Composites with graphene-like sulfide nanoparticles

Hanna Maria Wiśniewska-Weinert

Metal Forming Institute,

ul. Jana Pawła II 14, 61-245 Poznań, Poland

Corresponding e-mail address: weinert@inop.poznan.pl

Abstract

Goal: *The* ***main goal*** *of this dissertation is to explain the influence of the structure of the new composite, in particular, the structure created using the base of porous powder material modified with sulfide nanoparticles with a graphene-like structure, on its physical and chemical properties, with special consideration of tribological properties. The* ***scientific goal*** *of the dissertation is to explain the influence of forming technology for this composite structure, modified by graphene-like sulfide nanoparticles by the technology and during the friction process, and to determine the influence of contact stresses, sliding speed, and temperature on the friction coefficient and wear rate. The* ***utilitarian goal*** *of this dissertation is to create a new composite and apply it in a pilot lot of selected elements and to verify their suitability in industrial conditions. The correct design of the microstructure of the material and the application of unconventional technological processes make it possible to produce a new generation of materials for application in modern and developing branches of industry such as aeronautics or space technology.*

Project/methodology/approach: *The author's own works pertain to laboratory and industrial tests of the new composite made using bases of porous material as well as bulk material. The scope of the work includes the study of surface properties of elements made from the new composites, especially of those based on porous materials. Metal powder mixture compositions developed by the author were used for studies as the matrix of the porous composite. An innovative technology for production of the base composite material in two operations of plastic forming has been developed along with methods of modification of composite surface layer with nano- and micro-particle sulfides. Based on the results of these studies, the chemical composition for the powder mixture was developed and used to obtain the base material for the new composite. The next stage of tests was the development of innovative technology for production of sulfide nanoparticles and of techniques of impregnation of the base porous material with these nanoparticles. Another application of graphene-like nanoparticles is to introduce them into the volume of bulk material by means of special, laser-made micro-channels, which make it possible for the nanoparticles to be released to the contact surface. The physical, chemical and tribological properties of products made from the new composite with graphene-like sulfide nanoparticles were tested. Tribological tests were conducted on a high temperature friction tester of the author's own design.*

Achievements: *The achievements brought about by this work pertain to the development of the composition of the new composite with graphene-like sulfide nanoparticles within a matrix* *of powder material. This monograph contains a detailed analysis of the influence of the parameters of graphene-like sulfide nanoparticles on the friction coefficient and wear of elements made from the new composites. A method of friction parameter analysis based on physical friction models has been presented. The obtained results of experimental work and the evaluation of friction and wear parameters made it possible to optimize the structure of the porous composite modified by graphene-like sulfide nanoparticles. Graphene-like sulfide nanoparticles were also introduced into bulk material by making laser-made micro-channels at the surface. The micro-channels fulfilled the role of special lubricant reservoirs that allowed slow release of the lubricant during the operation of cold forging tools.*

Limitations of research/applications: *This monograph has been written on the basis of the results of the author's own research pertaining to iron-based powder materials, which was directed toward the needs of industry resulting from the Requests for Proposal submitted to the Metal Forming Institute. Limitations of tests of applications of the method for modification of the surface layer of the new composite with graphene-like sulfide structures are due to the dimensions of the developed device for impregnation of the porous sinter, adapted to the current capabilities of financing production of this device from metal by the Metal Forming Institute in Poznan from its own funds.*

Practical applications: *In order to augment the anti-abrasive, anti-corrosion, and mechanical properties of slide bearings for use in extreme conditions, a new porous composite modified with graphene-like sulfide nanoparticles (MoS_2 and WS_2) was subjected to semi-industrial tests. Semi-industrial tests of bearing sleeves made of the new composite confirmed that they can successfully replace the bulk material sleeves used until now. Optimization of the process parameters of porous composites production, the special technology for obtaining graphene-like sulfide nanoparticles and their impregnation made it possible to obtain a relatively low friction coefficient for bearing sleeves. Plastic working of materials sintered from metal and alloy powders, as well as powder composites gives capabilities of producing modern products with strictly defined structure and mechanical and functional properties. The graphene-like sulfide nanoparticles produced at the Metal Forming Institute in Poznan were applied to modify the cold forging tools by means of laser-made micro-channels. Industrial tests of cold extrusion tools confirmed that the life of tools made by such a way increased 2.5 times.*

Originality/value: *The application of graphene-like sulfide nanoparticles introduced into the matrix makes it possible for them to be released and to migrate to the surface of sliding elements of a friction pair, that results in considerable fall of the friction coefficient below <0.1, especially at higher temperatures, and increase of the durability of sliding elements 2-3 times in comparison counterparts made of the conventional materials. In order to obtain graphene-like sulfide structures based on molybdenum disulfide or tungsten disulfide, a mixtures of graphene-like lamella of molybdenum disulfide or tungsten disulfide are produced. Particularly advantageous tribological properties can be achieved by using graphene-like sulfide structures obtained based on molybdenum or tungsten disulfide with a thickness below 100 nm and length below 1.0 μm.*

Keywords: *Materials surface engineering; Composite; Graphene-like sulfide nanoparticles; Nanometric structure; Friction; Wear*

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