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Direct Approach in Modeling Particle Breakage Using Discrete Element Method

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Abstract : Current study is aimed to develop an available in-house discrete element method (DEM) code and link it with direct breakage event. So, it became possible to determine the particle breakage and then its fragments size distribution, simultaneous with DEM simulation. It directly applies the particle breakage inside the DEM computation algorithm and if any breakage happens the original particle is replaced with daughters. In this way, the calculation will be followed based on a new updated particles list which is very similar to the real grinding environment. To validate developed model, a grinding ball impacting an unconfined particle bed was simulated. Since considering an entire ball mill would be too computationally demanding, this method provided a simplified environment to test the model. Accordingly, a representative volume of the ball mill was simulated inside a box, which could emulate media (ball)–powder bed impacts in a ball mill and during particle bed impact tests. Mono, binary and ternary particle beds were simulated to determine the effects of granular composition on breakage kinetics. The results obtained from the DEM simulations showed a reduction in the specific breakage rate for coarse particles in binary mixtures. The origin of this phenomenon, commonly known as cushioning or decelerated breakage in dry milling processes, was explained by the DEM simulations. Fine particles in a particle bed increase mechanical energy loss, and reduce and distribute interparticle forces thereby inhibiting the breakage of the coarse component. On the other hand, the specific breakage rate of fine particles increased due to contacts associated with coarse particles. Such phenomenon, known as acceleration, was shown to be less significant, but should be considered in future attempts to accurately quantify non-linear breakage kinetics in the modeling of dry milling processes.

Keywords : particle bed, breakage models, breakage kinetic, discrete element method
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