Chair of Carbon Composites
TUM School of Engineering and Design
Technical University of Munich

Bachelor's Thesis, Term Paper, Master's Thesis

Analysis of influences on winding layups with different geometrical properties and subsequent testing

Fiber-reinforced polymer (FRP) composites, renowned for their exceptional strength-to-weight ratio, are increasingly employed as load-bearing structural elements in both the aerospace and automotive sectors. In recent years, both industries have witnessed a growing demand for composite overwrapped pressure vessels (COPVs), driven by economic, environmental, and competitive considerations. This rising demand has not only intensified market competition but also elevated the technical and regulatory requirements associated with these components. Consequently, new challenges have emerged across the entire value chain. To address these evolving demands and to enable further innovation and optimization, a comprehensive understanding of the design, development, and manufacturing processes of COPVs is essential.

In this research, key factors affecting the filament-winding process will be investigated. These include machine and CAM parameters such as winding speed, mandrel rotation, and fiber tension, as well as process-related influences like stacking sequence, compaction force, steering limits, and the interaction between fiber path and mandrel geometry. These factors were observed as crucial in previous research conducted at the LCC and will directly influence the development of a novel state of the art winding software you will work with.

Suitable characterization method, ranging from microscopy to mechanical testing, will be selected through a review of literature and relevant standards. Small-scale demonstrators with defined winding patterns will then be manufactured and tested to quantify how design variables such as core geometry, winding angle, and layer architecture affect manufacturability and structural performance of composite pressure vessels.

Figure 1: Volvo hydrogen concept truck [volvotrucks.de]

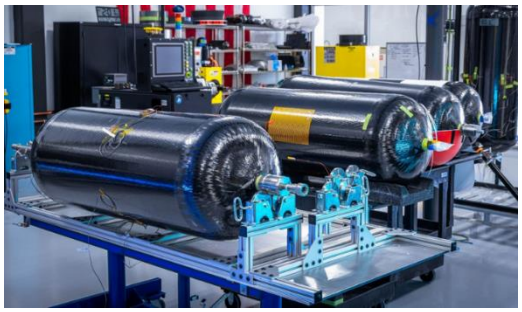

Figure 2: COPVs for spacecrafts [dawnaerospace.com]

Research focus of the thesis

- Research of influences on the laminate layup during and after the winding process
- Selection of testing methods based on current literature
- Creation of winding patterns with a novel winding software
- Winding and testing based on a schedule created beforehand

Requirements

- Reliable, analytic and independent way of working
- Good knowledge of mechanics and composites
- Experience with programming and data processing is beneficial (e.g. Python, Matlab)
- Knowledge of winding processes and testing of composites is beneficial
- Practical experience in student initiatives is beneficial

Starting date: January 2026

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