

## **SHORT INFORMATION CONCERNING COMPRESSIBILITY, MICROSTRUCTURE AND PROPERTIES OF MICROCOMPOSITE MATERIALS BASED ON COATED IRON POWDERS**

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Ecological societal thinking requires new advanced technologies for production of materials with specific properties according to market requirements. In many cases these requirements are possible to achieve by a suitable combination of two or several components, usually with different chemical natures, which will form the composite material. Its properties are generated by component properties, volume proportion and distribution of minority component in volume that can have one-dimensional (fibre, stick), two-dimensional (plate, lamella) or three-dimensional (spatial network) character with the degree of continuity varied from total up to discreet particles. According to matrix material, there are composites with ceramic matrix (CMCs), metal matrix (MMCs) and polymer matrix (PMCs). In relation to the properties, there are composite materials with high mechanical properties or with specific physical properties that are designated mainly for electrical engineering (engines, measuring apparatuses, etc.). In these advanced materials, which originated as a product of a basic research in the area of material science, physics and chemistry, characterised by the presence of structural components in size from nanometers up to micrometers, there appeared new phenomena which required substantial knowledge.

The uprising trend of energy and raw material prices increase support exploitation of new advanced technologies to which also belongs powder metallurgy. Recent research potential of PM is also focused to development of advanced multifunctional composites which follows directly from its unique competence to prepare the materials with unique three-dimensional structure configuration and unconventional combination of properties. During the last 15 years a special attention has been focused on development of coated powder composite materials of different types – metal/metal, metal/inorganic-ceramic coating, metal/organic-polymer coating. In general, the investigation in microcomposite powder materials is focused on optimal chemical composition and preparation techniques of coated powders.

One of the research institutes that are involved in powder metallurgy technologies is the Institute of Materials Research of the Slovak Academy of Sciences in Košice. The Department of Ferrous Powder Metallurgy is focused on fundamental research in the area of new types of sintered steels and advanced composite powder materials with special physical properties. Attention is focused on sintered steels with high static and dynamic service properties, while keeping the environmental-friendly chemical conception and on microcomposite materials based on iron coated powders with the insulation of inorganic/organic compound layers. Research fundamentally is a study of compaction, thermal activation of chemical and physical interactions during microstructure formation, theoretical calculations and modelling of their physical-metallurgical substance and experimental verification of predicted data.

The research topic concerning coated powder microcomposite material is solved in the framework of the project APVV-0490-07 “Compacting, microstructure and properties of microcomposite materials based on coated Fe powders”. The project is resolved in close cooperation with the Department of Physical Chemistry, Institute of Chemical Sciences of

the Pavol Jozef Šafárik University in Košice. There different micro and nanocomposite materials, based mainly on water atomised iron powder ASC 100.29 (Höganäs AB, Sweden) were prepared by different procedures:

- a) There were modified and specified coprecipitation phosphate and sol-gel methods for preparation of coated Fe/FePO<sub>4</sub>, Fe/Al<sub>2</sub>O<sub>3</sub> a Fe/SiO<sub>2</sub> powders with a defined portion of coating and substrate.
- b) Electrolytically were prepared composite systems based on iron powder with different coatings (Cu, Cu-Ni, two-layered Ni/Cu, Cu + multi-walled carbon nanotubes.
- c) The Fe+polypyrrol (PPy) systems were prepared chemically. Chemical synthesis of PPy coatings on the iron powder surfaces was studied as well as the influence of different parameters on internal and surface properties of the layer.
- d) Other prepared systems were based on the powder mixture Fe + thermoset fenol-formaldehyde resin (ATM). For the composite homogeneity improvement there was developed a homogenization technology by wet procedure, using acetone.

In all cases morphology and microstructure of powders as well as of green and sintered compacts were analysed. Changes of basic physical and technological properties of powder mixtures in dependence upon fraction portion of individual constituents were studied.

It is known that compacting of composite coated powders represents the „critical technological point“ which needs exact definition of compacting parameters, at which high powder densification, without failure of insulating coating, is achieved. The critical point in the sintered microcomposite materials processing cycle is associated with compacting processes, namely to the applied compaction and sintering concepts, geometrical, chemical and strength properties of the “coating-substrate couple”, lubricant and binder addition, parameters of sintering (atmosphere, temperature, time). All these factors influence the microcomposite material properties from the point of view of both the microstructure and the relevant required properties. So great attention was paid to studying the processes during the compaction process. It was realized by a single pressing (100 – 800 MPa) at room temperature. It was possible to obtain initial data for design of compressibility curves of the studied powder systems by continuous monitoring of pressing force and the change of specimen height. The parametric compaction equation was used for fitting the experimental data. The equation solution allows a quantification of the powder system densification by particle redistribution and development of deformation processes.

In context with current knowledge, the resolved project is focused on the analyses of microstructure development during the compacting process and its influence on mechanical, electric and magnetic properties of the final microcomposite material (it includes porosity monitoring, quantification of microstructural constituents after particular compacting steps, “step sintering”, continual monitoring of the sintering atmosphere, analytical description of relationships: microstructure parameters vs. properties of the final microcomposite).

We hope that the obtained experimental data will improve knowledge about manufacturing microcomposite materials.