Modeling and validation of liquid bridge force in DEM simulation

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Abstract

In chemical engineering, a handling process of fine particles is often difficult since various cohesion force works in fine particles. The cohesive capillary force caused by the formation of liquid bridge is one of the dominant forces which affect the behavior of fine particles. The discrete element method (DEM) has been widely used as an effective method to understand the complex particle system like wet conditions. Although many numerical studies have investigated the behavior of wet particles, the existing numerical modeling of liquid bridge force has some problems from a viewpoint of the effect of adhesion. That is, it has treated cohesive force as a constant value during contact states, whereas as a valuable value during nun-contact states. These means the effect of adhesion force depends on the spring constant in DEM simulation. Moreover, this effect of adhesion force is overestimated. Thus, it is necessarily to develop a numerical model considering the contact states.

In this study, the numerical model considering the contact states was developed and validated in pan-pelletizer. This study built a novel contact model considering quantitatively the effect of liquid bridge adhesion, which was based on the Johnson, Kendall and Roberts (JKR) theory. In this model, the normal elastic force is expressed by non-linear spring based on Hertz contact theory. Meanwhile the normal adhesion force is described by surface energy, Young's modulus, and the radius of the contact circle. In order to validate this model, a comparison of simulation results with experimental ones was conducted in a pan-type pelletizer system. According to this comparison, good agreements have been confirmed concerning the behavior and cascading angle of wet particles in the pan-type pelletizer. Therefore, the adequacy of this model is qualitatively validated.

Keywords: Discrete element method, Liquid-bridge, Contact force model, Validation,