TECHNISCHE UNIVERSITÄT DRESDEN

Fakultät Maschinenwesen Institut für Werkstoffwissenschaft, Professur für Anorganisch-Nichtmetallische Werkstoffe

Compaction of Granulates from Synthetic Ceramic Raw Materials

- An Ancient Technology -

Are There Really Unanswered Questions?

Ulrich Klemm, Dieter Sobek, Hermann Svoboda

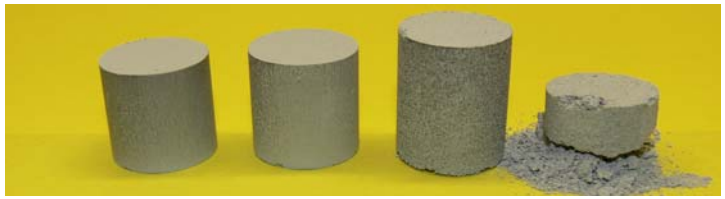
Which standards should the properties of a pressed compact fulfill?

It should reach the specified density…preferably with a low pressure.

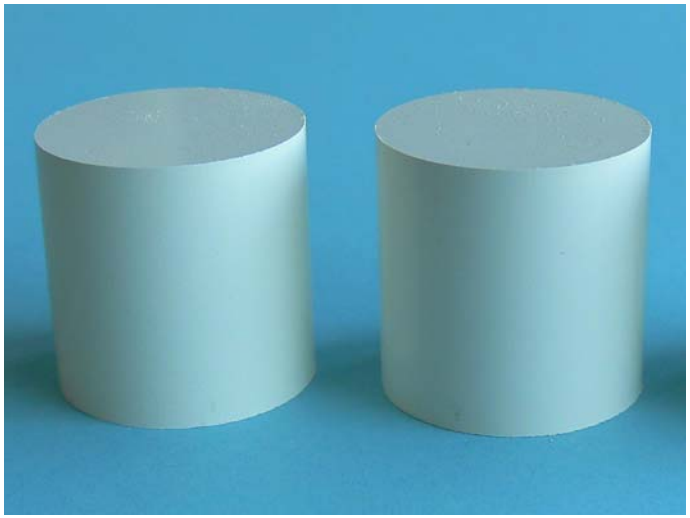
It should have a sufficient strength for further handling and probable mechanical machining.

It should be absolutely free of macroscopic defects.

The gradients of properties in axial and radial directions should be at a minimum.



Case 1: The compacts have excellent properties



Who wants to get compliments?

→ The powder producer!

→ The producer of the suspension!

→ The producer of the granulates!

→ The producer of the compacts!

Case 2: The compacts show macroscopic defects

Whose fault is it?

→ The powder producer?
Never!!

→ The producer of the suspension?
Never!!

→ The producer of the granulates?
Never!!

→ The producer of the compacts?
He has to prove his innocence!
But…How is that possible?

He should try to contact people who have to deal with the same problems !

FORTBILDUNGSSEMINAR

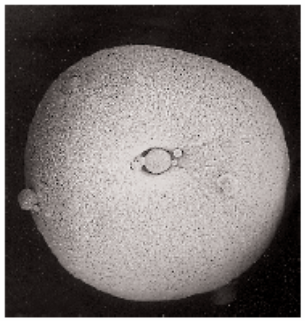
Deutsche Keramische Gesellschaft e.V. (DKG)

DKG

Technologische Grundlagen der Granulierung und Granulatverarbeitung

13. Auflage

24. / 25. April 2008
in Dresden



Fraunhofer-Institut
Keramische Technologien und Systeme

Technische Universität Dresden
Institut für Werkstoffwissenschaft

FORTBILDUNGSSEMINAR

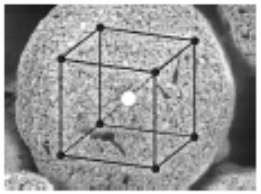
Deutsche Keramische Gesellschaft e.V. (DKG)

DKG

Sprühtrocknung keramischer Suspensionen

4. Auflage

- Technologie und Statistische Versuchsplanung -



10. - 12. September 2008
in Dresden

Fraunhofer-Institut für Keramische Technologien und Systeme

Technische Universität Dresden
Institut für Werkstoffwissenschaft

Einladung & Programm

What is reported there of an all-day of pressing life?

