Thesis proposal:
Numerical method for the modeling, design and dimensioning of resonant electromechanical de-icing systems

This thesis addresses the problem of designing resonant electromechanical de-icing systems based on new actuator or new architectures. The electromechanical de-icing system studied will be initially based on piezoelectric actuators, but could be open to other technologies. The principle of resonant electromechanical de-icing systems is as follows. Powered AC voltages, the piezoelectric actuators vibrate and excite the structure at a given frequency. When this corresponds to one of the structure's natural frequencies, the amplitude of the vibrations increases thanks to the resonance phenomenon, generating high levels of stress and strain, ultimately exceeding the mechanical strength of the ice and leading to ice shedding (Figure 1).

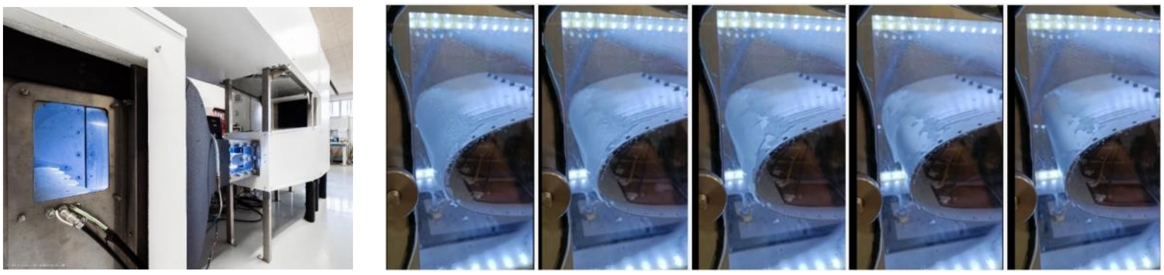

Figure 1 – Test in icing tunnel

In order to design an efficient and low-consumption resonant electromechanical de-icing system, a number of subjects come into play: ice fracture and debonding mechanisms, damping modeling, assembly of the actuator with the structure, impact resistance, maintainability of the technology.

Objectives

The first objective of this thesis is to **develop a method for the robust and predictive modeling of electromechanical system performance**. It required a detailed understanding of ice fracture and debonding mechanisms, and of the actuator/structure coupling. The aim of this methodology is to enable the design of an optimized system that meets aircraft-level requirements. This method will be developed through an iterative process of modeling and experimental confrontation. Numerous experimental tests will be carried out to identify the system's key physical parameters.

The second objective is to **develop a prototype** that could demonstrate, for different icing conditions, effective ice protection at low power consumption and short activation time leading to low overall energy consumption.

Planning

The thesis will be carried out over a three-year period, as follows:

- [T0 - T0+2] Bibliographical study of the latest advances in electromechanical de-icing to identify the most relevant systems (structure, actuators).

- [T0+3-T0+15] Study of fracture mechanisms, electromechanical coupling, damping and losses in assemblies. Identification of critical system parameters to be controlled. A methodology based on numerical models and tests on basic demonstrators will be set up to identify these, firstly in simplified configurations and, secondly, on industrial ones.

- [T0+16-T0+28] Implementation of the modeling method developed during the first phase of the thesis to study the design of an architecture enabling the de-icing of a demonstrator at the final product scale. Validation of the study by tests in an icing wind tunnel.

- [T0+29-T0+36] Capitalization of work carried out, publication of key results and writing of thesis manuscript.

Candidate

The candidate must have an engineering or master degree in mechanics or aeronautics.
The candidate must be rigorous and possess good skills in scientific computing and numerical simulation. He/she should be self-reliant and comfortable with experimental handling.
A good level of English is required.

Location

Toulouse

Start & Duration of the project

Start: Last quarter of 2024
Duration: 36 months

Supervision

Marc Budinger (INSA Toulouse), Valérie Pommier-Budinger (ISAE-SUPAERO) and 1 industrial partner

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