EXFAN

NOVEL RECUPERATION SYSTEM TO MAXIMIZE
EXERGY FROM ANERGY FOR FUEL CELL POWERED
GEARED ELECTRIC AIRCRAFT PROPULSION SYSTEM

NEWSLETTER

THE WINTER ISSUE 2025 (#01)

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ONE YEAR OF EXFAN: REDEFING THERMAL MANAGEMENT & EFFICIENCY

The exFan project marks the completion of its first year with significant steps in advancing hydrogen-electric propulsion for the aviation industry. This ambitious EU-funded initiative unites 10 leading partners across Europe to address critical challenges in aviation propulsion systems, focusing on innovative solutions for cleaner, more efficient flight.

Over the past year, the consortium has made progress in developing advanced thermal management systems, optimizing fuel cell integration, and exploring the complexities of performance under diverse flight conditions, including high-altitude cruising and hot-day take-offs.

By combining expertise in engineering, materials science, and environmental assessment, exFan is providing solutions that contribute to reducing emissions, enhancing fuel efficiency, and enabling the use of renewable energy in aviation.

The project aims to advance air transport by laying the groundwork for hydrogen-electric propulsion in future aviation.

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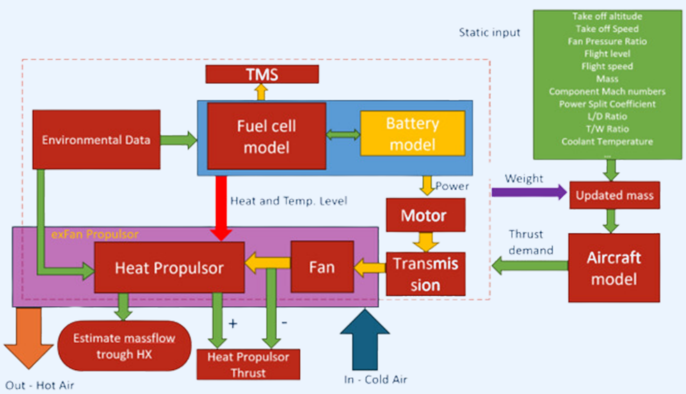
WP3 BALANCING PERFORMANCE AND EFFICIENCY

Key Highlights

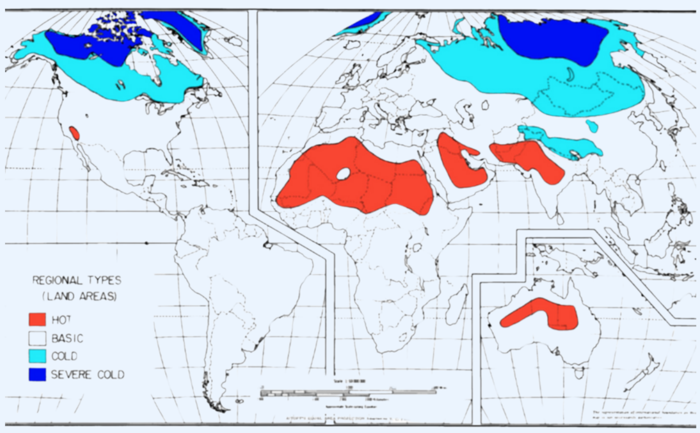
- The ambient temperature significantly affects the performance and mass of the aircraft using the exFan propulsion system.
- A detailed aircraft model was developed by combining contributions from all partners for their respective components, fused together by TU Wien.
- Two key operating conditions were analyzed: take-off and cruise.



Block diagram of the exFan system including the Thermal Management System (TMS)

Main Results & Achievements

- The low operating temperatures of PEM fuel cells (PEMFC) pose challenges during hot-day take-off due to the large heat exchangers needed to dissipate excess heat.
- Larger heat exchangers increase system mass and pressure losses, leading to inefficiencies during cruise.



Using a tool based on ISA and MIL-HDBK-310 was designed to predict real-world conditions

Potential Solution

System hybridization by integrating batteries for peak load conditions (e.g., take-off):

- Advantages: Smaller heat exchangers, reduced pressure losses during cruise, and improved propulsive efficiency.
- Trade-offs: Additional battery weight increases overall aircraft mass, requiring careful balancing.

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WP4 UNDERSTANDING SYSTEM INTERACTIONS

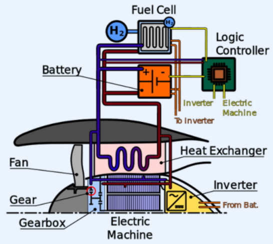
Key Highlights

- **Sensitivity analysis** to understand how components interact and impact the total system mass and power demand.
- **Component Modeling**: Developed models for key parts of the exFan system, including:
  - Thermal management system
  - Gearbox
  - Electric motor
  - Flowpath
  - Heat propulsor
- **Preliminary Concept**: Created an initial design for the exFan propulsion system.
- **Environmental Insights**: Gathered Life Cycle Assessment (LCA) data to evaluate environmental performance.

Main Results & Achievements

The **fuel cell** and **thermal management** system significantly affect the demanded overall mass. **Heat recuperation** efficiency is strongly influenced by **heat exchanger** and **flowpath design**.

