Understanding the dynamics of oscillating viscoelastic droplets

Master Thesis Project
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Introduction

Spray drying is a widely adopted technology in industry to turn solutions and suspensions into powders. Despite its widespread use, the state-of-the-art computer models used for simulating spray driers are not yet capable of giving accurate scaling and operation predictions. Therefore, spray driers are usually designed and operated in a trial-and-error based fashion. The models generally lack information on the complex collision dynamics that are observed when partially dried droplets collide with each other or with the wall of the drier. In those cases, the droplets sometimes stick together and form agglomerates or stick to the wall. It is expected that viscoelastic properties (rheology) of the nearly dried matter play an important role in these phenomena. Agglomerate formation and wall deposition have great influence on the product specifications and operation of the process, so there is a need for better understanding the collision dynamics of viscoelastic droplets and the drying on a single droplet scale.

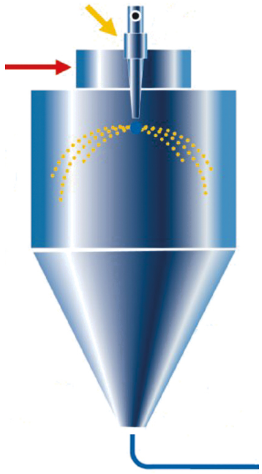

Figure 1. Schematic of a spray drier. Red arrow: hot air entrance. Yellow arrow: liquid feed entrance. After atomization droplets dry while descending in air. (figure obtained from www.GEA.com)

Recently, Hirschler et al.[1] have shown that smoothed particle hydrodynamics (SPH) is a suitable numerical method for simulating droplet collisions. The group developed a SPH code that supports Newtonian and simple non-Newtonian fluids. Unfortunately, viscoelastic models were not yet incorporated in the code. Implementation of such models will allow more realistic droplet collision simulations. To that purpose, a pairwise interaction force between the SPH particles has been implemented and tested by us. The preliminary tests show that implementation of these pairwise interactions results in tuneable rheological properties of the simulated fluid, but further research is needed in order to make the method widely applicable for realistic simulations of droplet collisions.

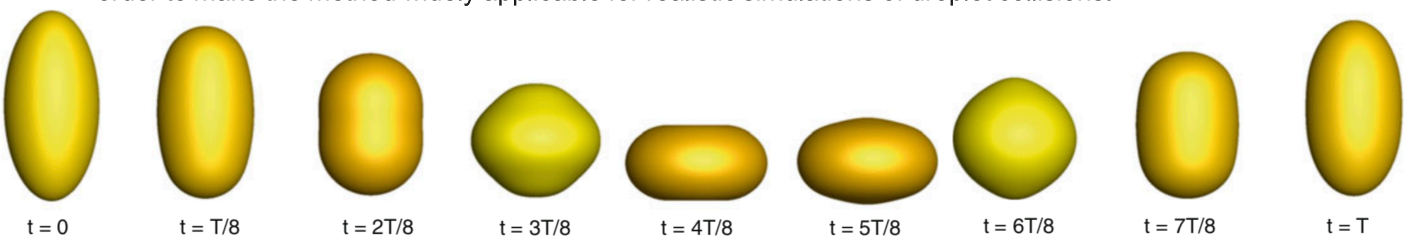

Figure 2. Second mode oscillation of water droplet in air during one period T. The figure is obtained by solving the full Navier-Stokes equations (figure obtained from Oscillations of Droplets and Bubbles, N. Ashgriz and M. Movassat, Handbook of Atomization and Sprays, 2011)

Project Objectives

It is expected that the implemented pairwise forces will also have an effect on the surface tension of the simulated fluid. The aim of this project is to investigate how the forces will affect the surface tension and how to tune the fluid rheology and surface tension independently in order to simulate real fluids. To study the effect of these two phenomena together, oscillating viscoelastic droplets coming to rest will be simulated. This can in the end be compared with simulations of oscillating Newtonian droplets, analytical solutions and/or experimental results from literature to study.

Prerequired Knowledge

Importantly, basic knowledge of fluid dynamics and numerical methods is required. Affinity for programming is highly recommended as C will primarily be used during the project. Knowledge about rheology (viscoelasticity) and particle-based simulations is useful but not necessary.

1. Modelling of droplet collisions using Smoothed Particle Hydrodynamics, M. Hirschler, G. Oger, U. Nieken and D. le Touzé, International Journal of Multiphase Flow, 2017.