PhD in Modelling and Control of Aircraft Systems
ECOLE DOCTORALE MEGEP
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PhD: Enhancement of the control laws for electro-mechanical resonant de-icing systems using real-time Hardware In the Loop (HIL) simulations under scaling problematics

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Context/background

Icing occurs when an aircraft flies through clouds containing supercooled droplets while the ambient air temperature is below the freezing point. When the droplets impinge on the aircraft, they freeze and cause ice accretion and may quickly lead to a drop of aerodynamic performances (wing edge) or constitute risk hazard (engine ingestion when accretion detach). To prevent these risks, de-icing systems are implemented to protect critical areas/systems. If they are mostly based on thermal de-icing technologies (hot air taken from the engines or electrothermal mats), the trend toward bleed-less or electric propulsion system means that de-icing should be redesigned with other energy sources and lower power and energy consumption.

One of the solutions under investigation at ISAE SUPAERO/ICA laboratory is electromechanical resonant systems that can be coupled to icephobic coating. The principle of these systems is to apply vibrations onto the structure that create high-level stresses greater than those required to bring about cracks and delamination to remove the ice accumulated on the structure. So far different studies have been carried out numerically and experimentally to understand the mechanisms leading to ice crack propagation [1], [2], [3]. To favour most efficient crack mechanisms and improve total protected area, modal forms of vibration modes have to respect or maximize de-icing criteria through topological optimisation [4], [5].

To assess the effectiveness of electromechanical resonant systems in terms of power/energy consumption and validate first technological readiness levels, computations and tests in wind tunnel bench are on-going in the icing wind tunnel facility [6], [7] of SUPAERO and ICA.

Objectives of the thesis

Most of wind tunnel facilities cannot be used to test a complete aircraft wing leading edge: only a reduced-scale section can be integrated for de-icing analysis. Therefore, to assess the performance of de-icing systems on large structures, scaling analysis should [8] be conducted. This problem represents one of the thesis objectives: one goal is to develop a method to design reduced experiments that are representative of the different analysed phenomena (mechanical dynamics, power flow, substrate/ice/actuators interactions) and techniques for scaling the extracted results. The second objective of this PhD work will be to develop real-time models and simulations (digital twins) to compute the power requirement at the aircraft level of the implementation of such resonant systems for protecting a real section. The computation will be carried out while analysing tests performed on the reduced-scale section in the wind tunnel test. This will enable the optimisation of the control process to minimize the power consumption. The difficulties here relate to very different dynamics involved (vibration, crack propagation, electric power-flow) and high-fidelity models such as FEM that need to be reduced for real time computation.

The third objective of this PhD concerns the assessment of the impact of the use of coatings in combination with resonant ice protection systems. Icephobic coatings can decrease the adhesive strength of ice to the substrate, which can be beneficial in reducing the power requirements of such systems.

The PhD student will have the opportunity to work in the ICA laboratory while joining the DCAS group at ISAE-SUPAERO.

Candidate profile

English-speaking students with a master degree in Mechanical or Aerospace Engineering, with a good knowledge in dynamics modelling (FEM analysis), Matlab/Simulink software.

A first experience in real-time simulation and coding (Python, C++) will be appreciated.

Conditions of employment

A full-time employment for three years, including:

- A gross monthly salary and benefits in accordance to the ISAE-SUPAERO standard
- Host institutions: ISAE-SUPAERO (Toulouse, France), Department of Aerospace Vehicles Design and Control (DCAS)& &ICA (Institut Clement Ader)
- Collaboration within the project with aeronautical industrial partners (Airbus, Safran, Liebherr) & IRT Saint Exupery

Candidates are expected to start around October 2023.

Application

All applications should be compressed (.zip, 10MB max.) and submitted by email to the addresses below, including:

- Cover letter including a statement of purpose
- Detailed curriculum vitae with previous experiences
- Course transcripts
- At least 1 recommendation letter

For more information regarding this position, please contact:

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References

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[8] M. Cabello, X. Roboam, S. Junco, E. Bru and F. Lacressonniere, “Scaling Electrochemical Battery Models for Time-Accelerated and Size-Scaled Experiments on Test-Benches,” *IEEE Transactions on Power Systems,* vol. 32, no. 6, pp. 4233-4240, 2017.