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

Bachelor's Thesis, Term Paper

Evaluation of Filament Wound Structures Focusing on Fiber Volume Fraction and Ply Thickness

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, the effects of various manufacturing parameters - such as fiber tension, winding time, winding patterns, and variations in the curing process - will be investigated with respect to compaction and void content. Newly manufactured filament-wound structures produced under different parameter settings, chosen after a literature review, will be analyzed alongside existing components. To ensure scientifically reliable imaging, all samples will be prepared through resin embedding and sanding. The subsequent microscopic analysis will focus on key parameters, including cured ply thickness, fiber undulations, and fiber volume fraction. These findings will be interpreted and benchmarked against results from the literature, compared with existing strength data, and potentially validated through additional structures that will be manufactured and tested in a later phase of the research.

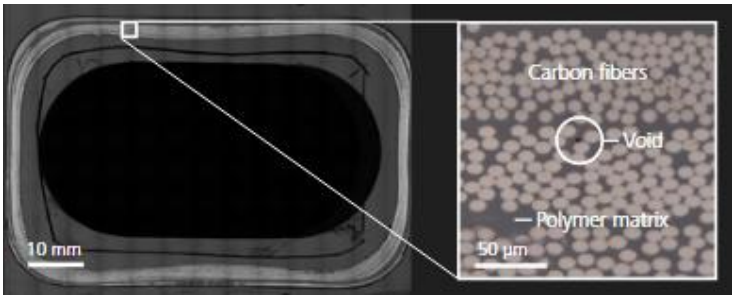

Figure 1: Microscopic image of a composite cross section [zeiss.de]

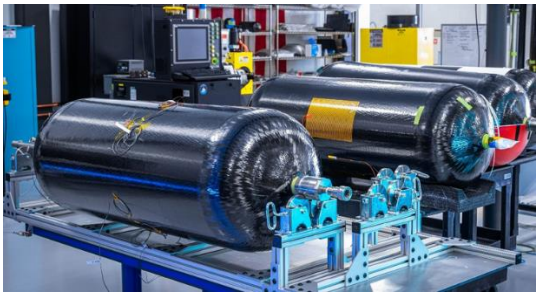

Figure 2: COPVs for spacecrafts [dawnaerospace.com]

Research focus of the thesis

- Research of influences on the laminate of wound structures
- Creation of embedded samples for the creation of microscopic images
- Conduction of thermal testing to determine the fiber volume fraction
- Interpretation and comparison of the results with current literature
- Verification of the gained data with newly manufactured samples

Requirements

- Reliable, analytic and independent way of working
- Good knowledge of material sciences and composites
- Experience in programming and data processing is beneficial (e.g. Python, Matlab)
- Practical experience in student initiatives is preferred

Starting date: As soon as possible

For more details please contact:
Kevin Banea, Room 5504.01.434, Fakultätsgebäude MW, Tel. +49 89 / 289 - 15128, kevin.banea@tum.de