PROCESSING, CHARACTERIZATION OF CARBON NANOTUBE-REINFORCED MULTISCALE COMPOSITE

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Abstract: At the present stage of technology development level of the requirements for construction materials are further enhanced. Many traditional materials such as metals, ceramics, and plastics do not meet all the requirements of new technology, which is solved by introducing most actual global problems. However, in many cases a combination of two materials can show properties superior to their individual characteristics. A well known example is the composites. Reducing the size of structural units and their uniform distribution led to the creation of more homogeneous materials, which significantly improved their properties. In this paper we propose an approach based on the principles of nanotechnology to produce composite materials of carbon-based, with improved physical and mechanical properties. This investigation presents the results obtained in the Vladimir State University, in collaboration with partners in the field of composites with different basis using as a reinforcing, modifying the structure-and phase carbon nanomaterials.

Keywords: NANOComposite; CARBON NANOTUBE AND NANOFIBERS; MENALLOCONTAINING NANOComposite; POWDER METTALURGY; HYBRID MATERIALS

1. Metalcontaining nanocomposites

Perspective direction of creating such materials is to obtain a nanocomposite consisting of a matrix based on traditional alloys and hardening phase, that has a characteristic size in the nanoscale (less than 0.1 microns). As a reinforcing phase carbon nanotubes (CNT) and nanofibers (CNF) have great potential. According [1-3], these materials have high modulus of elasticity - 0.8 - 1.2 GPa, which can expect to receive significant strength characteristics of materials based on them. The usefulness of nanostructures as dispersion hardening phases successfully demonstrated for the aluminum-based alloys [4], copper [5] and other metals.

In studies [1,2] carried out on nanocrystalline alloys based on aluminum-fullerene C60 are set uniquely high strength values up to 1200 MPa and a hardness of 4.5 GPa, resulting of formation in the structure of the consolidated procurement frame structure of clusters - aluminum core-shell C60. Similar cluster formation has been established on samples obtained from mechanically activated mixtures of aluminum-nanotube with subsequent pressing and sintering. The main problem - is the uniform distribution of carbon nanomaterials in composites.

We used different methods of mixing and mechanical activation for search the best ways to get powder compositions based on copper with a uniform distribution of the strengthening phase. They performed both dry and wet method in a protective atmosphere and in air. In the wet powder mixture CNT previously sonicated followed by separation of fractions in the liquid (surface, middle part and sediment). As a source of copper used copper powder and nanosized copper. Investigation of the structure of powders and compacted forms showed that under certain conditions treatment of the original components can achieve uniform distribution of CNT in compacted forms. The mechanical properties are largely dependent on the morphology and the structure of CNT. The highest possible hardness values were achieved by applying SWNT.

For today, there are few studies on the use of carbon nanostructures in the iron-based alloys. In addition, the difficulties of manipulating with objects as small size hamper the formation of regular structure of composites. Therefore of considerable practical interest are technologies of powder metallurgy, in which the mixing of the components takes place with the use of technological devices that provide an average composition of the material in the macro- and microscale, and the final structure is formed as a result of the processes of self-organization structure of the composite.

Were investigated processes of structure formation during sintering of powder materials "iron - CNT (CNF)." Chemical and physical properties of CNTs and CNF significantly differ from those of traditional phases in iron-carbon alloys, so the possibility of using traditional diagram "iron - carbon" for the analysis of possible structural transformations in the new materials is not obvious. As the research material was used a model composite consisting of a matrix formed of commercially pure iron powder (particle size less than 100 microns) and a mixture of CNT and CNF. As a result of investigations was found that the carbon phase, consisting of a mixture of CNT and CNF at sintering temperatures of 1000 - 1200 °C is dissolved in the iron matrix, while the dissolution rate increases with increasing temperature. Therefore, formation of composite material with iron-based matrix by method of sintering is possible at temperatures below the liquid phase formation. In order to achieve high-density blank to use pressures. The evolving structures of the eutectic and eutectoid transformation characterized by high dispersion, which allows to hypothesize the existence of modifying effect of fragments nanoparticles on phase separation processes during the transformation.

Another approach is the formation of hybrid materials based on carbon nanotubes and metal realized by the introduction on carbon component of composite organic periphery (eg, due to π-π interactions of the delocalized π-electrons of CNTs and aromatic organic compounds), and creation on its basis metal complexes [6, 7].

Fig.1. Example of linking agents and ligands used to attach inorganic nanoparticles to pristine CNTs via π-π interactions [7]
Using this approach we conducted a study the interaction carbon nanotubes with 8-hydroxyquinoline, which led to a steady-related products (Fig. 2). Infrared spectroscopy showed the presence absorption bands characteristic for 8-hydroxyquinoline. Further addition of copper salts (I) allowed to keep them stable on the surface of CNTs and form the basis for hybrid materials.

Fig.2. Modification of CNT by 8-hydroxyquinoline and copper compounds

2. Nanocomposites based on polymeric materials

Creation of polymer composites based on carbon nanotubes as the structure and property formed component devoted a significant amount of work that is explained by the potential of realization significant improvement of consumer properties of materials. Thus, in order to reduce the amplitude of the electronic equipment in the resonance, polymer with graphite inclusions used. The main drawback of such compositions is their low strength. Eliminating this problem is possible using CNM. On the basis of theoretical calculations and results of experimental studies, we can conclude that their introduction to the damping polymers leads to an increase that properties of the order

In contrast to initial polymer materials with carbon nanotubes can effectively function in a wide range of temperatures and pressures. For the rubber industry primary interested carbon materials as nanofillers. Research has shown that the modification of CNM alters the quantitative parameters of the fractal structure of the filler. In particular, the average size of aggregates and agglomerates, as well as their variation in size increases with the modification rubber. This also increases their ramifications. In this material one should expect a greater number of clutches contacts between neighboring units, which ultimately leads to improved mechanical properties.

The main problem is the introduction of CNTs in polymer systems and streamlining their structures. Carbon nanoparticles are prone to aggregation due to the excess surface energy. The disintegration of the nanomaterial, uniform volume distribution of the nanoparticles, the mobilization of their individual structural and electronic potential for interaction with the target object nanomodification (boundary interface) - the most problematic stages of nanotechnology.

One method of varying the properties of the resulting composite is the use of carbon nanotubes with different morphology and their chemical modification that would solve many of the problems: the formation of structures without aggregation (which actually makes the inclusion of micron dimensions), their mutual organization due to the interaction of grafted functional groups and significant interaction of carbon with a binder modifier components.

3. Building materials

Ways to create high-quality building materials, particularly concrete using nanotechnology have found quite a lot. These approaches are very diverse: increased dispersion and mechanical activation of cement (cement nanoparticles), the addition of nanodispersed phase fillers (nanoparticles aggregate) nanomodification fillers, plasticizers nanomodification polymer additives. In this study, a series of samples of porous concrete was added carbon nanomaterial. The results of mechanical tests showed that at certain concentrations of modifying agents, as well as the modes of ultrasound observed increase in mechanical properties. Studies of the structure revealed that the pores in the sample with a CNM, in contrast to reference samples have almost closed structure. In addition, the structure of the pore walls is observed at high magnification, also significantly different. The structure of the modified concrete walls was observed dispersed crystals oriented in a certain way. Other factors determining the increase in properties is the reinforcement of cement CNM. Thus, it was found that the main structural factors that contribute to improved mechanical properties, are changing the structure of pore walls, as well as dispersion hardening cement.

4. Literature

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