Applying nonsmooth DEM in geometric design optimization of a balling drum outlet

D. Wang*[×], M. Servin[×], K-O Mickelsson[†]

[×] Umeå University
SE-90187, Umeå, Sweden
e-mail: martin.servin@physics.umu.se, web page: http://www.umu.se

[†] LKAB R&D
SE-983 81, Malmberget, Sweden
e-mail: kjell-ove.mickelsson@lkab.com - web page: http://www.lkab.se

ABSTRACT

We consider the application of a *nonsmooth discrete element method* (NDEM) [1-3] to geometric design optimization of a balling drum outlet used in production of iron ore pellets. The geometric design optimization problem is based on the need for spatially and temporally homogeneous flow of pellets from the balling drum onto a wide belt conveyor feeding a roller sieve. Homogeneous pellet flow makes sieving most efficient and facilitates good control in the hardening furnace. The model of the pellet material and balling drum are specified in a NDEM framework. The simulation and analysis procedure is described. A material flow profile in terms of design parameters is computed from simulation data and used for solving the design optimization problem. The solution is compared with different designs used in a real production plants. It is demonstrated that the method can clearly distinguish between the original and improved design in that plant. The uncertainty in the optimal design parameters is discussed and put in relation to the assumptions and approximations behind the particular NDEM that is used. Proposal for how to improve and validate the material and balling drum model is given.

The particular NDEM is described in more detail in an accompanying paper [4] where the method is also contrasted to the more conventional *smooth discrete element method* (DEM) [5]. The nonsmooth approach allows for time integration using time-steps much larger than the characteristic elastic response time. Given an efficient solver and that the system and application justifies the nonsmooth approximation a considerable speed-up can be achieved, though it should be recognized that this is significantly problem dependent. The current paper includes analysis of the computational efficiency of the NDEM approach to the particular case of balling drum outlet flow analysis with a given error tolerance. Time estimates of a corresponding smooth DEM approach is provided for comparison.

REFERENCES

[1] F. Radjai, V. Richefeu, “Contact dynamics as a nonsmooth discrete element method”, *Mechanics of Materials*, **41** (6) p. 715-728, (2009).
[2] A. Tasora and M. Anitescu, “A convex complementarity approach for simulating large granular flows”, *Journal of Comp. and Nonlinear Dynamics*, **5**(3):031004, (2010).
[3] C. Lacoursière, M. Servin, A. Backman, “Fast and stable simulation of granular matter and machines”, *DEM5 - The Fifth International Conference on Discrete Element Methods*, London 25-26 Aug (2010).
[4] M. Servin, K. Bodin, C. Lacoursière, D. Wang, “Examining nonsmooth approaches to granular matter”, submitted to *PARTICLES 2011 -- II International Conference on Particle-based Methods - Fundamentals and Applications*, (2011).
[5] P.A. Cundall, O.D.L. Strack, “A discrete numerical model for granular assemblies”, *Geotechnique*, **29**:47–65, (1979).