Numerical Simulation of Turbulent Two-Phase Channel Flows

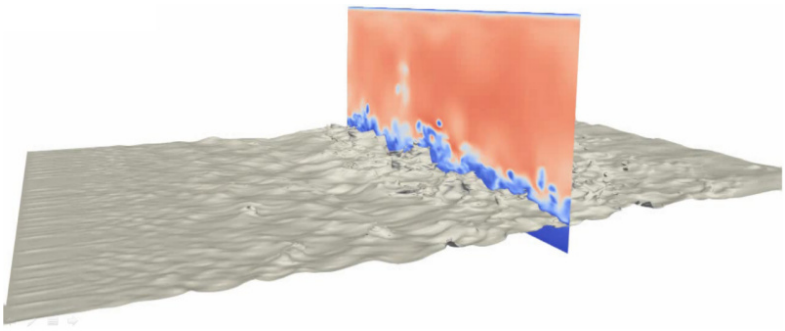


Figure 1: Liquid-gas interface disturbed by a turbulent co-flowing gas flow

Introduction

Liquid films, which flowing parallel to a turbulent gas flow, experience shear stresses at the liquid-vapor interface are considered in this project. This can lead to instabilities in the liquid film like wave formation as well as film rupture and droplet detachment [1-3]. Furthermore, it is known that the turbulent gas flow and the deformation of the liquid-vapor interface influences heat transfer in the system [4]. These effects are investigated numerically in this project.

Methods

The observed film deformations depend strongly on the relative velocity of the two fluids. The higher the velocity difference the stronger the growth of film deformations. Additionally, the structures become more irregular at higher velocities. Droplets might detach from the film or film rupture can occur. The conducted simulations show the exact size and shape of the film deformations by applying an adaptive mesh refinement strategy at the liquid-vapor interface. The computational load is distributed by a load-balancing technique. This was not possible in previous investigations.

Results

Previous results showed that at moderate gas velocities and in regions with a highly disturbed interface the wall temperature is high, where the flow velocity close to the wall is low and the the temperature is low, where the flow velocity is high. The wave formation in the film leads to better mixing and increases the heat transport [7]. New investigations are targeted at quantifying the heat transfer from the wall to the liquid and the vapor. It has been found that the heat transfer to the vapor increases significantly when the film interface is disturbed. Additionally, it has been found that higher film deformations can

Project Manager
Achim Bender

Principal Investigator
Prof. Dr.-Ing. Peter Stephan

Project Term
2018 - 2019

Project Areas
Heat Energy Technology, Thermal Machines, Fluid Mechanics

Clusters
Lichtenberg Cluster Darmstadt

Software
OpenFOAM

Institute
Institute for Technical Thermodynamics

University
Technische Universität Darmstadt

Funded by

Deutsche Forschungsgemeinschaft

JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN
TECHNISCHE UNIVERSITÄT DARMSTADT
UNIKASSEL VERSITÄT
Philipps Universität Marburg

be observed for thicker films.

Outlook

Further investigations are necessary, which will also include the effect of evaporation of the liquid in to the ambient gas phase.The computational framework is built on OpenFOAM's standard multiphase solver inter-DyMFOAM but has been extended with an iso-surface reconstruction heat transfer and evaporation modeling. [5-6] The high computational demand of two-phase turbulent channel flows requires parallelisation with up to 128 cores and can only bedone on the high performance cluster.

Reference

[1]: Yih, C.-S.: Instability due to viscosity stratification, Journal of Fluid Mechanics, Volume 27, Cambridge University Press, (1967) https://doi.org/10.1017/S0022112067000357

[2]: Boomkamp, P.A.M.; Miesen, R.H.M.: Classification of instabilities in parallel two-phase flow, International Journal of Multiphase Flow, Volume 22, Elsevier, (1996) https://doi.org/10.1016/S0301-9322(96)90005-1

[3]: Yecko, P.; Zaleski, S.: Transient growth in two-phase mixing layers, Journal of Fluid Mechanics, Volume 528, Cambridge University Press, (2005) https://doi.org/10.1017/S0022112005003307

[4]: Marati, J.R.; Budakli, M.; Gambaryan-Roisman, T.; Stephan, P.: Heat transfer in shear-driven thin liquid film flows, Computational Thermal Sciences, Article, Technical University Darmstadt, (2013)

[5]: Kunkelmann, C.: Numerical Modeling and Investigation of Boiling Phenomena, PhD thesis, Technical University Darmstadt, (2011) http://tuprints.ulb.tu-darmstadt.de/id/eprint/2731

[6]: Batzdorf, S.: Heat transfer and evaporation during single drop impingement onto a superheatet wall, PhD thesis, Technical University Darmstadt, (2015) http://tuprints.ulb.tu-darmstadt.de/id/eprint/4542

[7] Tannich, M.: ”Numerische Untersuchung von zweiphasigen turbulenten Kanalströmungen mit OpenFOAM.”, Master-Thesis (2017).

Last Update: 2022-04-25 16:56