**AIRFOIL FLOW CONTROL**

**BY**

**Sweeping Jets Actuators**

A bench-test implementation

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**Motivations and objectives**

**Sweeping jets actuators:**
Fluidic oscillators that spread air at their exit. Controlled only by the internal pressure, the oscillation occurs without moving parts, thanks to lateral channels that create instability inside. Resonance occurs at high frequencies (kHz) after the air reaches the speed of sound at the nozzle.

**Airfoil Flow control:**
Static measures have proved particularly effectiveness in changing the lift and flow reattachment on winged profiles. However their dynamic characterization seems to remain not yet fully understood.

**Objectives:**
Provide a tool that allows to investigate aerodynamic effects in order to exploit their actuation capability. Better understanding the dynamic could in the future provide more efficient application as the increase in wind energy production.

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**Wind-Tunnel**

**Specifications:**
The tunnel developed for the bench-test is in open configuration (Eiffel Design) with active wind-speed control capability. We could define it as a SMART-Wind-Tunnel. Varying the incoming wind-speed allows simulate and study precisely wind fluctuation phenomena that can happen in reality. Can reach speeds up to 20m/s in the test section.

**Wind-speed dynamic:**
A pressure sensor measures the pressure variation in the converging section by operating the propeller motor. Its dynamical response can be approximated to a first order linear system.

\[
\frac{d}{dt} p_x(t) = -\frac{\partial x}{\partial t} + \frac{\partial x}{\partial U} \frac{d}{dt} U(t)
\]

The pressure model is converted into the non-linear wind-speed dynamics according to physical relationships.

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**Experimental application:**
Wind-turbine oscillation: Wind-turbine blade are subjected to periodic load variation due to the gradient of the velocity profile. This cause structural efforts that reduce life cycles.

Active flow control:
The wind-tunnel allows to recreate these conditions. It is so possible to study how to control the Lift with active controls actuated by sweeping jets. Techniques to reduce the effects of wind-speed fluctuations on the wing have been tested. For example by modulating the pressure instead of fixing it at a constant value.

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**Results and Conclusion:**
Active flow control techniques show dumping capacity on the Lift oscillation of around 37% compared to static control. With the same amount of air in average it result in an effective and efficient way to reject wind-speed oscillations.

The bench-test has demonstrated to be an important tool to deepen the experimental effect of sweeping jets as actuators in active flow control. The advantage of not having mechanical parts allows a faster and efficient ability to attenuate wind fluctuations effects. In future it will be possible to identify dynamical models to better control the Lift at different wind-speeds and angles of attack.