Universidad Carlos III de Madrid

OO/UC3M/48- NEW HARDENABLE CERMETS FOR CUTTING AND FORMING APPLICATIONS

The University Carlos III has developed a new metal matrix composite (MMC) constituted by a dispersion of ceramic particles of TiCN in a steel matrix. The matrix can be hardened by heat treatment, leading to a material with high hardness and toughness, and lower ceramic content and density than the commercial cutting materials. For the further development it is necessary the collaboration with manufacturers of forming and cutting tools, as well as end users of those materials.

Description and special features

A metal matrix composite constituted by 50 % vol of TiCN particles in a steel matrix has been developed. The processing route has been conventional Powder Metallurgy (PM), consisting on blending of powders, pressing and vacuum sintering. To obtain a homogeneous microstructure and good properties, the starting powders should present the appropriate characteristics, being the particle size of particular importance.

The sintered materials can reach hardness values of 1200 – 1400 HV30, and fracture toughness of 10-15 MPa $m^{1/2}$. After heat treatment of quenching and double tempering, the hardness increases about the 25 % and the fracture toughness the 40 %. Moreover, the material presents an excellent wear and oxidation resistance. Oxidation tests in static air at temperatures up to 800 ºC, and exposure times up to 240 hours show mass gain lower than those of cemented carbides at less exigent conditions. These results are particularly interesting due to the reticence of using Fe-based composites for the tendency of Fe to oxidation. The proposed material is protected thanks to the formation of a protected layer of titanium oxide formed due to the descomposition of TiCN on the surface.

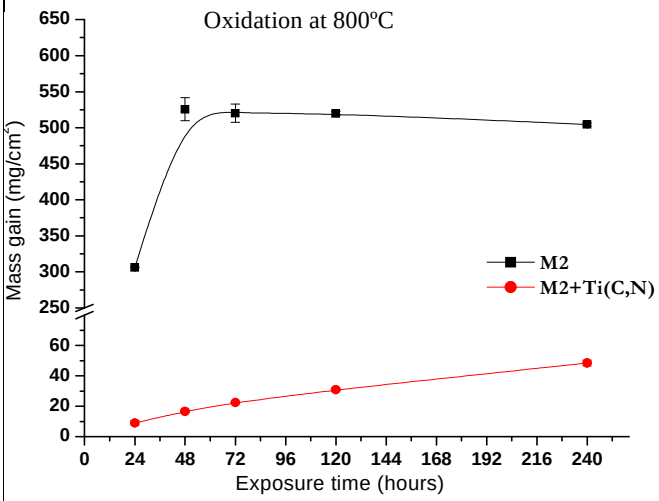

Figure 1. Oxidation behaviour at 800 ºC of the composite M2-TiCN in comparison to the high-speed steel M2 obtained by PM.

The market offers similar materials, constituted by an steel matrix and TiC particles as reinforcement. However, the percentage of ceramic particles is lower and the manufacturing process more complex and costly. The material developed by the UC3M can be process by conventional PM techniques and shorter sintering times, with the possibility to improve the properties by heat treatment, although its characteristics permit it to be used in the as-sintered state.

Among the advantages of this material in front of the conventional cutting materials (cemented carbides and cermets) are the lower density (both for the composition of the matrix and for the ceramic particles), the lower cost (the steel matrix is cheaper than Ni or Co), less harmful and more environmentally friendly (Ni is consider to be carcinogen effects), excellent wear and oxidation resistance, and the possibility to adjust the properties by heat treatment of quenching and tempering.

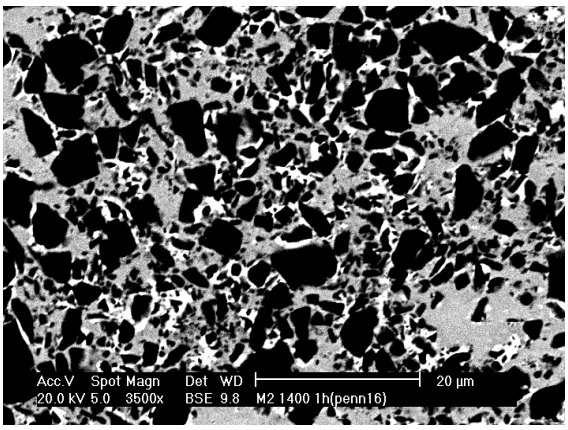

Figure 2. Microstructure of the composite material steel-TiCN.

Although the material is currently being tested as cutting tool, it would be necessary to check the viability of industrial manufacturing, as well as a detailed study of applications: cutting, forming and applications where materials with high wear resistance and lower density compared to other cermets are required.

Innovative aspects

A new material for cutting and forming is proposed. The material presents high hardness and good toughness, together with excellent wear and oxidation resistance at high temperature. The material is hardenable by heat treatment as it is constituted by a steel matrix, which permits to improved hardness without increasing the percentage of hard phase and thus reducing the cost of the material.

Competitive advantages

For end-users of cutting and/or forming materials, the proposed material has lower cost in front of the conventional.
For companies manufacturers of cutting tools, the material could mean an advantage as it is a new material with competitive properties.
For both, as the material is Ni-free, it will be adapted easily to the European REACH. The properties of the material can be modified by conventional heat treatments as it is constituted by a steel matrix.

Technology Keywords

Hardening, heat treatment; Mixing (powder, etc.), separation (classification, filtration); Iron and steel, metallic structures; Metals and alloys; Properties of the materials, corrosion / degradation.

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