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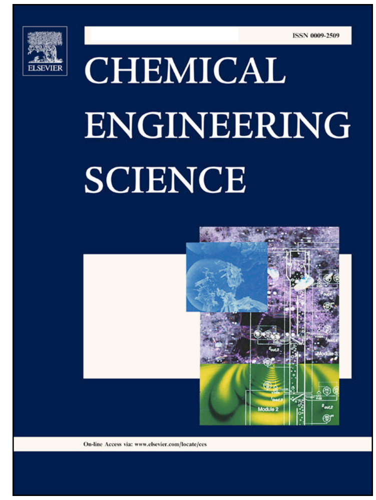

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A liquid bridge model for spherical particles applicable to asymmetric configurations

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Abstract

The modeling of wet granular materials is an important research topic in chemical engineering. This study focuses on the numerical model for the capillary liquid bridge force in sphere-sphere and sphere-plane configurations, which is an indispensable ingredient of wet particle simulations. The first part of this study describes a direct approach via optimization of the interfacial energy of the liquid bridge system. The results, referred to as the optimal solutions, can be used as reference values for the exact solutions of static liquid bridges. In the second part, a force model is presented based on a toroidal approximation of the liquid bridge profile. Particularly, its advantage resides in the generality, which is applicable to a wide range of liquid volumes, contact angles and radius ratios. Predictions by the proposed model are validated against experimental data and optimal solution, from which good agreements are obtained. Numerical tests indicate that the relative error by the proposed model is generally below 10% within a wide range of contact angles and liquid volumes, showing its satisfactory accuracy for calculating the capillary force. It is expected that the present model will be useful for practical numerical analysis of wet granular materials.

Keywords: liquid bridge, surface tension, capillary force, contact angle

1. Introduction

Wet granular materials are widely encountered in chemical engineering. When the liquid amount is relatively low, pendular liquid bridges are found between particles inside the solid layer (Mitarai and Nori, 2006). Usually, the liquid bridge force arising from capillary pressure and tensile force