

ADP, Master Thesis

Novel Lightweight Design Concepts for Cryogenic Hydrogen Tanks with Superellipsoidal Geometry

Neuartige Leichtbau-Designkonzepte für kryogene Wasserstoffbehälter mit superellipsoidaler Geometrie

Problemstellung

While green hydrogen has proven to be a promising energy carrier for achieving net-zero emissions, a critical bottleneck on the path to a hydrogen economy remains safe and cost-effective storage. Super-ellipsoidal storage tanks offer enhanced geometric flexibility compared to conventional cylindrical vessels and thus present a promising approach for storing cryogenic hydrogen (LH_2). However, exposure to extremely low temperatures ($\sim 15\text{K}$) induces severe stress concentrations.

To address these challenges, advanced tank designs incorporating vacuum insulation, liners, and composite-overwrapped pressure vessel (COPV) technology are under investigation. In particular, the manufacturing techniques associated with COPVs (filament winding, braiding, etc.) must be assessed for compatibility with complex super-ellipsoidal geometries.

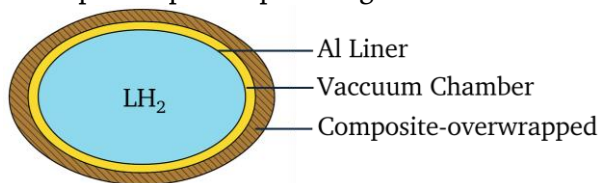


Figure 1: Cross-section view of an advanced tank concept

Tasks

The goal of this work is to develop and evaluate novel design concepts for cryogenic hydrogen storage tanks with super-ellipsoidal geometries. This includes identifying critical design parameters and evaluating stress distributions through FE simulations. Transient thermal loads as well as manufacturing processes need to be considered.

The problem statement leads to the following subtasks, which will be addressed in this thesis:

- Introduction to curved composite structures and parameterised numerical modelling (CAD/CAE)
- Literature review on advanced tank design concepts for LH_2 vessels and manufacturing of composite-overwrapped storage vessels
- Implementation of fully parameterised 2D and 3D numerical models of storage vessels for structural analysis
- Conducting parameter studies for a comprehensive evaluation of the resulting stress fields
- Documentation, discussion, and critical assessment of the modelling approach

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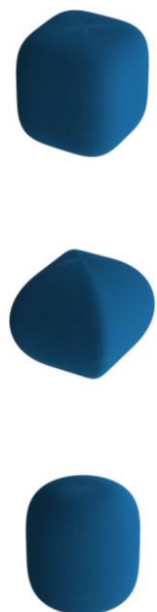


Figure 2: Various superellipsoidal geometries