- ☹ we compact in the same way as yesterday but our granulates are suddenly not pressable...
- ☹ ever since we spray our granulates during wintertime we don´t have any problems...
- ☹ although the characteristics of the granulates are identical, we need higher pressure for reaching the specified density of the compact ...
- ☹ sometimes the situation changes to the better if we store the granulates open...
- ☹ sometimes there is just no pressing weather ...
- ☹ ever since we freeze our granulates it can be compacted better...
- ☹ often we have pressing noises, then we just close the doors of our factory, since it is located in a residential area...

- ☹ then we lubricate the die with an oiled brush approximately after every 50 pressures...
- ☹ we used the same additives as cited in literature but nothing is working...
- ☹ our compacts show cracks latterly ...
- ☹ suddenly we observe that our compacts adhere to the punches...
- ☹ all at once the wear of our tools rises...

Σ The poor pressurer is yet not alone with his problems!

"All development has not been more than a tumbling from one error to the next until today."
Henrik Ibsen

Which influences can actually contribute to all these annoyances?

Raw material parameters	Additives	Pressing procedure
Specific surface Particle size Particle morphology Status of agglomeration Density of granulates Structure of granulates Granulate strength Deformability Bulk density Strike density Flowability	Binders Polyvinyl alkohole, Polyacrylates, Polysaccharides, Polyvinylacetat, Dextrine, Celluloses, Waxes, Paraffines, Polyvinylbutyral, Polyethylenglycoles…. Lubricants Fatty acids, Waxes, Oils, Salts of fatty acids, “preparations“….. (221additives on the homepage of only one producer) Concentration of the additives, Chemical and physical properties, Technology of admixture...	Type of the press Modus of compaction Construction of the die Die material Roughness of the die Pressure Rhythm of compaction Velocity of compaction Geometry of the compact

In which way the producer of the compact can prove his innocence?

➲He must try to measure the effects of the plurality of all influencing parameters immediately at pressing.

What is most important to be measured?

Stress transmission

Axial and radial distribution of the pressure

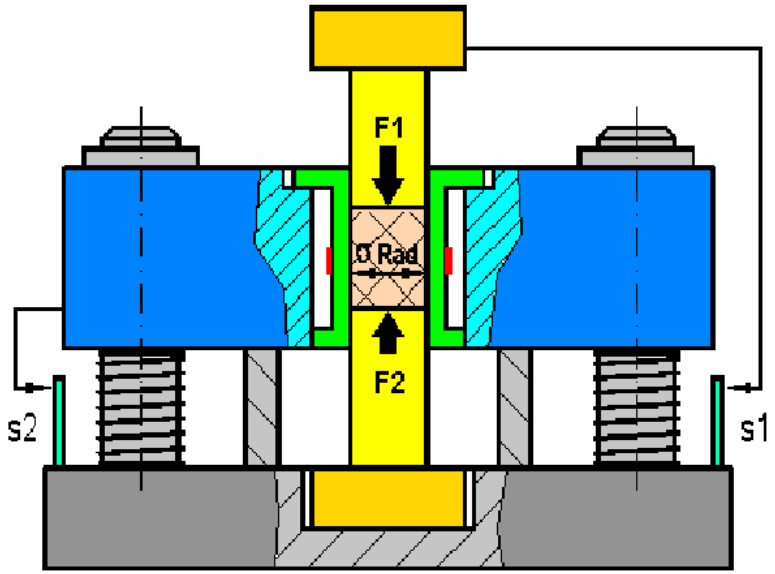
Compressibility

Ability of the bulk to densify under the influence of the pressure

Pressability

Ability of the bulk to generate a compact, which is free of macroscopic failures and can be handled without any problems

Instrumented Compacting Tool



Variable:	F1	Upper punch force
Die material	s1	Way of the upper punch
Die geometry	F2	Lower punch force
Pressure	s2	Way of the die
Climatic conditions in the compaction laboratory	σRad	Radial stress

