PhD position @ ISAE-SUPAERO

Effect of flexibility on the performance of a rotor blade

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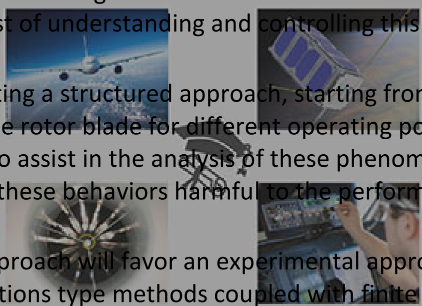
Scientific domain: Aerodynamics, Fluid structure interaction

Keywords: Aerodynamics, Fluid structure interaction, rotor, blade

Summary: In the case of a flexible blade, the structural properties of the blade determine the main modes of bending and twisting. For some operating points (i.e. for certain rotation speed and advance ratio), these modes may be excited and lead to flutter instability. In this case, the blade stalls uncontrollably and aerodynamic performance is severely degraded. This problem is general to rotors. However, it takes an even more significant scale in the context of passively adaptive blades (the blade is deformed under the centrifugal effect of rotation to operate at optimal effective incidence over a wide range of operating points). One of the consequences of these behaviors is the divergent aeroelastic flutter of the structure which can cause the destruction of the blade. The interest of understanding and controlling this phenomenon is therefore essential.



The thesis work will consist of adopting a structured approach, starting from the analysis, understanding and modeling of the behavior of a flexible rotor blade for different operating points. Experimental and numerical means will be developed and used to assist in the analysis of these phenomena. A control strategy can be implemented in order to overcome these behaviors harmful to the performance of the rotors.

On the methodological level, the approach will favor an experimental approach completed by numerical simulations by Navier-Stokes simulations type methods coupled with finite element methods.

From an experimental point of view, the tests will be conducted jointly with the Clément Ader Institute (UMR CNRS 5312) and the Department of Mechanics of Structures and Materials at ISAE-Supaéro, on an existing rotor test bench. This test bench makes it possible to carry out global measurements (performances, efforts), local measurements embedded in the blades (network of accelerometers, pressure), as well as structural measurements of dynamic deformations by camera and rotary vibrometer. These measurements can thus be used to validate the computation results in strong coupling, but also as forcing in a weakly coupled computation. Modal analysis would allow us to determine the frequencies and deformations for the future control of the structure. The tests will be carried out on a rotor configuration at the fixed point (zero advance speed), but in a second step, a measurement campaign can be envisaged in the Aero-Acoustic Wind Tunnel of ISAE-Supaéro (SAA).

Concerning the numerical point of view, the Department of Aerodynamics and Propulsion (DAEP) of ISAE-Supaéro, as well as the laboratory of the IRPHE of Marseille, develops codes of interaction fluid-structure, mixing calculations of the type Navier-Stokes for the fluid, at finite element resolutions for the dynamic part of the structure. The experimental databases will allow a validation of these calculations as well as a fine modeling of the phenomena.

The challenge of this thesis will be to carry out experimental and numerical campaigns on controlled rigidity rotor configurations in order to achieve a thorough understanding of the phenomena involved as well as a model reduction intended both for the design of adaptive rotor blades and development of optimal control means.