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

Pressure Tanks, Vessels and Conduits

Materials, characterization, design and processes for sustainable mobility

Motivation

Pressure vessels made of composite materials are becoming increasingly important. Lightweight carbon fiber-reinforced plastics (CFRP) are of great relevance here, especially for mobile hydrogen applications. In order to meet the industry-specific requirements, it is necessary, for example, to save material and costs, as well as to develop faster and more robust processes.

Goals

- Optimization of manufacturing processes
- Development of innovative manufacturing and design concepts
- Weight and cost reduction of pressure vessels

Applications

Aerospace Automotive Oil & Gas

Development and processing of new material systems

The development of new material systems for CFRP pressure vessels is important to ensure good processability and to improve the performance, operational safety and sustainability of tanks. The further advancement of the towpreg manufacturing process, for example, offers potential to achieve high material quality at fast process speeds. New, more sustainable material systems and processes enable the production of tanks with a better environmental impact. At the LCC, for example, bio-based materials are being investigated with regard to their mechanical and process-technological suitability for pressure tanks. The aim is to produce materials that offer high strength, stiffness and resistance to extreme conditions, yet are weight- and cost-efficient as well as sustainable.

Characterization

At the LCC, standard tests can be performed to generate material data for tank laminates. These tests are usually carried out on flat samples. If, for example, the influence of fiber tension during wet winding is investigated, the so-called split-disc test can be used. This allows a tensile test to be carried out on cylindrical specimens. In addition to existing characterization methods, own test methods are also developed at the LCC, for example, to determine the tack of the developed towpreg.

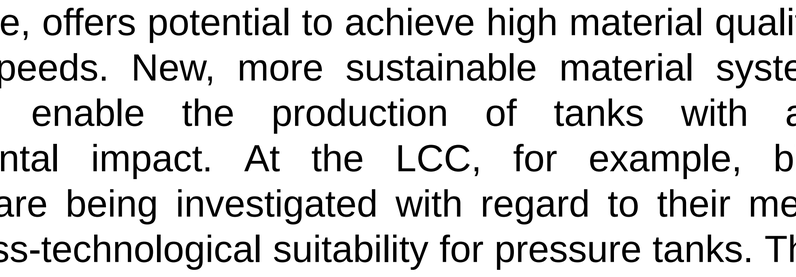

Fig. 1: Principle of the split-disc test.

Design and simulation

The stringent cost and safety criteria for pressure vessels require a deep understanding of the mechanical properties of the CFRP structure. Finite element analysis focuses on the study of static stiffness, stress analysis and damage modelling. To develop more cost-efficient tanks, liner geometry and fiber layup can be optimized in terms of stiffness, strength and lightweight objectives.

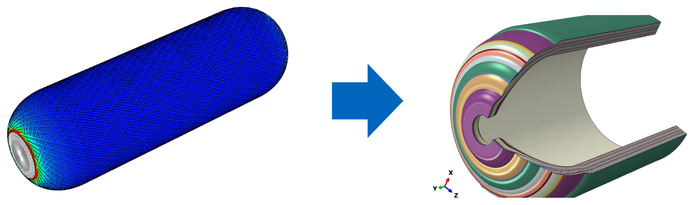

Fig. 2: Model of winding path for process simulation (left) and pessure vessel layup for mechanical simulation (right).

Manufacturing Technology

According to the current state of the art, pressure tanks are manufactured using the wet winding process. As an alternative to wet winding, pre-impregnated tows, so-called towpregs, can be used. By separating the winding and impregnation step, faster process speeds and a more uniform impregnation can be achieved. The towpreg machine at the LCC enables a complete representation of the process chain, from production of customized towpregs, through processing to the finished component.

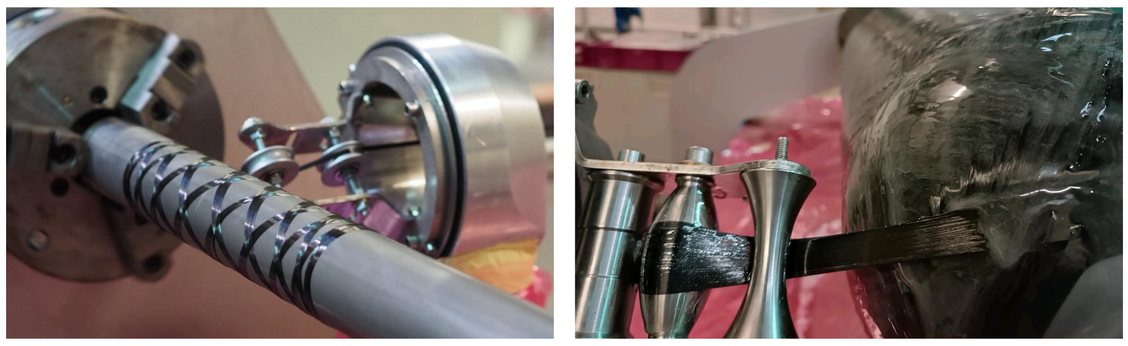

Fig. 3: Setup for towpreg winding (left) and wet winding (right).

The robotic thermoplastic automated fiber placement process (TP-AFP), opens up possibilities for the production of tanks with thermoplastic matrix material. The TP-AFP process is an in-situ process in which the tape is consolidated directly at deposition using a laser. This means that layups can be realised that deviate strongly from the geodesic path and even large structures can be optimally produced.

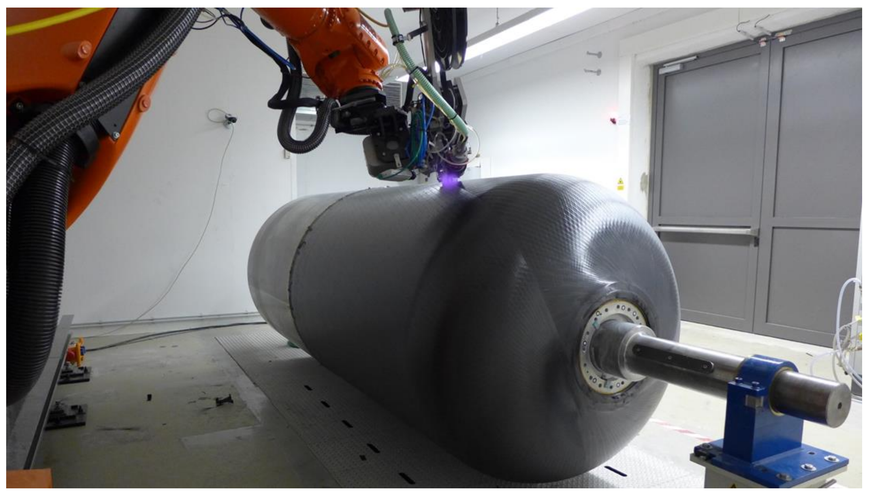

Fig. 4: Thermoplastic automated fiber placement machine at LCC.

Furthermore, the LCC is working on processes for novel tank designs e.g. to conform designated installation spaces, resulting in pressure vessels that deviate from the conventional cylindrical shape.

More information and contacts: