Numerical simulation of dimensional changes during sintering of tungsten carbides compacts

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During sintering of very porous green bodies, as obtained by compaction of hard powders - such as tungsten carbide or ceramics - or by injection moulding, important shrinkage occurs. Due to heterogeneous green density field, gravity effects, friction on the support, thermal gradients, etc., this shrinkage is often non-uniform, which may induce significant shape changes. As the ratio of compact dimension to powder size is very high, the mechanics of continuum is relevant to model such phenomena. Thus numerical techniques, such as the finite element method can be used to simulate the sintering process and predict the final shape of the sintered part. Such type of simulation has much been developed in the last decade firstly for hot isostatic pressing and next for die compaction. Finite element modelling has been recently applied to free sintering.

The simulation of sintering should be based on constitutive equations describing the thermo-mechanical behaviour of the material under any state of stress and any temperature which may arise within the sintering body. These equations can be drawn either from experimental data or from micromechanical models. The experiments usually consist in free sintering and sinter-forging tests. Indeed applying more complex loading conditions at high temperature under controlled atmosphere is delicate. Micromechanical models describe the constitutive behaviour of aggregates of spheres from the deformation of two-sphere contact either by viscous flow or grain boundary diffusion. Such models are not able to describe complex microstructure and mechanisms as observed in real materials but they can give some basic information on the formulation of constitutive equations. Practically both experimental and theoretical approaches can be coupled to identify the constitutive equations.

Such procedure has been performed for modelling the sintering of compacts obtained by die pressing of a mixture of tungsten carbide and cobalt powders. The constitutive behaviour of this material during sintering has been described by a linear viscous constitutive model, whose functions have been fitted from results of free sintering and sinter-forging experiments. This model has next been introduced in ABAQUS finite element code to simulate the sintering of heterogeneous green compacts of various geometries at constant temperature. Examples of simulations are shown and compared with experiments.