DY 25 Granuar Matter and Contact Dynamics I

Time: Tuesday 14:30–16:30 Room: SCH 251

DY 25.1 Tue 14:30 SCH 251

3D-Modelling of Powder Flow and Application to Gravity Die Filling — •Claas Bierwisch, Torsten Kraft, Michael Moseler, and Hermann Riedel — Fraunhofer-Institut für Werkstoffmechanik, Wöhlerstraße 11, 79108 Freiburg, Germany

Gravity filling of a cavity (die) via filling shoe movement as used in powder technological molding is investigated by means of three-dimensional discrete element method (DEM) simulations. A homogeneous spatial density distribution of the powder after the filling stage is crucial for the quality of the produced part. Powder properties, filling shoe kinematics, and die geometry influence the density distribution.

The used powder model comprises granular friction and cohesion whereas particle morphology is taken into account by describing the grains as clusters of spherical subunits. This way powders with significant different rheological behavior can be simulated. Powder flow is characterized in terms of the dimensionless Beverloo coefficient C [1] and validated by experimental flow meter data.

Realistic die filling processes including up to 10^7 particles are studied using a highly parallelized numerical code. Effects of cavity geometry and filling shoe movement on the final density distribution are presented for different powders. Comparisons with die filling experiments [2] will be given.

[1] W. A. Beverloo *et al.*, Chem. Eng. Sci. **15** (1961) 260-269
[2] L. C. R. Schneider *et al.*, Powder Metallurgy **48** (1) (2005) 77-84

DY 25.2 Tue 14:45 SCH 251

A discrete particle model for long time sintering — •Stefan Luding — Particle Technology, Nanostructured Materials, DelftChemTech, Julianalaan 136, 2628 BL Delft, Netherlands

A model for the sintering of polydisperse, inhomogeneous arrays of cylinders is presented with empirical contact force-laws, taking into account plastic deformations, cohesion, temperature dependence (melting), and long-time effects. Samples are prepared under constant isotropic load, and are sintered for different sintering times. Increasing both external load and sintering time leads to a stronger, stiffer sample after cooling down. The material behavior is interpreted from both microscopic and macroscopic points of view.

Among the interesting results is the observation, that the coordination number, even though it has the tendency to increase, sometimes slightly decreases, whereas the density continuously increases during sintering – this is interpreted as an indicator of reorganization effects in the packing. Another result of this study is the finding, that strongly attractive contacts occur during cool-down of the sample and leave a sintered block of material with almost equally strong attractive and repulsive contact forces.

DY 25.3 Tue 15:00 SCH 251

A granular meltdown — •Andreas Götzendorfer[1], Chi-Hwang Tai[2], Christof A. Kruelle[1], and Ingo Rehberg[1] — [1]Experimentalphysik V, Universität Bayreuth, 95440 Bayreuth — [2]Department of Mechanical Engineering, National Central University, Chung-Li 32054, Taiwan

The behaviour of vibrated granular matter is of paramount importance to many industrial processes, and is therefore studied extensively by engineers. But also in the physics community the fluidization of granular beds by vibration has evolved into a very active field of research during the last fifteen years. In our experiments we submitted a two-dimensional granular packing to vertical sinusoidal container oscillations. The initially close packed bed consists of six particle layers. With increasing shaking amplitude at first the particles close to the free surface start to become mobile. When a critical value of the forcing strength is reached the remaining crystalline structure suddenly breaks up and the bed fluidizes completely, causing the centre of mass height to increases by leaps and bounds. Further investigating into this discontinuous transition we examine the distribution of particles and their displacements as functions of the forcing strength.

DY 25.4 Tue 15:15 SCH 251

Axial segregation of granulate in a long horizontal rotating drum — •Tilo Finger[1], Andreas Voigt[2], and Ralf Stannarius[1] — [1]Otto-von-Guericke-University Magdeburg — [2]Max-Planck-Institute for Dynamics of Complex Technical Systems Magdeburg

The axial segregation of granular material in a long horizontal rotating drum is a well known phenomenon. We investigate experimentally the structures and the long time behaviour of this process. The drum is half filled with a mixture of glass beads of two different diameters and filled up with water. After starting a constant rotation, the material shows a radial segregation on a time scale of few seconds. On a time scale of few minutes, an additional axial segregation appears and a stripe pattern along the cylinder axis becomes visible. The initial width of stripes is more or less regular. When the rotation continues, the number of stripes decreases. The time scale of coarsening of the pattern is of the order of several hours up to days. We measure the coarsening at different rotation frequencies and determine the three dimensional distribution of the grains by magnetic resonance imaging. By preparation of initial stripe patterns with well defined geometry, we analyse details of the coarsening process and the relation between the 3D segregation structures and coarsening dynamics.