Results of Instrumented Compaction Tests

Homogeneity

Force transmission
Wall friction
Powder friction
Stress distribution

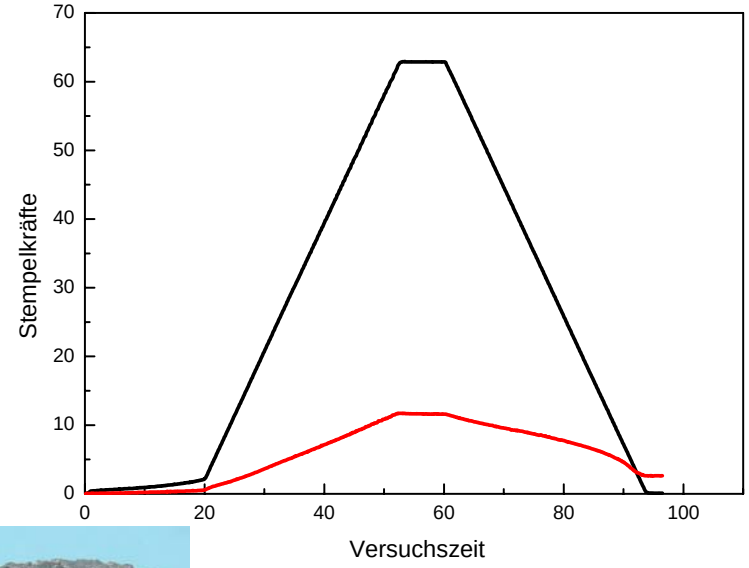
Faultlessness

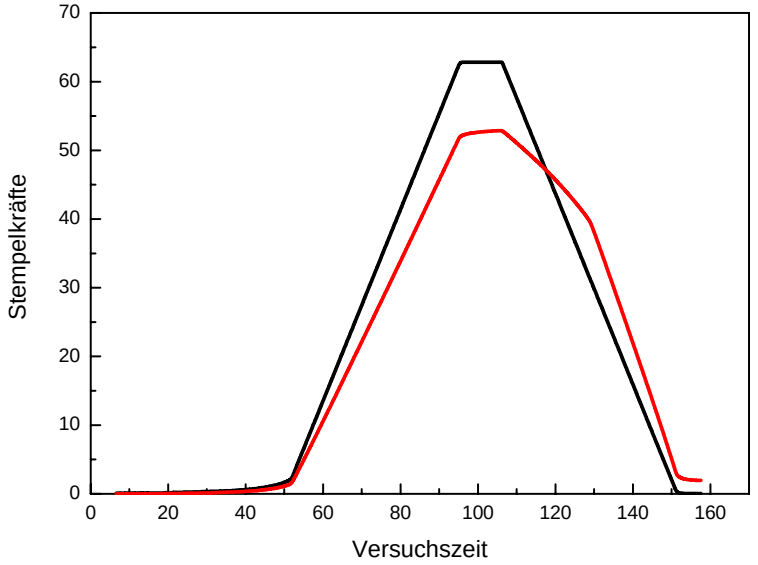
Compaction energies
Deformation behaviour
Relaxation conditions
Shear stresses
Ejection forces

