Computational Fluid Dynamics Simulations of Cryogenic Storage Tanks

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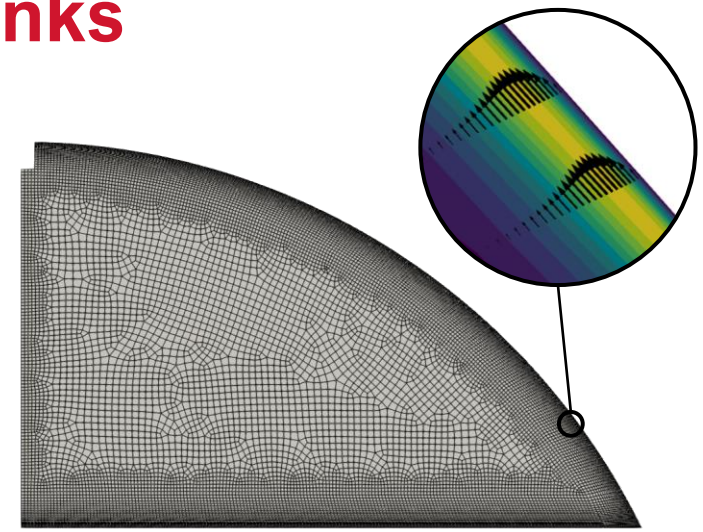
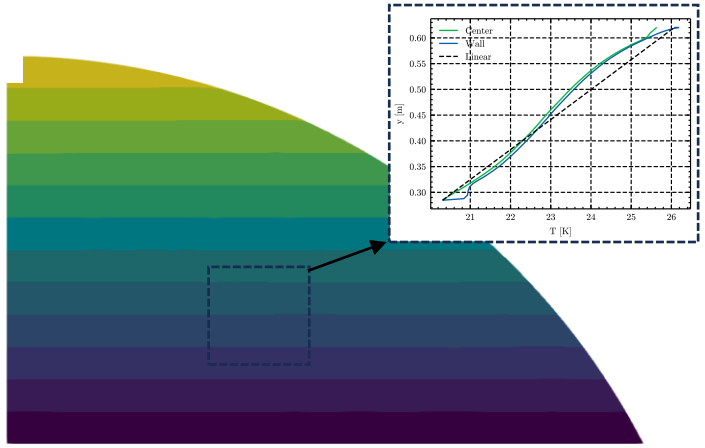
- 2022: MSc Mechanical Engineering (NTNU) – CFD simulations of heat exchangers
- 2022-2023: Master of Science at Sintef Energy Research (CFD, heat exchanger modelling)

Estimated progress of the PhD project:

Just started ... | < 50 % | > 50 % | Almost done ☺





Introduction

To minimize boil-off losses during large-scale storage and transport of liquid hydrogen (LH_2), accurate prediction of evaporation rates and boil-off temperatures is essential.

In my PhD, I use Computational Fluid Dynamics (CFD) to simulate how natural convection influences evaporation and thermal stratification inside LH_2 tanks. Heat ingress through the tank insulation drives convective flow in the gas phase, enhancing heat transfer to the liquid surface and accelerating evaporation.

These flows are highly transient, can transition to turbulence, and span a wide range of spatial and temporal scales. Due to the cost and safety challenges of detailed LH_2 experiments, CFD can be a valuable tool to predict flow behaviour under various conditions.

Primary objective

- Use CFD (OpenFOAM) to predict evaporation and thermal stratification in LH_2 storage tanks

Secondary objectives

- Use CFD to improve accuracy of heat transfer correlations in thermodynamic models of larger tanks
- Use two-phase direct numerical simulations to model effect of wall superheat on phase change during sloshing conditions.

Publications

- Espelund, J., Gjennestad, M., Blakseth, S., & Netzer, C. (2024, November). Assessment of turbulence models for evaporation and stratification in cryogenic storage tanks. In *APS Division of Fluid Dynamics Meeting Abstracts* (pp. J32-001). (conference presentation)

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