DY 25.5 Tue 15:30 SCH 251

The Horizontal Brazil-Nut Effect — •Kerstin Morber, Christof Kruelle, and Ingo Rehberg — Universität Bayreuth, D-95440 Bayreuth, Germany

The behaviour of spheres rolling on a circularly vibrating table in a circular container is observed. In detail, transport effects in a monolayer consisting of a binary mixture are studied. Depending on the ratio of the particles' material density and size, migration of the larger particles occurs either towards the boundary or to the center of the circular container. The precise crossing point between both migration effects is determined by varying the intruder's size and maintaining its material density.

DY 25.6 Tue 15:45 SCH 251

Behaviour of Granular Flow under Variable Gravitational Level — •Antje Brucks[1], Tim Arndt[1], and Richard M. Lueptow[2] — [1]Zentrum f. angew. Raumfahrttechnologie u. Mikrogravitation, Universität Bremen, Am Fallturm, 28357 Bremen — [2]Department of Mechanical Engineering, Northwestern University, Evanston, IL 60208, USA

While gravity drives most granular shear flows including geologic situations (landslides and sandpiles on a beach) as well as in industrial applications (processing of food and pharmaceuticals), the effect of changing the gravitational acceleration is largely unexplored. Hence, our understanding of gravity-driven granular flows is based almost exclusively on experiments under Earth's gravity, with one exception (AIAA J. 28(10),1701-1702 (1988)). We explore the behaviour of the flowing shear layer flow in a tumbler of radius r rotating at ω and the underlying creeping motion subsurface flow over a range of g-levels from $1g$ to $25g$. We show that the dynamic angle of repose, or slope, of the flowing shear layer is properly characterized by the Froude number, $Fr = \omega^2 r/g$, when the gravitational acceleration g is varied over several orders of magnitudes of the Froude number in a large centrifuge. However, the flowing layer thickness is essentially independent of the g-level for identical Froude numbers, suggesting that the shear rate in the flowing layer must increase with increasing g-level.

DY 25.7 Tue 16:00 SCH 251

Discrete element model based simulation of the sintering of powders — •Andreas Wonisch, Torsten Kraft, Michael Moseler, and Hermann Riedel — Fraunhofer-Institut für Werkstoffmechanik, Wöhlerstraße 11, 79108 Freiburg

Sintering is an important process step in powder technology in which the separate grains are bonded together by heating them at high temperature below the melting point. While this process has been successfully described by continuum-mechanics modeling there are still many open questions regarding the influence of grain rearrangement. By applying the discrete element method (DEM) we investigate how rearrangements on a microscopic scale change macroscopic properties like densification rate or viscosity. We simulate both free and pressure assisted sintering (sinter forging) by starting from a random aggregate of particles in a simulation box with periodic boundary conditions. We also observe crack formation when simulating constrained sintering with low density isotropic configuration of several hundred thousand particles. We further show how anisotropic starting configurations (e.g. from DEM powder compaction simulations) have a significant influence on the sintering behavior.

DY 25.8 Tue 16:15 SCH 251

Relaxation Times in Sheared Granular Matter — •Lothar Brendel, Dirk Kadau, and Dietrich E. Wolf — University Duisburg-Essen, Theoretical Physics

A significant feature of granular matter is the existence of memory effects, making a thermodynamic-like approach not generally applicable. In this context, monitoring of temporal correlations within the microstructure can provide crucial insights. We present auto correlation functions related to the local fabric, measured in discrete element simulation of non-cohesive as well as cohesive materials. We mainly focus on steady state flow which is an important concept for characterizing granular materials in the applied field of powder technology.