Properties of the Compact

Density
Strength

Temporal Courses of the Punch Forces





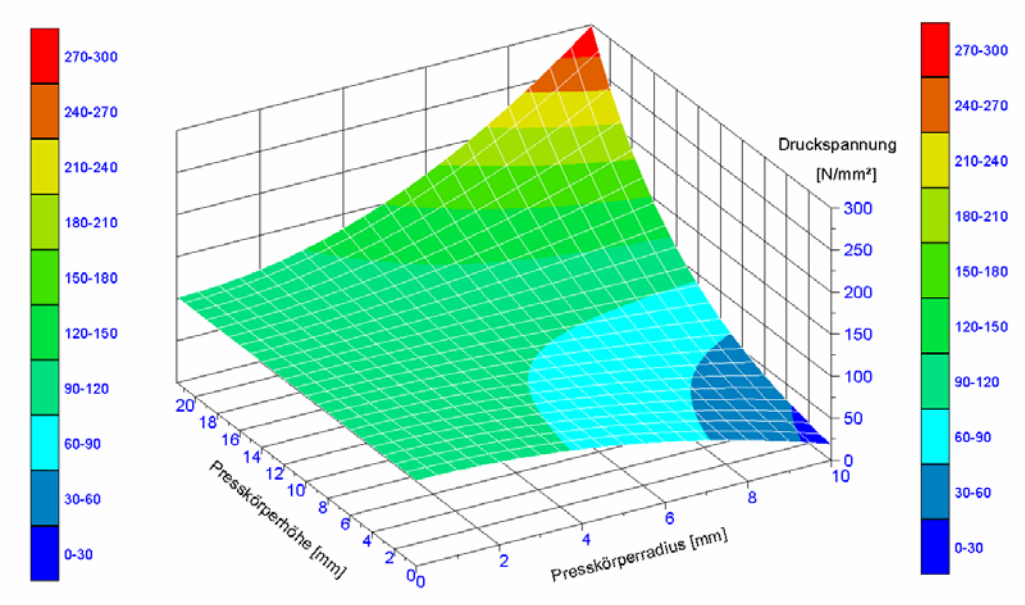
F_2/F_1
μ_w
η
μ_p

Upper punch force
Lower punch force

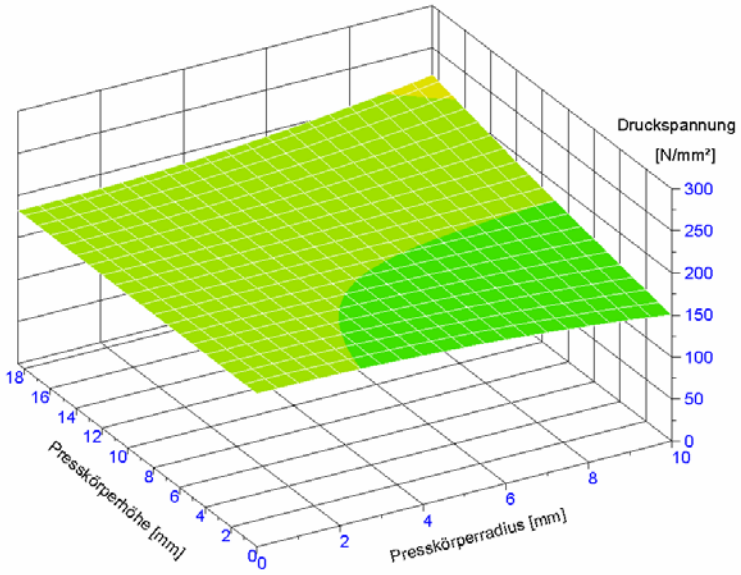
High friction
Force transmission rate 19 %

