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для новых технологий и надежных конструкций»**

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MECHANICAL ACTIVATION OF SELF-PROPAGATING HIGH TEMPERATURE SYNTHESIS IN TITANIUM, CARBON BLACK AND IRON-BASED ALLOY POWDER MIXTURES

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Metal matrix composites TiC-metal binder are of great interest as hard and wear-resistant coating materials. The best and well-known method to create that kind of composites is self-propagating high temperature synthesis (SHS). Binders in these composites act as thermally inert additives and from specific amount, they start to block the reaction initiation. However, the presence of a large amount of binder makes possible to obtain a composite structure strengthened by a finely dispersed carbide particles, which greatly improves the homogeneity and mechanical properties of the composite [1]. The possibility of the synthesis on samples with high inert binder content can be provided by reaction mixtures mechanical activation (MA) [2-4].

Powder mixtures of titanium (ТПМ-8, <160 μm , 99,4 %), carbon black (П-803, 0.3 μm), high-speed steel (HSS, < 56 μm), high chromium cast iron (HCCI, HCCI Russian trademark, < 56 μm) are used. The content of titanium and carbon in the reaction mixtures corresponded to the equiatomic composition of titanium carbide. Powder mixtures were prepared by dry mixing for 4 hours. Synthesis was carried out in air-tight reactor in argon gas medium under 0.5 bar excess pressure.

The mechanical activation of powder mixtures was carried out in a planetary mill "Activator - 2S" with a ball/powder ratio of 20/1. The planetary disk rotation speed varied to receive different intensities of mechanical activation: high (960 rpm - 88g) and medium (720 rpm - 49g) load.

