Design Optimisation and Experimental Testing of Composite T-joints

Master's thesis project — HEIG-VD COMATEC / EPFL LPAC

Context

Within the Innosuisse CompImpH2 project, Greene Tweed and the HEIG-VD aim to manufacture high-speed impellers made from thermoplastic composites. Numerical and experimental studies have shown that one of the critical drivers of impeller failure is the blade-to-disk interface, which behaves structurally as a T-joint. Designing, optimising and testing various T-joint sub-element families will therefore help identify the critical stress states and the most important geometric parameters that drive failure at this interface. This approach remains tractable for manufacturing and testing and could ultimately lead to critical structural improvements for the impeller.

Project scope

The thesis combines computational design and experimental mechanics on an active industrial problem. The student will build a parametric finite-element optimisation pipeline, the core deliverable, and apply it to produce 2 to 3 T-joint geometries ready for manufacturing. Alongside this, existing T-joint specimens will be tested under quasi-static loading with full-field DIC, providing both the experimental data that anchors the optimisation and direct hands-on experience of structural failure testing. Subject to Greene Tweed's manufacturing timeline, the most promising designs could also be fabricated and tested, closing the loop between numerical prediction and experiment.

Tasks

- **Literature review** on T-joint design and failure in composite structures, focused on geometries representative of blade-disk-type interfaces.
- **Numerical framework and optimisation pipeline:** consolidation and extension of the parametric Abaqus framework into a formal optimisation pipeline; parametric optimisation of T-joint geometry families; topology optimisation as a stretch goal.
- **Experimental campaign** (existing geometries): quasi-static testing with full-field DIC of existing T-joint specimens; extraction of damage-onset states to inform and ground the optimisation.
- **Manufacturing handoff:** technical specification of the optimised geometries and coordination with Greene Tweed on the fabrication schedule.
- **Conditional validation campaign** (if compatible with the manufacturing timeline): quasi-static testing of fabricated optimised geometries and comparison with numerical predictions.
- **Reporting** and final defence.

Prerequisites

This project suits a student with a background in solid mechanics and an interest in composite materials, who is comfortable with Python and has some FEA experience (prior Abaqus exposure is a plus). An appetite for experimental work is a real asset — hands-on testing is a significant part of the thesis, though no prior DIC experience is required. The student will work within an established numerical framework and coordinate with an industrial partner, so autonomy and effective communication are important.

Practical information

Duration: Standard EPFL master's thesis, 17 to 25 weeks (TBD) + 1 mandatory week of vacation, full-time.

Location: HEIG-VD, Yverdon-les-Bains. On-site presence expected; the student will be embedded in the COMATEC research group.

Supervision: Day-to-day by Pierre-Alexandre Boschert (PhD candidate, COMATEC/LPAC). Academic: Prof. Joël Cugnoni (HEIG-VD COMATEC) and Prof. Véronique Michaud (EPFL LPAC).
Contact: pierre-alexandre.boschert@epfl.ch

Manufacturing: One or more reference geometries will be made available at the start of the thesis. The fabrication of the student-optimised geometries by Greene Tweed is subject to industrial scheduling and will determine whether the conditional validation campaign is feasible within the duration of the thesis.