Composite Overwrapped Pressure Vessel (COPV) Development

Cryogenic COPV development with additively manufactured Propellant Management Devices (PMD)

Graduate

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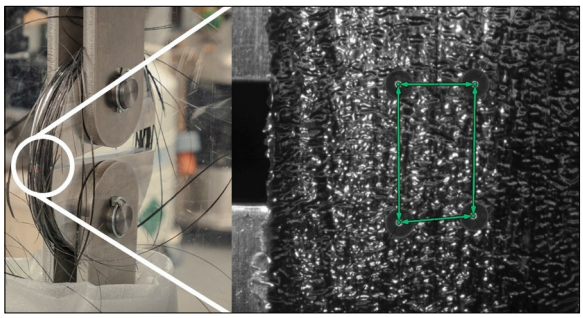
Introduction: Composite Overwrapped Pressure Vessels (COPVs) offer significant mass-saving potential compared with metallic propellant tanks. Their development combines composite design, filament winding, liner technology, structural simulation, manufacturing and experimental validation. This thesis establishes the fundamental capability for COPV development at OST, with the long-term objective of lightweight propellant tanks with integrated Propellant Management Devices (PMDs). The methods were transferred to a full-scale ethanol COPV for the ARIS ASTERIA rocket.

Objective: Establish a complete design, simulation, manufacture and test workflow for COPVs. This included commissioning a filament winding machine, material characterization using non-standard tensile tests, optical (GOM) and fiber (FBG) sensors, and structural design using analytical and FEM methods. Development progressed from material specimens to dummy and burst-test tanks and finally the full-scale ASTERIA tank, including liner/core concepts, composite-metal interfaces, filament winding and autoclave curing.

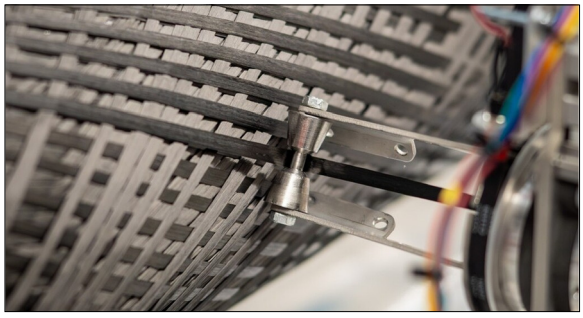
Result: A complete COPV development workflow was established, including 21 tensile specimens, four dummy tanks and three burst-test specimens. FEM predicted delamination failure of the burst-test vessel at 30 bar, while first experimental leakage occurred at 36 bar (+20%). The vessel was subsequently pressurized to 54 bar without catastrophic rupture, supporting the conservative simulation approach while identifying liner leak-tightness as a remaining challenge.

The workflow was transferred to the full-scale 60 bar ASTERIA COPV. The manufactured tank achieved 2.93 kg compared with 5.65 kg for the reference steel tank, corresponding to a 48.7% mass reduction. Manufacturing and simulation identified remaining limitations in low-angle winding, fiber placement, liner sealing and structural design. The prototype therefore provides a development demonstrator and foundation for future flight-qualified COPVs at OST.

Tensile test specimen with GOM illustration
Own presentment



Filament winding
Own presentment



ARIS Asteria rocket with COPV
Own presentment

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Subject Area
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