fen research | Green Energy Center | universität innsbruck | AB Technische Mathematik

Master's thesis

Shape optimisation of hydrogen drone fuel tanks (funding possible)

Shape optimisation aims to find the optimal geometry for a given object, subject to physical, practical or legal constraints. This project combines modelling, finite element simulations and techniques for shape optimisation to propose the geometry for the hydrogen fuel tank mounted on a drone [5, 3].

The project will be in close cooperation with the Green Energy Center and FEN Research, who provide data and embedding in current industrial research on sustainable energy systems. Depending on the outcome, a prototype for the tank may be 3D printed by partners in the *Wasserstoff-Drohne* project (`hydrone.at`).

Background

Unmanned aerial vehicles, commonly known as drones, are increasingly employed for tasks from delivery and observation to emergency support. The usefulness of drones is often limited by the short flight times and slow recharging possible with standard Lithium polymer batteries. Hybrid power supply systems composed of Polymer Electrolyte Membrane (PEM) hydrogen fuel cells and batteries can decrease the weaknesses of strictly battery powered systems. They combine the advantages of hydrogen (high energy density, light weight, fast refuelling) with the constant specific energy of a battery powered system.

Commercially available hydrogen drones are mostly equipped with standard cylindrical hydrogen tanks. Due to their shape they can only be mounted above or below the drone platform, with potential negative impact on flight stability.

Figure 1: Prototype hydrogen drone, *Wasserstoff Drohne* project [1]. ©TWINS GmbH.

Directions

Depending on the student's interests, the thesis may investigate the optimal shape or mechanical stability of the fuel tank:

1. Shape optimisation

   Optimise the geometry of the fuel tank to maximise the amount of hydrogen while minimising the weight of the tank. This requires the finite element modelling of the tank's elastic behaviour, models of constraints, and to learn about state-of-the-art optimization methods.

2. Mechanical stability and safety

   Numerical analysis: Develop efficient and reliable finite element methods [2, 4]. Modelling: Apply them to compute the mechanical stresses and material failures of the fuel tank.

Prerequisites

Numerical methods or optimisation, some coding experience.

Funding

Part-time employment (geringfügige Beschäftigung) is possible, but not required.

Contact

Univ.-Prof. Dr. Heiko Gimperlein (heiko.gimperlein@uibk.ac.at)
Dr Kieran Quaine (kieran.quaine@fen-research.org)

References

[1] Mario Döller. Hydrogen drone development of a hydrogen-powered drone with a spherical tank design. Date Accessed 07/06/2023.

[2] M. Iqbal, H. Gimperlein, M. Shadi Mohamed, and O. Laghrouche. An a posteriori error estimate for the generalized finite element method for transient heat diffusion problems. *International Journal for Numerical Methods in Engineering*, 110(12):1103–1118, 2017.

[3] Youngheon Lee, Eu Tteum Park, Jinseok Jeong, Hayoung Shi, Jeong Kim, Beom Soo Kang, and Woojin Song. Weight optimization of hydrogen storage vessels for quadcopter UAV using genetic algorithm. *International Journal of Hydrogen Energy*, 45(58):33939–33947, 11 2020.

[4] Kieran Quaine and Heiko Gimperlein. Space–time enriched finite elements for elastodynamic wave propagation. *Engineering with Computers*, pages 1–15, 2023.

[5] Ashleigh Townsend, Immanuel N. Jiya, Christiaan Martinson, Dmitri Bessarabov, and Rupert Gouws. A comprehensive review of energy sources for unmanned aerial vehicles, their shortfalls and opportunities for improvements. *Heliyon*, 6(11):e05285, 2020.