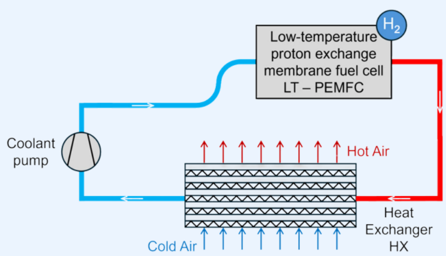
- Selecting the Mach number at the heat exchanger was shown to be crucial for optimizing performance.
- Integrating the heat exchanger within the ducted fan improved performance but increased weight, affecting efficiency gains.



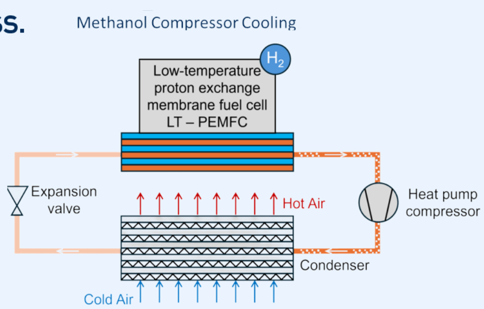
Proposed exFan technology concept

For the thermal management system, direct liquid cooling may not be feasible for hot-day conditions.

- Two-phase cooling systems show promise in improving heat transfer and reducing thermal management system (TMS) mass.

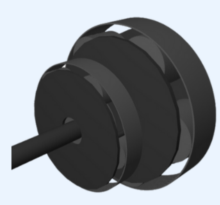


Liquid coolant cycle, baseline for TMS-design



Heat pump system to raise heat quality, reduce heat exchanger size

- Electric motor and gearbox concepts were compactly designed, nearing the desired power densities for future SMR (Small Medium Range) aircraft.



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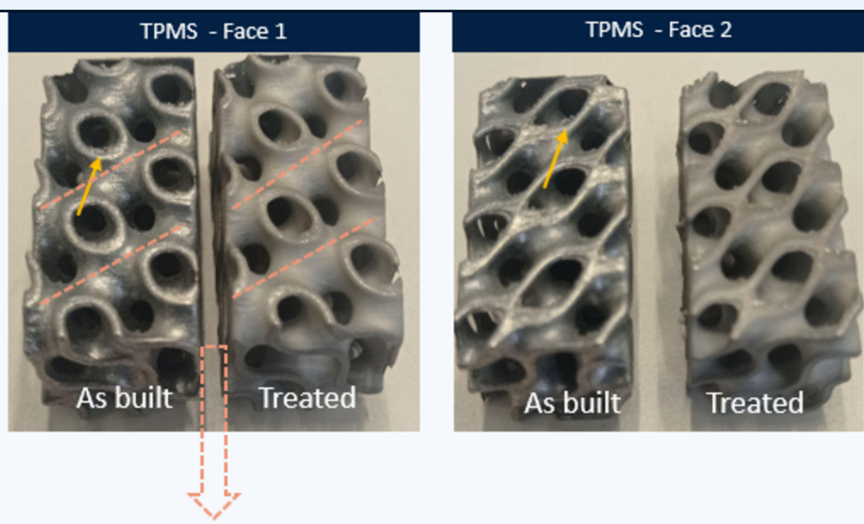
WP6 ADVANCING HEAT EXCHANGE EFFICIENCY WITH SURFACE COATINGS

Key Highlights

- **Chemical surface treatmen**t methods selected to **enhance heat exchanger performance**".
- Studied chemical treatments to **modify surface roughness** of AlSi10Mg alloy (L-PBF technology).
- Developed electroless nickel (Ni-P) **coatings** to protect AlSi10Mg alloys, achieving coatings with **different thicknesses** and **good adhesion**.
- Tested treatments on TPMS structures to **ensure uniform surface modification in complex geometries**.

Main Results & Achievements

- Modulated surface roughness on AlSi10Mg alloys to analyse its impact on heat transfer and pressure loss.
- Developed NiP coatings demonstrate good adhesion and the potential to enhance heat exchanger performance by protecting against wear and foulings.



Roughness	As built	After chemical treatment
Ra (µm)	5,53 ± 1,74	3,87 ± 0,72
Rz (µm)	39,76 ± 14,29	19,91 ± 3,03

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NEXT STEPS FOR THE EXFAN PROJECT

The next steps focus on tackling critical challenges and advancing the exFan propulsion system:

- **Hot Day Take-off Solutions (WP4)**: Focus on addressing challenges with battery hybridization and optimizing fan pressure ratios for different flight phases .
- **Heat Exchanger Improvements (WP4)**: Reduce heat exchanger size for more efficient nacelle design
- **System Enhancements (WP4)**: Enhance power density and fuel cell efficiency under high load, refining the exFan concept with the latest results..
- **Coating Evaluation (WP6)**: Evaluate Ni-P coating properties and thermal conductivity of AlSi10Mg/NiP system for improved heat exchanger performance

CONTRIBUTION TO THE EXFAN SCOPE

WP3, **WP4**, and **WP6** play key roles in advancing the exFan system. **WP3** optimizes operating conditions, focusing on "**Hot Day Take-off**" and fan pressure ratios. **WP4** enhances component interaction for a compact, efficient system and increased power density. **WP6** develops advanced surface treatments and coatings for better heat transfer. Together, they provide essential design parameters, efficiency gains, and material innovations for the **exFan project**.

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