Numerical simulation and validation of powder filling using particle based methods

Simon Larsson[1*], Josep Maria Carbonell[2], Juan Manuel Rodriguez Prieto[1], Gustaf Gustafsson[1], Pär Jonsén[1], Hans-Åke Häggblad[1], Miquel Angel Celigueta[2] and Salvador Latorre[2]

[1]Luleå University of Technology
Mechanics of Solid Materials, 971 87 Luleå, Sweden

[2]Centre Internacional de Mètodes Numèrics en Enginyeria (CIMNE)
Universitat Politècnica de Catalunya (UPC)
Campus Norte UPC, 08034 Barcelona, Spain

*e-mail: simon.larsson@ltu.se, web page: http://www.ltu.se

ABSTRACT

Powder pressing is a complicated process as the mechanical behaviour of the powder material changes with increasing density. Manufacturers tend to produce components with shapes of increasing complexity requiring improved pressing equipment and methods. Mechanical properties of powder materials changes dramatically from the beginning to the end of the compaction phase. Previous investigations have shown that powder transfer and large powder flow during filling affects the strength of the final component significantly. Combined experimental and numerical studies can improve the understanding of the impact the filling stage has on the final component, e.g. to explain the non-homogeneity of the density of powder pressed parts.

This work covers numerical modelling and simulation of powder filling using two different approaches, the discrete element method (DEM) [1,2] which is a micro mechanical based method and the particle finite element method (PFEM) [3] which is a continuum based method. Experimental measurements with digital speckle photography (DSP) [4] from a previous study [5] are used to validate the numerical simulations. The numerical results are compared in terms of agreement with the experimental results, such as velocity- and strain field data. The numerical simulations are further compared in terms of computational efficiency.

The comparison of DSP measurements and simulations gives similar flow characteristics. In conclusion, experimental measurements with DSP together with numerical simulation are powerful tools to increase the knowledge of powder filling and also to improve the numerical model prediction. Improved numerical models will facilitate future product development processes and decrease the lead time.

References

[1] Cundall, P. A., & Strack, O. D. (1979). A Discrete Numerical Model for Granular Assemblies. *Geotechnique*, **29**(1), 47-65.

[2] M. Santasusana, E. Oñate and J.M. Carbonell. (2016). Numerical Techniques for non-linear Analysis of Structures combining Discrete Element and Finite Element Methods. *PhD Thesis*.

[3] E. Oñate and J.M. Carbonell. (2014). Updated Lagrangian Mixed Finite Element Formulation for Quasi and Fully Incompressible Fluids. *Computational Mechanics*, **54**, 1583-1596.

[4] Larsson, S., Gustafsson, G., Oudich, A., Jonsén, P. & Häggblad, H.-Å. (2016). Experimental Methodology for Study of Granular Material Flow Using Digital Speckle Photography. *Chemical Engineering Science*, **155**, 524-536.

[5] Larsson, S., Gustafsson, G., Jonsén, P. & Häggblad, H.-Å. (2016). Study of Powder Filling Using Experimental and Numerical Methods. In: World PM2016 Congress & Exhibition, Hamburg, October 9-13 2016.