Low friction
Force transmission rate 83 %

Distribution of Stresses

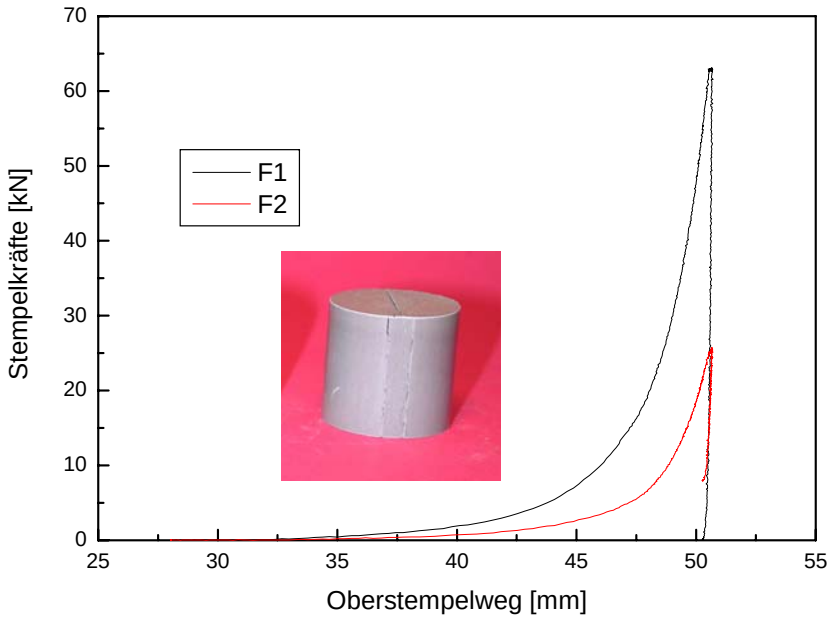


Axial gradient 280 MPa
Radial gradient 197 MPa

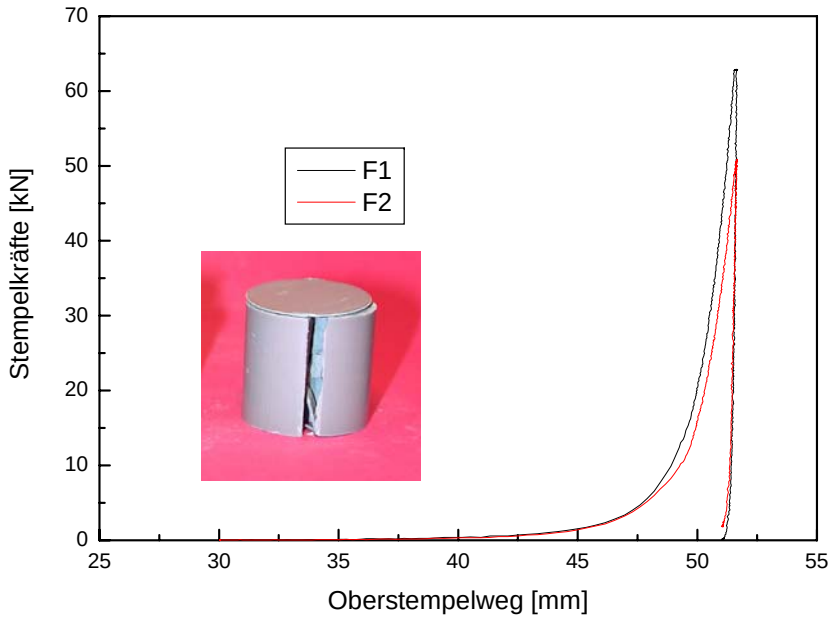


Axial gradient 67 MPa
Radial gradient 36 MPa

Force - Way - Diagrams

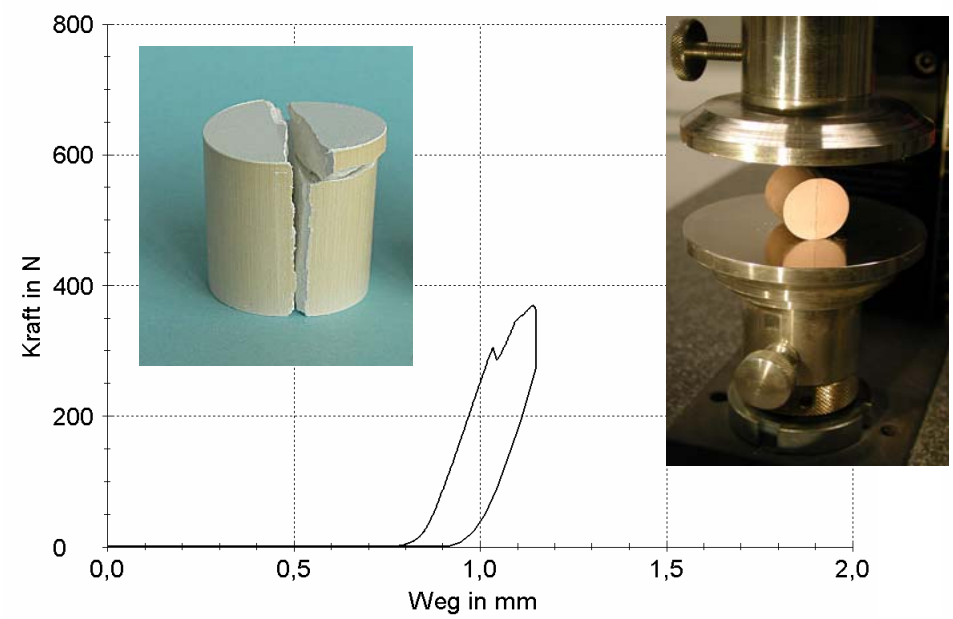


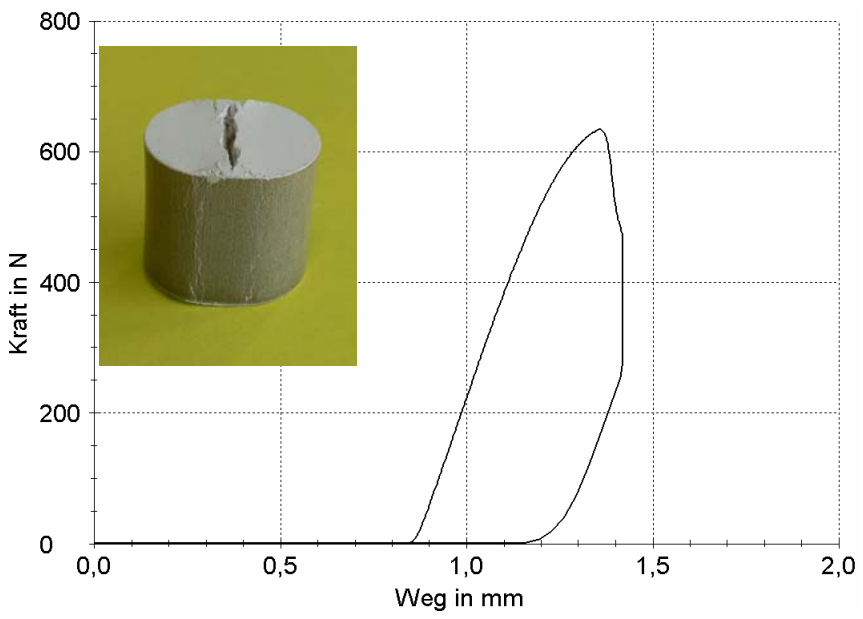
Total energy 165 Nm
Loss of energy 105 Nm



