THREE-DIMENSIONAL GEOMETRIC MODELING OF THE SINTERING PROCESS

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Introduction

In practice, a rigorous geometric characterization of microstructural evolution during sintering is difficult mainly because the obstacles in the experimental access to topographical and topological parameters. With the aid of a computer it is possible to calculate those parameters using models of particle packing and sintering simulations. In this work it is proposed to implement a sintering simulation using a computer graphics environment with solid modeling extension. This approach allows the creation, editing and displaying of the objects, using supplied functions, and the implementation of specific programs written in high-level languages to simulate the involved processes.

Geometric modeling

To simulate the structure of a green body, a set of monosized spherical particle is randomly packed in a cylindrical box, under the influence of an uniaxial (gravitational) force. The proposed stability conditions of the settling particles are: when a particle hits the container floor; when a particle hits three others; and when a particle hits two others and a wall. However, in the last two conditions, the falling particle could still be unstable if its projected center in a direction parallel to the uniaxial force can be confined to an imaginary triangle formed by the three contact points on the surface of the falling particle. During computer simulated sintering the mass of the system was conserved. The used sintering algorithm simulates the densification of the particle set.

The number of possibilities of geometric models that are suitable for representing the microstructures resulting from sintering is enormous. Depending on the materials and processing conditions involved in real cases to be analyzed, many decisions have to be taken in order to implement those models. When simulating the powder compacts, initial decisions on size and shape of particles and molds, and involved forces during packing, have to be taken. Another important decision is on the use of two- or three-dimensional models. Sometimes the study of two-dimensional system is a first step, in a systematic way, of the analysis of more complex three-dimensional systems. Moreover its results can be directly applied to sections of three-dimensional models and to systems in which two dimensions are much larger than the third one. In order to tackle these problems, one can use a decision table, like the one shown on Table I. The options shown in the Table I refer to monosized or multivariate sizes of powders, attractions or not between particles during packing, vertical forces acting during packing or central atractors, and occurrence or not of shaking during packing. As an application example it was chosen the packing model number 06, which involves monosized particles, without attractions, under action of vertical forces and without shaking on the particles.

Table I - Decision table showing some possibilities of implementation of models of particle packing.

Model	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16
monosize (n sizes)	Y	Y	Y	Y	Y	**Y**	Y	Y	N	N	N	N	N	N	N	N
attractions (without)	Y	Y	Y	Y	N	**N**	N	N	Y	Y	Y	Y	N	N	N	N
vertical (central)	Y	Y	N	N	Y	**Y**	N	N	Y	Y	N	N	Y	Y	N	N
shaking (without)	Y	N	Y	N	Y	**N**	Y	N	Y	N	Y	N	Y	N	Y	N

Microstructural characterization during simulated sintering

Over 3000 monosized spheres with a diameter of 0.84 arbitrary units (*au*) were randomly placed in a cylinder with a diameter of 25 *au*, resulting in a volumetric fraction of pores (V_v^P) of 0.41. This value is nearly the same observed for random loose particle packing of monosized spherical powders [1]. The topographical distribution of the porosity in the simulated green body and the frequency distribution of contacts per particle after some sintering (V_v^P=0.314) are shown on Figures 1 and 2, respectively. The data obtained in this work present a good agreement with available experimental and theoretical results [1-3].

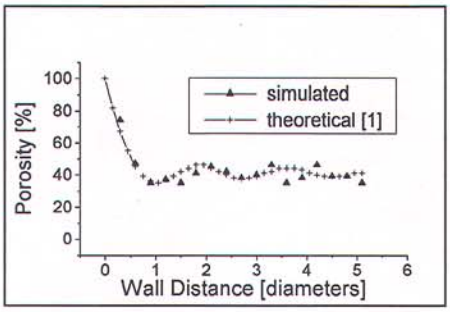

Figure 1 - Radial distribution of porosity.

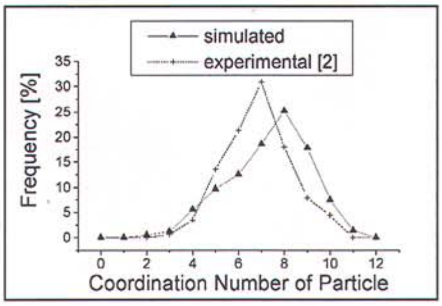

Figure 2 - Topological parameters (V_v^P=0.314).

Conclusions

The three-dimensional geometric model developed in this work allowed good agreement with experimental and theoretical data. The geometric modeling permits the easy evaluation of topological and topographical parameters.

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References

[1] GERMAN, R.M. Particle packing characteristic. Metal Powder Industries Fed., Princeton, N.J., 1989.

[2] RHINES, F.N., DeHOFF, R.T., KRONSBEIN, J. A topological study of the sintering process - Final Report. US Atomic Energy Commission, Gainesville, Florida, 1969.

[3] MUELER, G.E. Prediction of radial porosity distributions in randomly packed fixed beds of uniformly sized spheres in cylindrical containers. Chemical Engineering Science, 46(2): 706-8, 1991.