronzes; to examine the basic macrokinetic characteristics of powder-alloy burning for copper-base materials, including the working properties; and to determine the main technological parameters of SHS sintering for materials of optimal composition.

We gave particular attention to bronzes because the widest range of friction units consists of sliding bearing sleeves made of copper-base alloys, which often contain intermetallides, carbides, and anti-seizure additives.

A major condition in devising optimal compositions for powder bronzes and composites based on them is to omit the very scarce tin without any deterioration in the working characteristics. An important point is that our alternative sintering technologies are simple as regards equipment and cheaper than traditional ones, while the new materials retain their familiar advantages such as porosity, self-lubrication, lack of change in shape and size after sintering, ease of size adjustment, and so on.