3-D Analysis of sinter processes by X-ray computer tomography

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Abstract

Microfocus computer tomography (µ-CT) gives the opportunity to observe the positions of individual particles in 3-D powder samples. The description of sinter processes, leading to the formation of bonds, the growth of sintering necks and particle centre approach, is based on two particle models. These models neglect the complex geometry of real powder specimens, like particle size distribution, irregular particle shape and inhomogeneous specimen densities. 2D models can be used to prove rearrangements of particles during sintering. These movements are attributed to the attempt to form low energy grain boundaries, asymetric sintering necks and stress caused by the inhomogenous particle centre approach. Up to now, an observation of particle movements inside of 3-D specimens has not been possible.
The first method to measure the particle arrangement in 3-D specimens is the µ-CT. In this paper the motions of spherical copper powder particles (average particle size 500…750 µm) during sintering are investigated. The positions of all particle centres were measured during several sintering stages. The analysis of movements with respect to the initial particle positions was performed by mathematical models. It is possible to prove movements of particles into larger pores, an increase of the average coordination number and the breaking of sintering necks.

Introduction

The optimisation of sinter processes requires detailed knowledge of the development of bonds between the individual particles and of the changes of particle constitution as well. Actually sinter models are based on the description of two particle boundaries and neglect the influence of particle constitution and often assume ideal contact zones between the particles [1,2]. Thus in the past great effort has been made to achieve experimental data, that are suitable to give a self-contained description of the complex geometries of real sinter specimens. Up to now this experiments were limited to the observation of rows of metal balls, 2D models and the observation of surfaces of 3-D models [3-6]. It is possible to follow translations and rotations of particles during sintering. The significant inconsistance between a theoretical description of shrinkage and the behaviour of real powder specimens during sintering is attributed to motions of whole particles. This movements occur due to the attempt to form low energy grain boundaries and stress caused by inhomogenous particle approach. Unfortunately the movements cannot be quantified on basis of the currently available experimental data. Microfocus computer tomography (µ-CT) is the first method to measure the particle arrangements inside of 3-D powder samples, giving the opportunity to analyse the particle motions in detail. The presented paper describes first experiments in process research using this method to create sequences of 3-D datasets describing several sintering stages of one sample.
Crucibles filled with copper powder were sintered in a hydrogen atmosphere. The sintering was interrupted several times to measure the particle distribution by µ-CT. The obtained data sets representing sequences of sintering stages were analysed by mathematical models. This