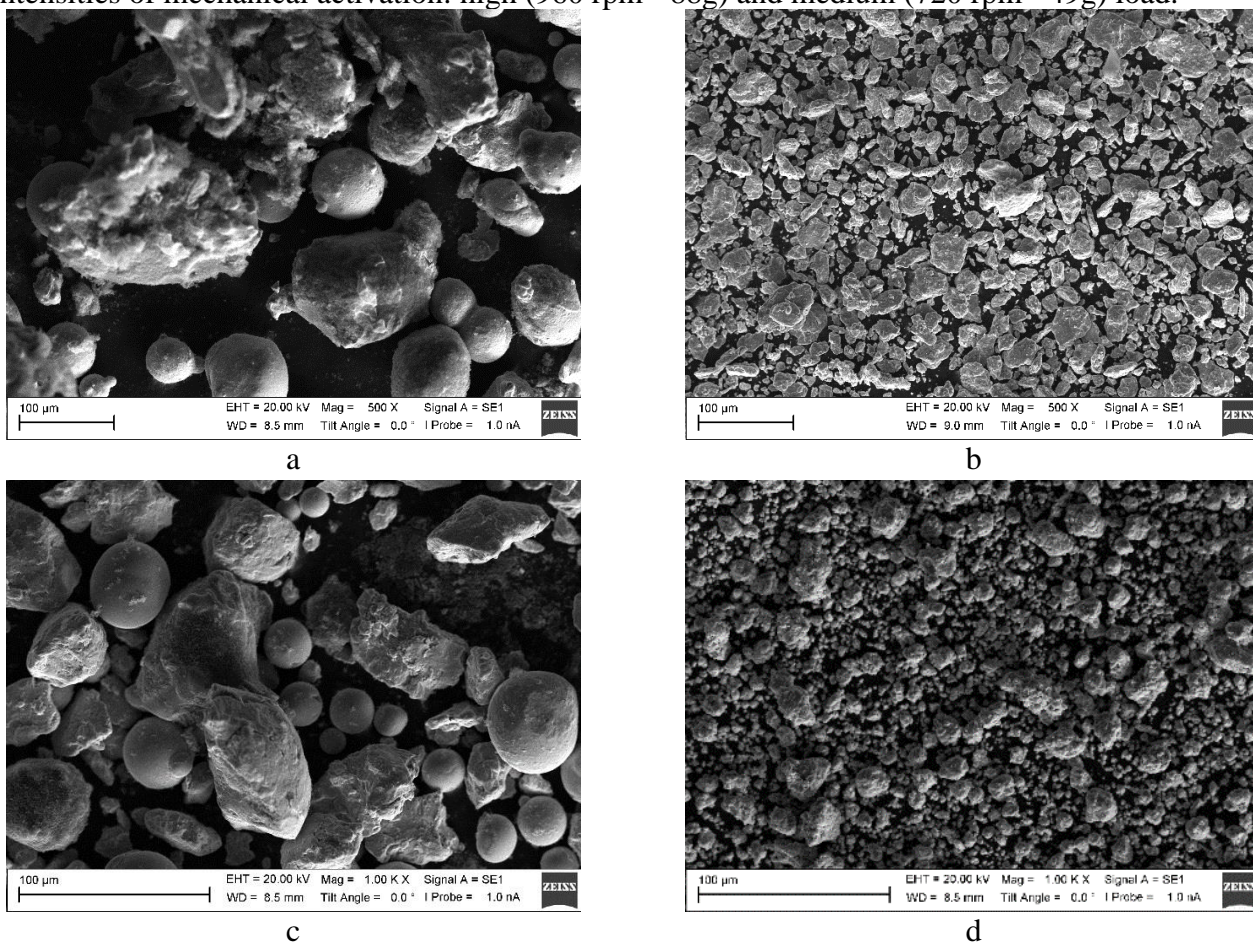


Fig 1. Structures of powder mixture before and after MA: a) Ti+C+60 vol % HSS b) Ti+C+60 vol % HSS MA (49g, 15 min) c) Ti+C+50 vol % HCCI, d) Ti+C+50 vol % HCCI MA (88g, 10min)

Секция 4. Научные основы разработки материалов с многоуровневой иерархической структурой, в том числе для экстремальных условий эксплуатации

The dispersion and morphology of powder mixtures before and after mechanical activation are significantly different. After MA, the structure of the MA mixture is more dispersed and homogeneous. The steel spherical particles and large titanium powder granules are grinded and then agglomerate to granules of $24 \pm 10 \mu\text{m}$ at 49g load. Powder mixtures with cast iron has granules of $10 \pm 5 \mu\text{m}$ at 88g load. Unlike the mixture with HSS, much more granules with a size of 3-5 μm in mechanically activated cast iron mixtures are found (Fig. 1).

The powder mixture with a target content of 60 vol. % HSS did not ignite without MA (table 1), as well as with MA in medium load (15 min., 49g). At high load (10 min, 88g), the combustion front stopped by the thermocouple and the temperatures recorded in this case differed greatly from sample to sample. SHS on a 50 vol. % HSS sample without prior mechanical activation was unstable. However, after mechanical activation in medium load, the stability of the combustion of the sample was achieved and the temperature was measured with sufficient accuracy.

Table 1. Combustion temperatures of Ti+C+ HSS and HCCI.

Target phase composition	MA properties	Combustion temperature
TiC+50 vol. % HSS	No activation	1090±293°C, unstable
	MA 49g, 15min	1361±20 °C
TiC+60 vol. % HSS	MA 49g, 15 мин	No ignition
	MA 88g, 10 мин	Unstable
TiC+50 vol. % HCCI	No activation	No ignition
	MA 88g, 15 мин	No ignition
	MA 88g, 10 мин	1215±5°C
TiC+60 vol. % HCCI	No activation	No ignition
	MA 49g, 10 мин	No ignition
	MA 88g, 15 мин	No ignition

The both mixture compositions with HCCI binder without mechanical activation do not ignite. After 15 minutes high load MA (88g) of each of the compositions, the initiation of the synthesis also did not observed. The reason of such inefficiency of MA could be connected with the formation of titanium carbide layers on the surface of titanium particles with 15 minutes of processing (mechanical synthesis). These layers isolate titanium and carbon and prevent chemical reaction in wave combustion mode. Stable combustion was obtained only on the composition of TiC + 50 vol. % HCCI after high load (10min, 88g) , when the mechanical synthesis has not yet started.

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