Powder compaction modelling and shape optimization against potential damage of the product

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DIE COMPACTION is a forming process for metallic, pharmaceutical, mineral, and food powdered materials.

In the framework of continuum mechanics, elastic and plastic behavior play important role in die powder compaction. During the loading, densification proceeds plastic deformation of particles, while during the unloading the elastic behavior is most important leading occasionally to cracking due to the density gradient distribution.

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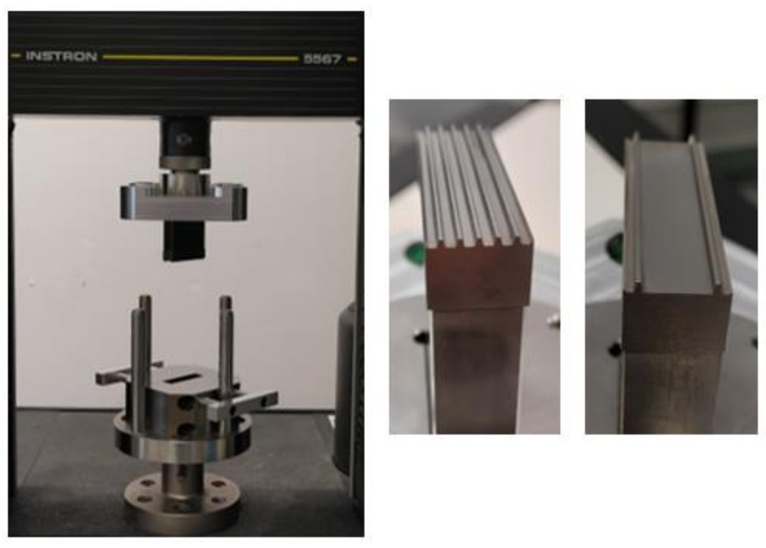
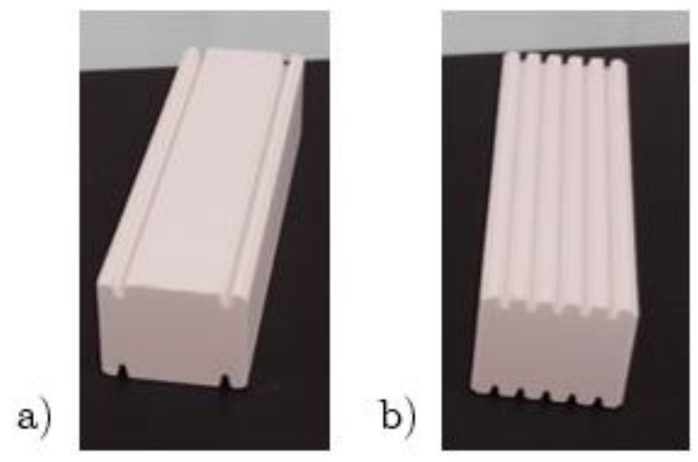
▶ EXPERIMENTAL AND NUMERICAL APPROACHES

- Understanding the powder flow and densification under deep grooved punch surface
- Characterizing the internal microstructure of compacted powder by µCT
- Modelling powder behaviour using elastic-plastic behaviour (Drucker-Prager Cap model - DPC)
- Calibrating model material parameters using small cylindrical instrumented die
- Development of an hybrid method to scale DPC parameters for compaction simulation at larger scale
- FEM simulation of the compaction of complex geometry using ALE method
- Validation of the modelling : comparison between FEM predictions of relative density and µCT characterization
- Parametric study of groove shape and position on the punch surface according to the density gradient distribution



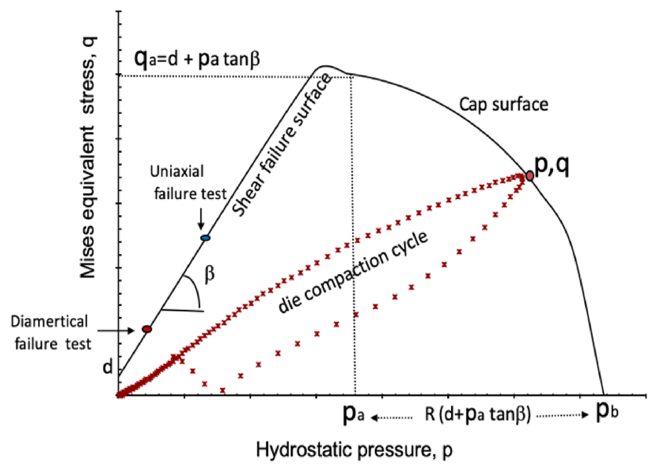
Compaction set up (left) and compaction punches (right)



