History of Powder Metallurgy Research at IMR SAS, Košice

Powder metallurgy and powder technology can be considered among the most progressive and dynamic fields of metallurgical development. On the occasion of the 50th anniversary of the establishment of the Institute of Materials Research of SAS in Košice, we can state that even then, in 1955, the Laboratory of Engineering and Metallurgical Technologies was investigating sintering of Fe-P systems. Parameters for the production of powder iron Hametag were solved and the experimental groundwork for the production of metal powders by the DPG method was performed.

The independent Department of Ferrous Powder Metallurgy was founded during the 1960`s, and in 1966 systematic research had begun. Development and production problems of iron sponge powder were solved, directly impacting on the production process at ZVL Dolný Kubín. Concurrent studies included the microstructure and properties of sintered compacts, nitriding of sintered Fe and the analysis of the resultant properties. In 1971 PM research expanded into 4 research fields dealing with starting powders, compaction and sintering conditions and their influences on the final, mainly mechanical, properties. During 1974 - 1977, research begun on alloying sintered steels with manganese and chromium, elements with a high affinity for oxygen. Subsequently studies of the formation and development of microstructure, in relation to manufacturing properties, of low and medium mixed alloyed sintered steels were initiated. Between 1981 and 1989 the theoretical questions relating to alloying and sintering of PM steels were addressed. The original physical model of the compaction process, quantified by the new alloying curve, was formulated. Significant knowledge of the heterogeneity of strain/stress deformation processes during both static and dynamic loading was acquired. The work was extended to fracture mechanics and fractographic analyses of the micromechanisms of failure of sintered porous bodies. Correlations were presented relating to the influence of microstructure and porosity on strength, plasticity, fracture characteristics and fracture toughness.

Relating to applications, materials were developed and verified under operating conditions of diesel and petrol engines. In the 1990`s questions of sintering of heterogeneous systems were resolved. Sintered material with a high combination of strength and wear resistance was developed. In the quest for high-strength sintered materials, research on sintering in the presence of a liquid phase of e.g. boron–containing steels was studied. To develop high speed steels, rapidly solidified highly alloyed powder microcrystal steels were researched. Short term cutting tests showed that the best newly-developed materials are equal to polycrystalline diamond.

Mathematical relationships correlating microstructure, composition and porosity with fracture toughness and yield strength of a wide spectrum of sintered steels were proposed. From the view point of the limiting status, terms such as critical defect size, damage zone, and failure micromechanisms of a porous body were defined. New knowledge concerning an influence of boron on the sintering process, microstructure development and final material properties was reported.

Conditions for mechanical alloying with NbC of PM high-speed steels were defined. Propagation speeds of elastic waves in modelled porous material were calculated and the influence of fractal dimensions on changes in the propagation rate was interpreted. Mathematical formulations for bending stiffness and effective Young`s modulus of sandwich structure samples were deduced.

Over recent years, great attention has been given to optimizing the sintering of Fe-Mn-(Mo)-(Cr) systems, including studies of: thermodynamic chemical reactions, kinetics of diffusion alloying of Fe matrix by manganese and the effect of a reducing "microclimate" on the formation of optimal microstructures. The research included also the complex analysis of the strength, plasticity and fracture properties of these materials. Research continued on development of PM high speed steels with excellent cutting properties. Plasma nitriding technique for a further increase of beneficial properties was used. Information on the influence of microstructure of metal foams (Fe, Cu) on the elastic properties in tension and bending was gained.

In the area of non-ferrous PM metals, during the 1960`s and 70`s the main attention was focused upon sintered systems on the basis of Cu, namely Cu - Pb for applications in sliding surfaces of bearings and on metal-graphites. Research was initiated on dispersion strengthened systems such as Ag - MgO, Ag - Al_2O_3, Cu - Al_2O_3, Cu - MgO, Al - Al_4C_3, Pt - Y_2O_3. Mechanical alloying of Al - C systems was investigated. Studies of mechanical properties included the influence of the dispersoid on strength, plasticity and fracture characteristics, as well as creep and high temperature characteristics. In recent years attention has been focused on nanostructured materials. By the use of dynamic phase transformations in systems based on Cu with various types of secondary phases (Al_2O_3, CuO, MgO), nanometric microstructures resulted. Phase interfaces were studied.

The various areas of research were supported by national scientific projects VEGA, international projects within the EU such as FP5, NATO, COST, EUREKA and others. From the viewpoint of organisation, research is divided into two scientific departments: Department of Ferrous Powder Metallurgy (head: Assoc. Prof. Dr. Eva Dudrová) and Department of Nano Structured Materials (head: Dr. Juraj Ďurišin). For the area of internal development and realization of research work up to prototype production stage of specific PM parts/components, there is the Department of Technology and Design (head: Vladimir Katana, M.Sc.).

Over the past several years, IMR SAS has gained a significant international standing. It has a working contact with numerous prestigious Institutes in Europe. The Institute cooperates also with Vienna University of Technology, Polytechnic of Torino, the firm Höganäs AB and others. In the year 2007, the Institute will organize a PM Summer School under the coordination of EPMA.

On the occasion of the 50th year of existence of PM at IMR SAS, we express our thanks to all co-workers and organisations in Slovakia and abroad for their help and support. We believe that we shall continue to meet upon the pages of our journal.

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