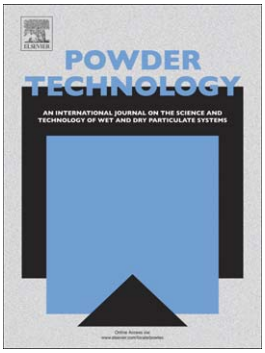

Distance-dependency of capillary bridges in thermodynamic equilibrium

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Distance-dependency of capillary bridges in thermodynamic equilibrium

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Abstract

Capillary forces are very important considering the handling of powders as they, in general, exceed other adhesion forces. These capillary forces are dependent on several different parameters. Especially the distance between the particles is an important parameter. For example, in moving bulk solids a large variety of distances between particles will occur. Therefore, the distance-dependence of capillary bridges was investigated with a numerical simulation method, assuming thermodynamic equilibrium which is attained very fast for small particles. This method uses the Kelvin equation and the Young-Laplace equation to calculate numerically the shape of the capillary bridge without any assumption regarding the shape. The force is eventually derived from the meniscus shape.

The distance becomes extremely important when the capillary liquid bridge between two surfaces is only determined by capillary condensation depending on relative humidity. Only a slight increase of the distance within the fraction of a nanometer changes the behaviour of the capillary force significantly. Furthermore, the influence of the force on the separation of particles will be presented. The force decreases almost linearly with increasing distance for a wide range of distances and consequently, a contact stiffness for capillary bridges could be derived. These results may e.g. be used in DEM models. Also, the maximum separation distance of capillary bridges in thermodynamic equilibrium and the correlation with the according bridge volume was investigated. As two limiting cases for capillary bridges at varying distances one can assume either a constant curvature, i.e. infinitely fast attainment of equilibrium, or a constant volume, i.e. infinitely slow attainment of equilibrium. Therefore, a comparison of these two possibilities will be presented and discussed as well.

Keywords

- Capillary bridge
- Nanoscale
- Contact stiffness
- Thermodynamic equilibrium
- Separation distance