PhD in Chemical Engineering

Research Title:
Multi-scale and multi-approach investigation of hydrogen uses in aircraft

Keywords: Electrification, Fuel Cell, Hydrogen Storage, Aircraft, LOHC

Funded by	Leonardo S.p.A.

Supervisor	Alessandro Monteverde, alessandro.monteverdevidela@polito.it Massimo Santarelli, massimo.santarelli@polito.it Pennino Raffaele, raffaele.pennino@leonardocompany.com

Contact	https://www.disat.polito.it/it/la_ricerca/gruppi_di_ricerca/crest/processi_chimici_e_catalitici_per_l_energia_e_la_protezione_dell_ambiente https://www.denerg.polito.it/la_ricerca/gruppi_di_ricerca/gruppo_di_ricerca_m3es

Context of the research activity	In order to meet the increasing demand to reduce fuel consumption, Green House Gas emissions as well as operating and maintenance costs, while optimising aircraft performances, hydrogen technologies are considered as one of the best options for efficient power generation systems in the context of more electric aircraft (MEA). One of the most key objectives of the development roadmap of the aeronautic industry for 2020 to 2050 is the reduction of emission – CO_2, NO_x, SO_x and particulates – with a focus on electrical power supply obtained from renewable energies. In this context, Fuel Cells are outlined as one of the technologies to deliver on-board electrical energy, or an e-APU independent of the aircraft engines. The aeronautic industry will provide a large market for FCH technologies, around 40000 new aircraft will be required in the next 20 years. Adding the potential retrofit market, this will be a significant market for installation and use. Leonardo S.p.A. leading company specialize in aerospace, defence and security is focusing through this PhD their effort in evaluating the next generation of aircrafts.

Objectives	The objective of this PhD is the investigation of the potential, the constraints and the technical feasibility relating to the use of "onboard" hydrogen as an energy carrier on future generation hybrid electric aircraft. The main focus will be on storage technologies, compatible with aeronautical requirements, which allow the maximization of the volumetric density of energy. The study will also analyze how hydrogen can be used in an integrated manner for direct propulsion (eg: hydrogen-powered engines) and fuel cells. To this end, technologies such as high-pressure gaseous storage, cryogenic liquid and chemical storage (i.e: LOHC) will be considered and evaluated through quantitative benchmarking and modeling analyzes. The dual use of hydrogen, for purposes other than propulsion (eg cooling of superconducting electrical systems), will also be taken into account within the study. Your tasks • Development of physics-based level electrochemical-thermal models • Translate the physics-based understanding into models to be implemented in the energy management system • Analyse test data to derive thermodynamic, physical, chemical processes to explain various ageing performance datasets. • Develop innovative techniques to improve accuracy of the models in extreme usage scenarios (e.g. high power output/ low temperatures).

Skills and competencies for the development of the activity	We seek to recruit an individual who investigates the use of hydrogen technologies into aircraft applications. Relevant research areas include, but are not limited to, Fuel Cell; Hydrogen Storage; Synthetic Aircraft fuel (SAF) and Batteries. We expect that you: • embrace the responsibility to plan and execute modelling and experimental research (if needed) • ideally have experience with modelling (ASPEN, MATLAB, CFD Codes such as COMSOL or ANSYS) • have excellent engineering skills and an analytical mindset • are motivated to contribute to technology enabling sustainable energy and fuels • appreciate teamwork and have the ability to interact and collaborate with researchers, laboratory technicians and Leonardo

	engineers in a very cross-disciplinary environment Hydrogen technologies combine several physical-bio/chemical phenomena such as: multiphase flow, radiation transport, mass transport, chemical-electrochemical reactions and heat transfer. It is mandatory to study the system through multiphysics simulations in order to correctly predict energy performance and design the aircraft dimensions. The combination of accurate models with experimental data, will lead to optimize this technology and make it economically applicable.