Total energy 105 Nm
Loss of energy 21 Nm

Deformation Curves at Measurement of Strengths

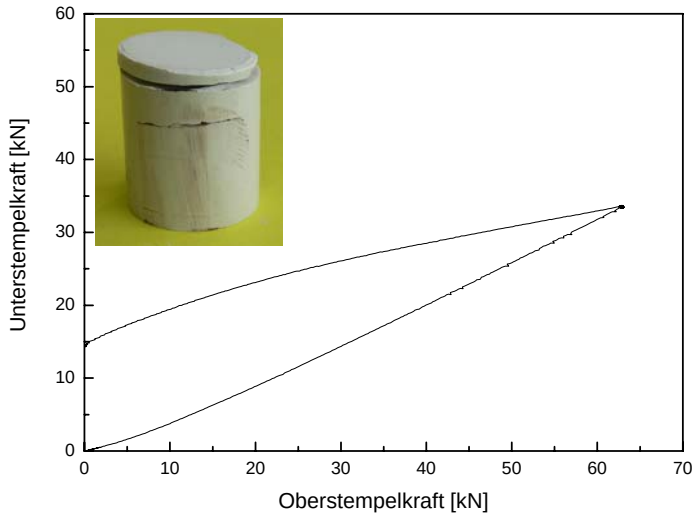


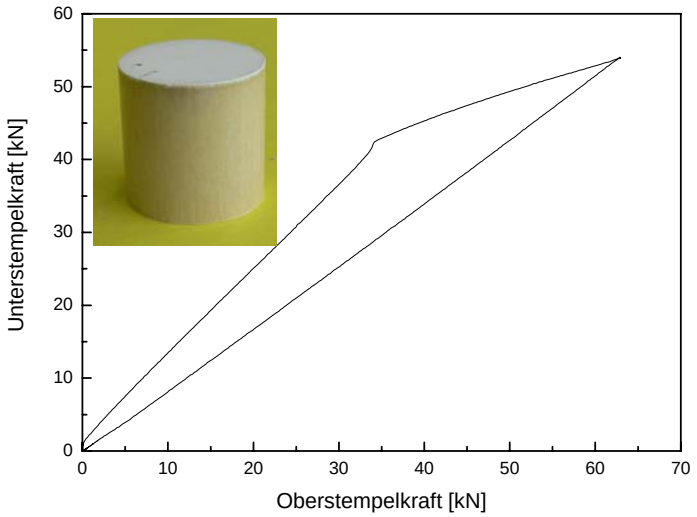


Strength 0,60N/mm² ???

