Institute of Fluid Mechanics
and Environmental Physics
in Civil Engineering

Master thesis – Numerical simulations of wettability behavior using a Hoffman-function-based dynamic contact angle model

Examinier: Prof. Dr. sc. nat. ETH Insa Neuweiler
Supervisors: MSc. Ahmed Elewaily
MSc. Rahul Krishna

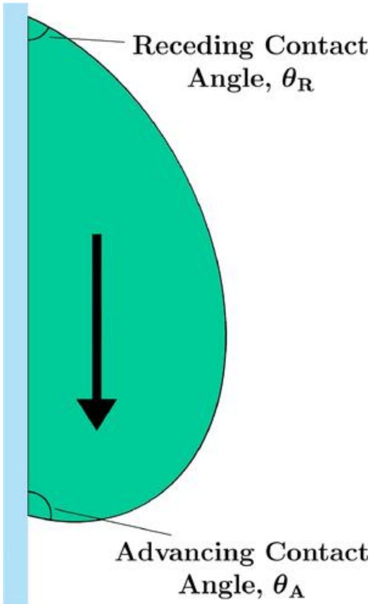

Figure 1: a drop resting on a window (Göhl et al., 2018).

Description

The flow of two immiscible fluids is relevant to numerous technical applications, such as the movement of bubbles in channels and the movement of immiscible fluids in porous media. These processes are critical for the efficient operation of systems like electrolyzers and fuel cells. Modelling these flows is essential for optimizing system design to enhance performance and efficiency.

One of the key challenges in this area is accurately capturing the movement of droplets along solid surfaces. At the fluid-fluid interface, the droplet or the bubble forms a contact angle where it meets the solid surface. This contact angle is represented in numerical models through specialized contact angle models. Contact angle models that rely on a single angle, typically the equilibrium or Young's contact angle, are commonly used to describe the wettability of ideal surfaces. However, for real surfaces, surface roughness cannot be ignored, and wettability behaviour is better represented by a range of angles, known as dynamic contact angles. One model, where the dynamic contact angle is modelled using a particular function, the so-called Hoffman function, has demonstrated promising results compared to other models (Jiang & Zhou, 2019).

The aim of this work is to explain and describe the Hoffman function-based model and evaluate its performance against benchmark problems of moving droplets over solid surfaces. Simulations will be conducted using OpenFOAM software, and the results will be compared with results from the literature. This work can be extended to include the implementation of dynamic contact angle models in OpenFOAM, if the student is interested.

Objective

Validation of the Hoffman-function-based dynamic contact angle model implemented in OpenFOAM, compared to results from the literature and existing models in OpenFOAM.

Main tasks

1. Literature review.
2. A Hands-on Introduction to Engineering Simulations using open source CFD software (OpenFOAM).
3. Setup of the cases.
4. Convergence analysis.
5. Analysis and interpretation of the results.
6. Comparison with the experiential and numerical results from literature.
7. Writing of the thesis.

Requirements

- Background knowledge - Numerical methods in fluid mechanics.
- Basic programming knowledge.
- Motivation and ability to work independently.
- English is the working language for this work.

Contact Information

- elewaily@hydromech.uni-hannover.de

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3) Russo, A., Icardi, M., Elsharkawy, M., Ceglia, D., Asinari, P., & Megaridis, C. M. (2020). Numerical simulation of droplet impact on wettability-patterned surfaces. Physical Review Fluids, 5(7), 074002.
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