Lehrstuhl für
Aerodynamik und
Strömungsmechanik

Term paper/master's thesis
Simulation of a Chill-Down process
(theoretical/simulative)

For the main stage of space transportation systems mainly liquid rocket engines with cryogenic liquid oxygen and hydrogen/methane as propellant are used. Before the propellant is injected and burnt, it is used for structural cooling. Around the combustion chamber cooling channels are located, through which the propellant is pumped (fig. 1). After that, the propellant together with the cryogenic oxidizer is injected into the combustion chamber and burnt.
Before the rocket launch all engine components being in contact with cryogenic liquids, have to be cooled down to saturation temperature. This so-called chill down process has to be optimized with respect to duration of the cool down and fuel consumption.

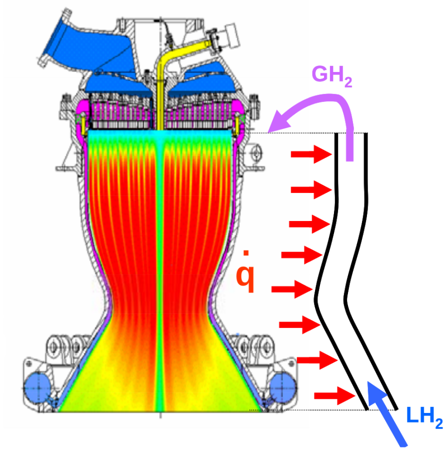

Fig. 1: O. Knab, M. Frey, J. Görgen, C. Maeding, K. Quering, & D. Wiedmann. "Progress in Combustion and Heat Transfer Modelling in Rocket Thrust Chamber Applied Engineering". In: 45th AIAA/ASME/SAE/ASEE Joint Propulsion Conference & Exhibit. American Institute of Aeronautics & Astronautics, 2009.

At the von Karman institue for fluid dynamics (VKI) experiments with liquid nitrogen have already been conducted. For gaining a deeper understanding, these cases should now be investigated via RANS-simulations. The chill down comprises several steps from film boiling over the Leidenfrost point and nucleate boiling to single phase convection with heat transfer (fig. 2). These phases should be identified in the simulation and compared to the experimental results. At the inception of the film boiling large amounts of steam are generated in a relatively short time due to the hot walls. This leads to a short-term blocking of the channel. The blocking process has a characteristic frequency, which can be identified in the simulations and compared to the VKI-measurements.

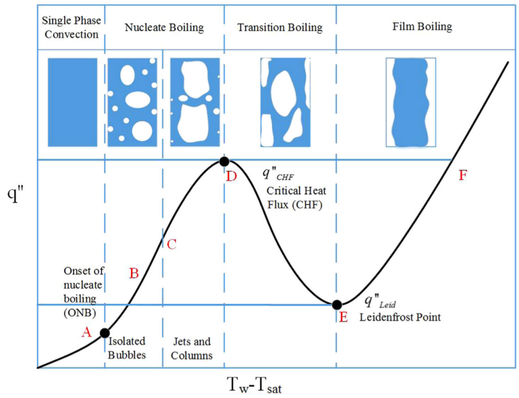

Fig. 2: R. Shaeffer, H. Hu & J.N. Chung. "An experimental study on liquid nitrogen pipe chilldown and heat transfer with pulse flows". International Journal of Heat and Mass transfer 67, 955 – 966, 2013

The work comprises the following steps:

- Familiarization with Ansys CFX / Fluent
- Grid generation with ICEM
- Investigation of the boundary conditions
- Conduction of an instationary 3D RANS simulation
- Postprocessing of the simulation results
- Comparison with experimental results from the literature

The final report should be written in English.

Start: from now on (announcement: 05.04.2019)

Requirements:

- Ability to work independently
- Basic knowledge of numerical flow simulation
- Knowledge of linux advantageous
- Lectures: Angewandte CFD, fluid mechanics I, Fundamentals of multiphase flows

Contact:
Alexander Doehring, M. Sc., (alex.doehring@tum.de)
Dipl.-Ing. Thomas Kaller, (thomas.kaller@tum.de)