Strength 1,02N/mm²

Lower Punch Force at Loading and Unloading



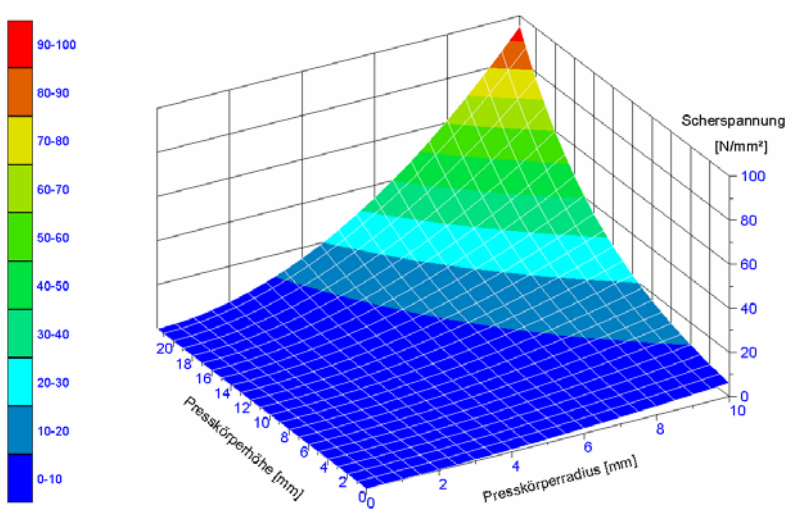


Part of relaxation inside the die

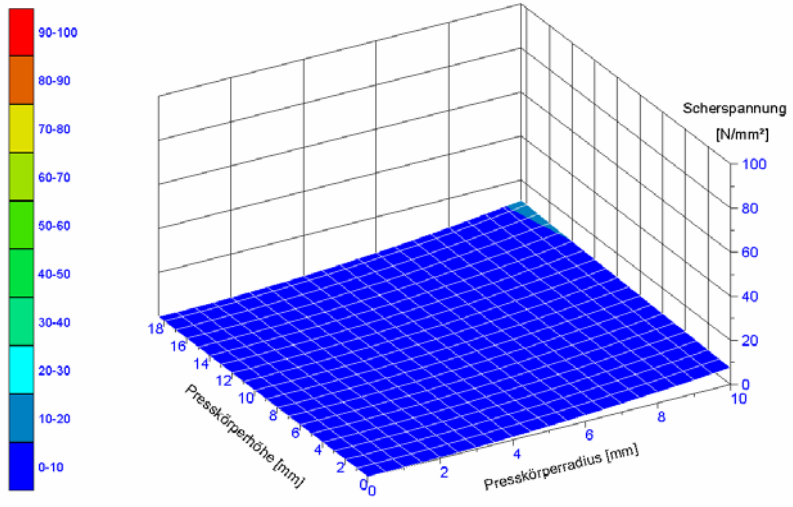
45%

92%

Distribution of Shear Stresses

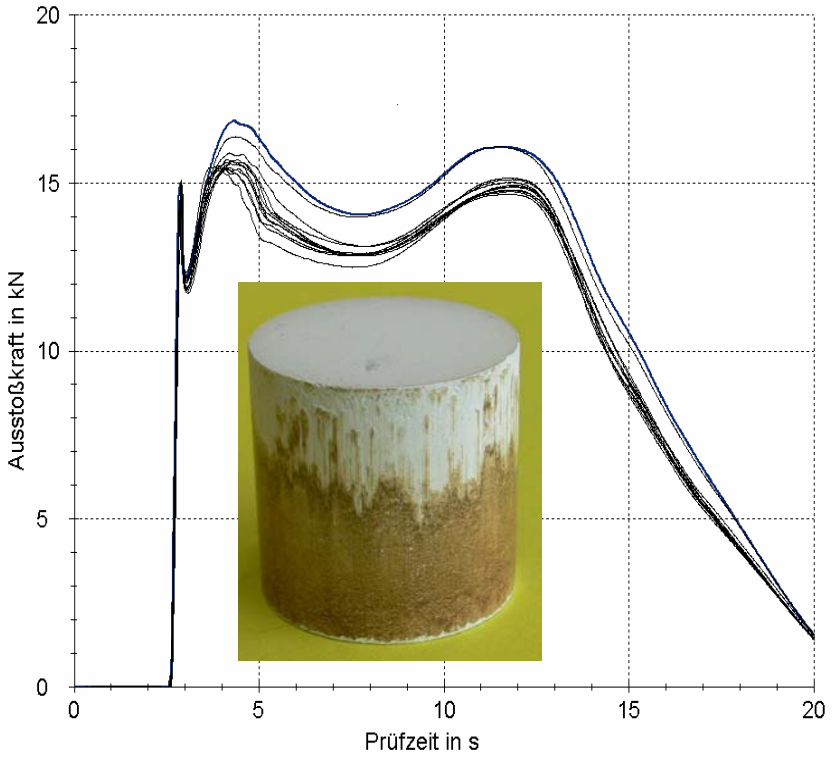


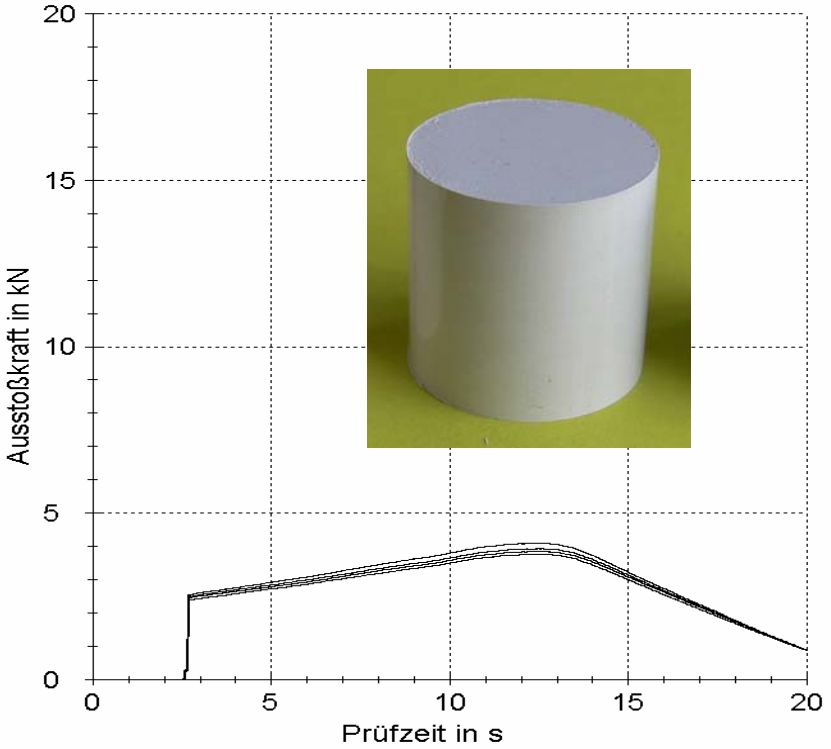
High shear stresses must be compensated by the binding forces of the additives



Low shear stresses diminish the risk of end-capping-defects

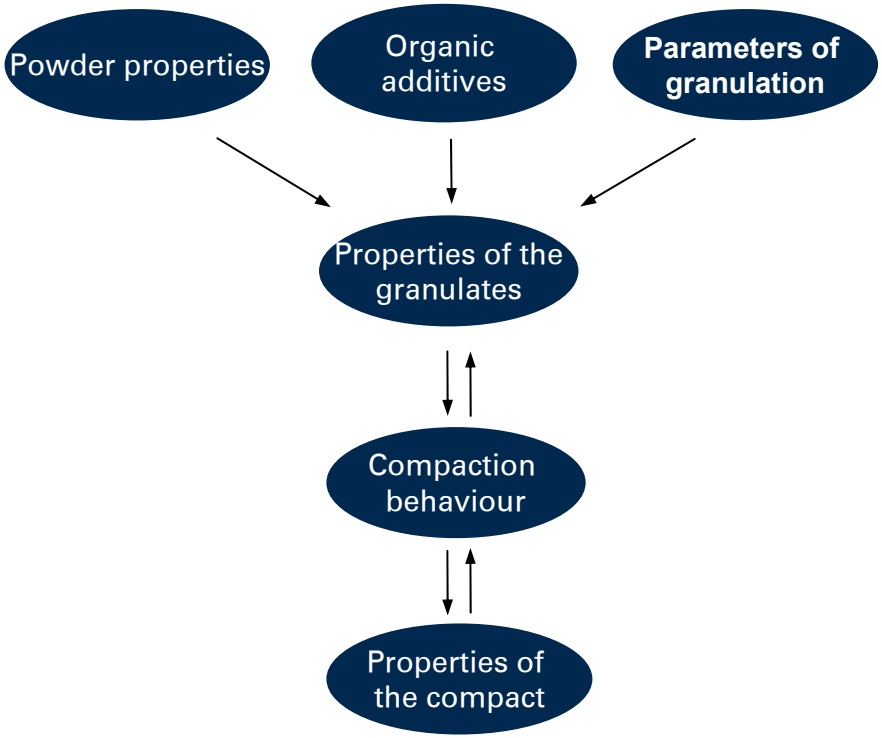
Ejection Curves





Focus of Research

Examination of interactions within the system



Basic research by precise measurements from low to high pressure regions

- Propagation of the pressure in axial and radial directions
- Mechanisms of ceramics compaction
- Determination of correct input data for simulation

Organic additive for the pressing process

- Systematization of the efficacy of binders and lubricants
- Influence of physical and chemical parameters of the additives (Influence of the producer)
- Characterization of the efficacy for different raw materials
- Influence of climatic conditions (“pressing weather“, stability of storage, glass transition temperature)

Examinations on the influence of the die

- Material (hardened steel, hard metal, ceramics, CPM-steels)
- Surface (roughness in interaction with the size of the primary powder particles)

Evaluation of the limits of uniaxial compaction

- Compaction of nano-sized powders
- Instrumented vacuum compaction

Continuous Problems

- Characterization of compaction behaviour of granulates for industrial applications (in cooperation with IKTS Dresden for new developments)
- Monitoring of the industrial production processes with respect to the “culture of production“ and reproducibility