Liquid Transport in Bi-disperse Particle Beds revealed by Direct Numerical Simulations

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Motivation

- Flow of highly saturated wet granular matter is encountered in wide range of engineering applications, particular in the pharmaceuticals, food industries and energy sectors.
- We focus on liquid transport between particles of different sizes, as well as build a dynamic liquid bridge model to predict liquid transport between two wet unequally-sized particles based on Direct Numerical Simulation, which is an extension of our previous work (Wu et al., AIChE Journal, 2016).

Objectives

- Build a dynamic dynamic liquid bridge model to predict liquid transport between two wet particles of different sizes.
- Using the following model equations and parameters:
  - Early stage model by defining a parameter $K_e$:
    \[ K_e = \frac{r_{eff}}{r_{eq}} \]  
  - Proposed model for liquid bridge filling stage:
    \[ \frac{dV_{eff}}{dt} = -\sum \frac{dV_{ref}}{dt} \]  
  - Key parameters:
    - Dimensional parameters
    - Dimensionless parameters
    \[ R_i = R_e \div R_j \]  

Simulation Strategy

- System initialization and formulation
- Direct simulation based on volume of fluid approach

Results

- Early stage model
  - Choose one reference time at $t'=1$ as the early time.
  - Initial bridge volume obtained at the one reference time.
  - Define a variable $K_e$ by initial bridge volume over particle ratio and the initial film height to the power of some exponents.

Viscous filling stage model

- An application of liquid bridge model to wet fluidized beds
  - Agglomerate size increase with $Bo$

Conclusions

A liquid transport model between wet particles of different size has been presented in this paper. This model is an extension of our previous work. The model is based on DNS data which were obtained by extracting the interface position, defining the characteristic neck position, and integrating the interface position to quantify the liquid bridge filling process. This model allows us to predict the dynamically evolving liquid bridge volume, and the liquid remaining on the particle surfaces in polydisperse particle systems.

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References