Visualisation of compacts with a)-2 and b)-5 grooves

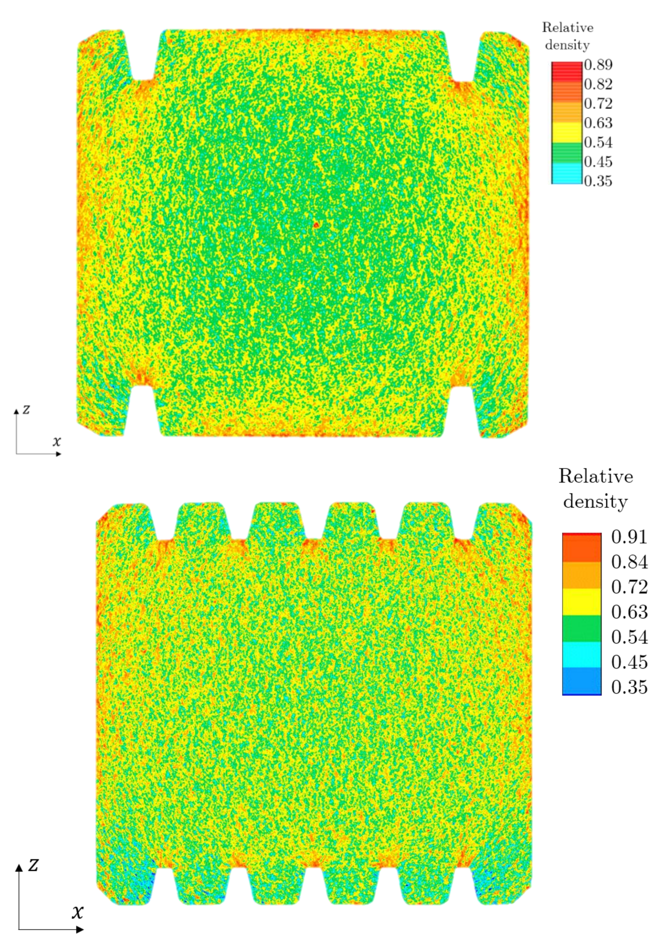
▶ FINITE ELEMENT MODELLING

- Drucker-Prager Cap as model behaviour and material parameters density-dependent
- Arbitrary Lagrangian-Eulerian method for numerical simulation of boundary problem (loading and unloading steps)



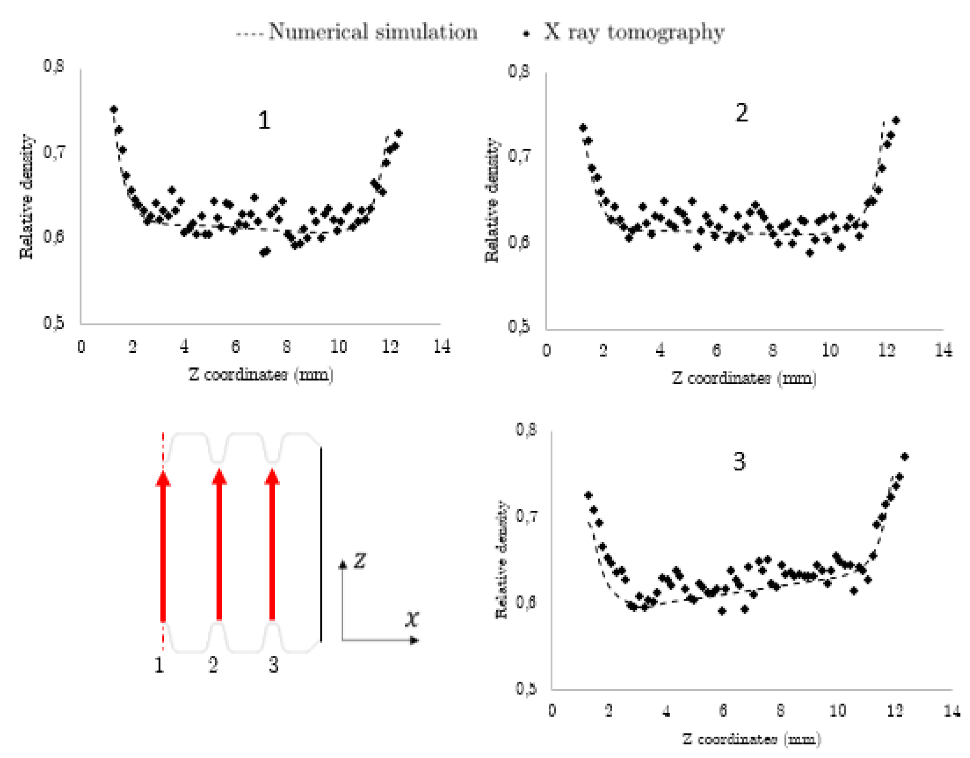
Density dependent Drucker Prager Cap elasto plastic model (Drucker 1952)

