Design of novel tool steels by Mechanical Milling and Spark Plasma Sintering

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Power metallurgy is a well consolidated route to produce tool steels. The conventional process, involving the consolidation of atomized powders by Hot Isostatic Pressing (HIP) followed by thermomechanical processing (extrusion, forging…) and final heat treatment leads to a finer microstructure and improved properties than similar wrought grades obtained from ingots.

Tool steels microstructure can be further refined by mechanical milling. The repeated impacts between powder particles and the balls/vial cause the their fragmentation and induce a high defects density. The crystallite size is progressively reduced down to nanometric scale and considerably strain hardening is observed. During sintering recrystallization is generally easier that in unmilled powders, according to the higher internal energy of the system. Sintering techniques assisted by pulsed current, like Spark Plasma Sintering (SPS), permits to get near full dense materials at lower temperature and for shorter time than HIP. This allows to preserve parts of the benefits induced by mechanical milling, leading to a very fine microstructure of the consolidated steels. Present results highlight a final grain size close to 1µm for AISI H13 hot work tool steel and even finer for AISI M3:2 high speed steel.

The process described above has been extended to the production of a *hybrid tool steel* obtained by mechanical milling and spark plasma co-sintering blends of these two grades. The results highlight the possibility to modulate the properties (hardness, fracture toughness) of the new steel according to the relative amount of the two base powders.

Finally, the same powder metallurgical route has been used for the production of particle reinforced tool steel. A tool steel powder has been mechanically alloyed with TiC particles showing that a remarkable increase in wear resistance can be obtained. Properties like density, hardness and fracture toughness are strictly related to distribution of TiC particles, which must be tuned by proper selection of processing parameters.