AN IMPROVED CONTACT DETECTION ALGORITHM FOR DEM MODELING OF POLYDISPERSE SYSTEMS: APPLICATION TO COAL-ASH MIXTURE FLUIDIZATION

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Discrete element modelling (DEM) are becoming increasingly common for modelling of particulate flows such as avalanches and landslides and in many "solids-only" unit operations like grinding and milling, as well as in numerous gas-solid applications such as pneumatic conveying, fluidized beds and circulating fluidized beds (1). In such simulations, realistic size distributions have not been taken into account in the past. In real operations, sizes of dispersed entities can vary over several orders in magnitude. This issue is particularly pronounced when one is trying to simulate polydisperse systems, such as coal-ash mixtures, wherein a single coal particle may be (in general) surrounded by many much smaller ash particles, even when the overall mass fraction of the ash may be only a few percent. Figure 1 shows the idea schematically.

One of the main reasons for this challenge is the DEM calculations required contact detection in the dispersed objects. When the sizes of these objects vary to a great degree, the contact detection poses a computational bottleneck. Amongst others, notably Perkins and Williams have proposed "Double Ended Spatial Sorting" (DESS) for contact detection which is insensitive to variation in particle sizes (2). It had been shown in their contribution in that DESS has a complexity of N log(N), where N is the number of entities being simulated.

In this contribution, we propose an improved algorithm called "Recursive Double-ended Spatial Sorting" (RDESS), which builds on the DESS logic. First, we show that the average complexity for dense packed particles for the DESS algorithm is N2. Further, we show that with our proposed algorithm, the complexity of the intersection phase in DESS is reduced to order N1.5, which rapidly increases the overall performance way beyond that of earlier DESS. Test cases are simulated with particles of various sizes and configurations. The above said modification to DESS yields a speed-up of 27 times compared to DESS and increases rapidly further with increase in number of particles (Figure 2).

Finally, we present results from DEM simulation of coal-bottom ash mixture fluidization in which the RDESS algorithm has been successfully implemented for contact detection (Figure 3).

REFERENCES
1.   P. W. Cleary, "Large scale industrial DEM modelling," *Eng. Comput.*, vol. 21, no. 2/3/4, pp. 169–204, 2004.
2.   E. Perkins and J. R. Williams, "A fast contact detection algorithm insensitive to object sizes," *Eng. Comput.*, vol. 18, no. 1/2, pp. 48–62, 2001.
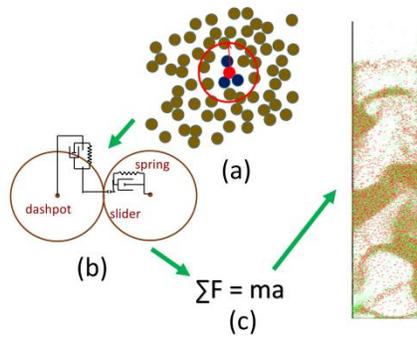
Figure 1. Schematic representation of the "contact neighbor search" in DEM
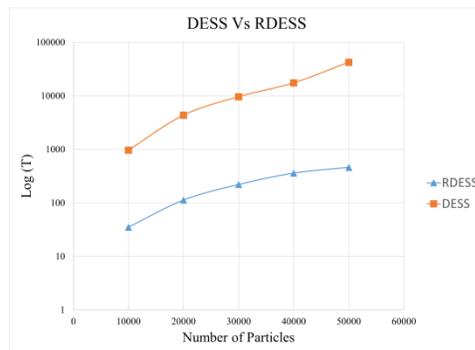

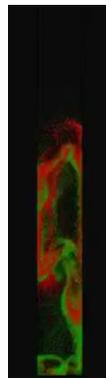*Figure 2. Scaling of time of convergence with number of particles for DESS and RDESS*

Figure 3. DEM model of coal-bottom ash mixture fluidization using RDESS