11th. World Congress on Computational Mechanics (WCCM XI)
5th. European Conference on Computational Mechanics (ECCM V)
6th. European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

TOWARDS A REFINED MODEL FOR LIQUID BRIDGE FILLING BETWEEN WET PARTICLES

M. Wu,[1] J.G. Khinast,[1,2] and S. Radl[1]

[1] Institute of Process and Particle Engineering
Graz University of Technology, Graz, Austria,
[2] Research Center Pharmaceutical Engineering GmbH, Graz, Austria

mingqiu.wu@tugraz.at
radl@tugraz.at, http://ippt.tugraz.at/

Key Words: *Volume of Fluid (VOF) Method, Direct Numerical Simulation (DNS), Liquid Bridges*

Flow of highly saturated wet granular matter is encountered in a wide range of engineering applications, including chemical and pharmaceutical food processing. A significant amount of research has recently focused on dundamental understanding of wet particle systems [1,2]. However, the detailed understanding, modeling and simulation of the effects stemming from the liquid bridges in these materials still pose significant challenges.

Previous research in the area of wet granular flows mainly focused on forces connected to liquid bridges, and there is much less theory concerned with the process of liquid transfer upon collisions. For example, to study the liquid transfer upon bridge rupture, solution of the Navier-Stokes equation (i.e., direct numerical simulations, DNS), or solution based on a quasi-static approximation of the bridge shape has be used [1,2]. For this second stage of liquid transfer (i.e., liquid bridge rupture), models are already available in literature [3]. Unfortunately, little is known about the initial fast filling process during which liquid drains into the meniscus.

We study the drainage process of free liquid at the surface of two wet particles using (i) DNS based on the Volume of Fluid method (see Figure), as well as (ii) a solution of the film height equation. The latter approach neglects the fluid’s inertia, and is based on a fixed shape of the velocity profile across the film height. By scanning a large parameter space using DNS, our overall goal is building a dynamic model for the bridge volume during filling based on detailed DNS data. Such a model assumes that the particles’ relative motion has no effect on the filling rate. In this talk, we present results of DNS of two identical particles coated with films having different thickness to supplement our previous work [4]. Also, we analyze the filling process of a bridge between two particles with different diameters. From these simulations, we extract parameters for our dynamic bridge filling model, taking different liquid film heights and particle diameters into account.

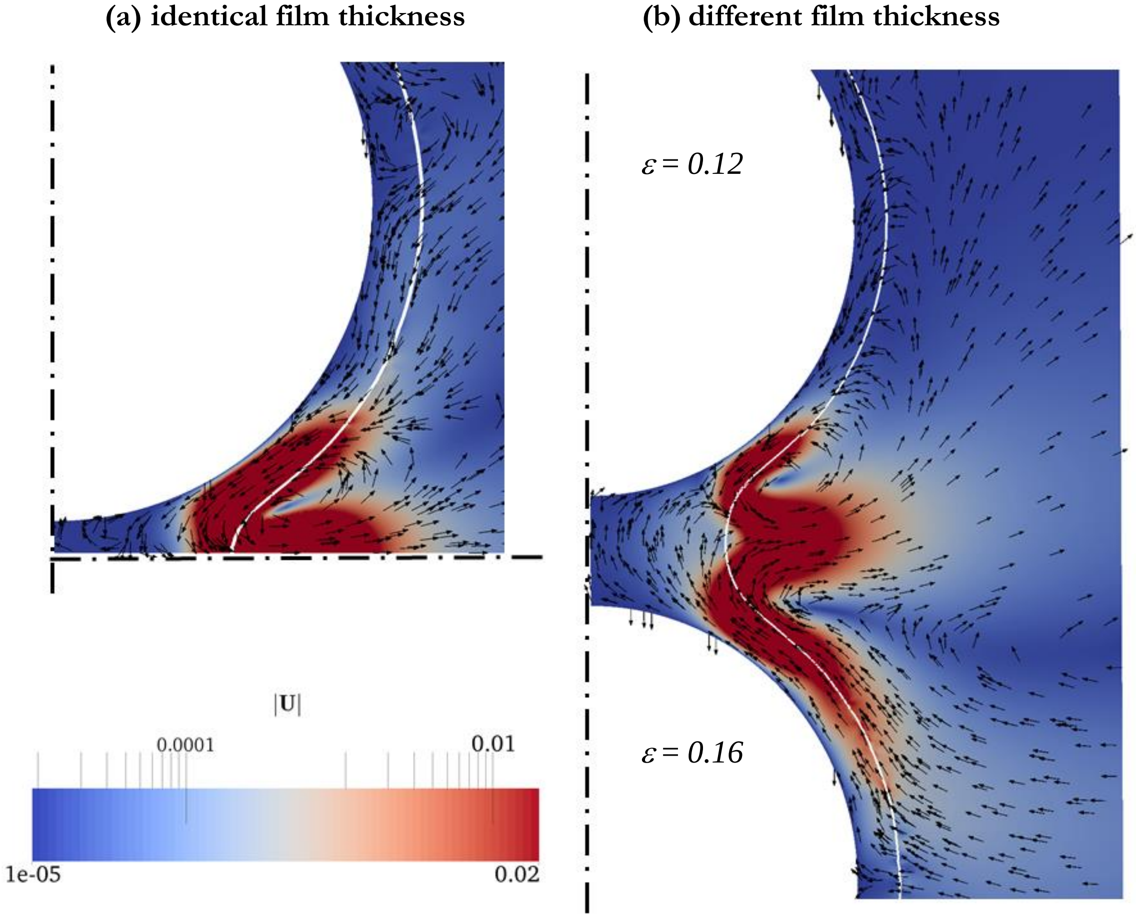

Figure 1: Comparison of the velocity field of film flow on coated particles $T = 1$ (a: particles with identical radii and film thickness; b: particles with identical radii and film thickness; ε … dimensionless film thickness; T … dimensionless time).

REFERENCES

[1] P. Darabi, T. Li, K. Pougatch, M. Salcudean, D. Grecov, Modeling the evolution and rupture of stretching pendular liquid bridges, Chemical Engineering Science. 65 (2010) 4472–4483.

[2] S. Dodds, M. Carvalho, S. Kumar, Stretching liquid bridges with moving contact lines: The role of inertia, Physics of Fluids. 23 (2011) 092101.

[3] D. Shi, J.J. McCarthy, Numerical simulation of liquid transfer between particles, Powder Technology. 184 (2008) 64–75.

[4] Radl et al, On the Filling Rate of a Liquid Bridge Between Wet Particles AIChE Annual Meeting. San Francisco am: 03.11.2013