Film formations of aggregates due to lateral capillary forces

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ABSTRACT

The lateral capillary force is of significant importance in liquid film coating processes [1]. This force, for particles much smaller than the capillary length, decays with separation distance between particles and is thus considered a long-range force [2]. In this paper, we study the role of this long-range force on the final structure of a film containing partially submerged nanoparticles.

We have used computer simulations based on Discrete Element Method (DEM) to investigate film formation of monodisperse and polydisperse systems, which contains nanoparticles, in the range of 50-150 nm. To determine the nearest neighbours for the calculation of the lateral capillary force a Delaunay Triangulation method was used. The solid concentration of the partially submerged particles ranged from 0.1 to 0.5, which coincides with a parallel experimental research. The forces included in the model are the lateral capillary force, contact forces, hydrodynamic resistance, fluid drag and Brownian motion. A preliminary comparison of the strength of these forces demonstrate the importance of the lateral capillary force when compared to the van der Waals force.

The simulation results show that the particles in the film form aggregates of hexagonal packing due to the attractive lateral capillary forces. Defects in the crystalline structure are found due to particle interlocking, which restricts the displacement necessary to minimise the potential energy of the system. In the polydisperse system, there were sections of disorder regions due to the difference sized particles. The predictions of the model are consistent with SEM imagining of real systems and demonstrate the capability of the model to be expanded to analyse film formation during liquid evaporation.

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