▶ INTERNAL MICROSTRUCTURE



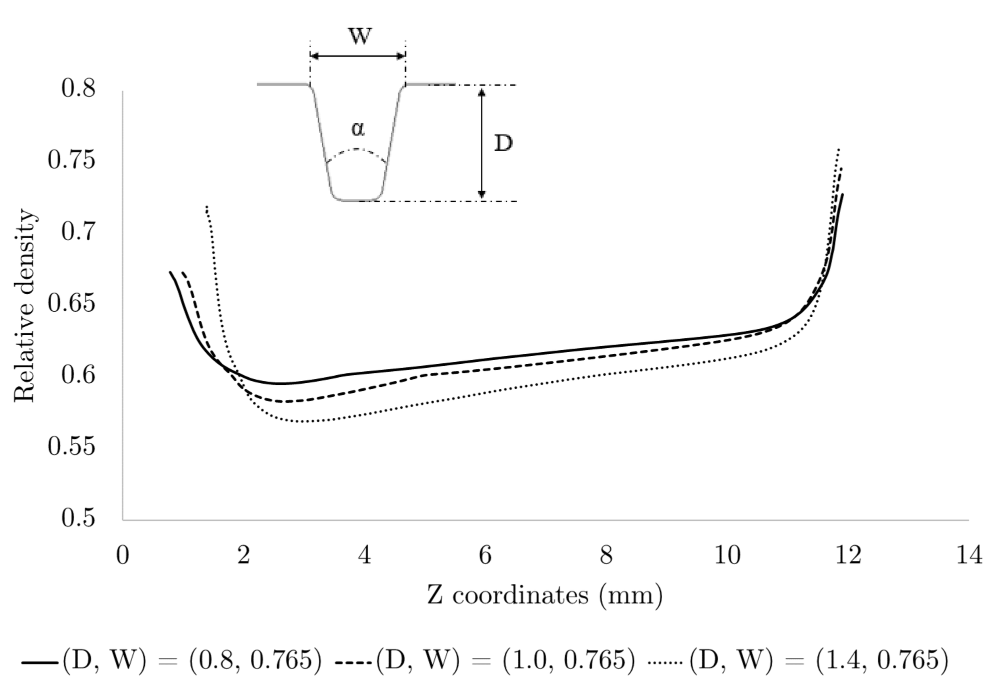
Density distribution in 2 and 5 grooved compacts obtained through µCT

▶ VALIDATION



Comparison of experimental and predicted density gradients observed between facing grooves for a compact with 5 grooves

▶ EFFECT OF GROOVE SHAPE AND POSITION ON DENSITY



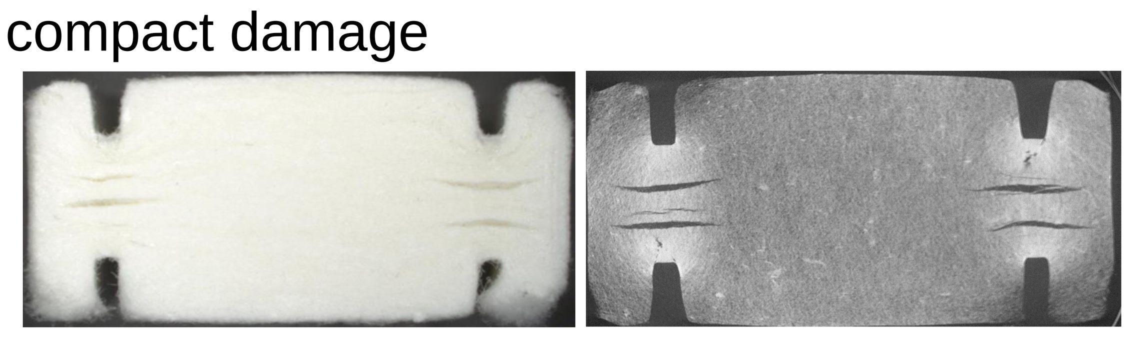
Density gradient between facing grooves – effect of depth (unit mm)

▶ CONCLUSION

- Development of FEM modelling of powder compaction with complex shapes: prediction of material flow around punch singularities and density distribution
- Development of µCT analysis to validate the modelling
- Parametric study of how the groove shape and position on top punch surface can reduce the cracking risk

▶ PERSECTIVES

- Cracking modelling with new approach based on non-local and gradient damage models
- Optimisation of punch's surface shape and powder formulation to reduce compact damage



µCT image of failures localized between opposite grooves