Towards a flow control method based on PSJ actuators: a feasibility study

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Nowadays, effective methods to improve aircraft performances are based on the active flow control, which involves different types of devices. Among them, plasma synthetic jets (PSJ) actuators are able to produce very high jet velocities, without the aid of any moving parts, affecting the structure of the flow-field to be controlled and allowing a positive variation of the aerodynamic forces on the aircraft. A PSJ actuator, or Sparkjet, is mainly composed of 2 or 3 electrodes embedded in a small cavity linked to the external environment through an orifice. The operating cycle begins with an electrical discharge between the electrodes, which sharply increases pressure and temperature inside the cavity. The high-pressure air exhausts through the orifice, converting the increased air internal energy into kinetic one. In the end, fresh air is drawn back inside the cavity, refilling the device for the next pulse. After a limited number of cycles the device reaches a periodic behavior, generating a plasma synthetic jet, [1].

Within the CleanSky2 framework, one of the largest research projects funded by the European Union, a novel multi-modal camber morphing flap was conceived for the enhancement of the aerodynamic performances of the next generation green regional aircraft. Thanks to different morphing modes, the shape of the flap can be suitably adapted in order to preserve an optimal configuration as the aircraft trim parameters change according to the specific flight phase (take-off, climb, cruise, descent, landing). To further improve the benefits brought by such a technology on the wing aerodynamic efficiency, an active flow control system based on PSJ actuators was investigated for a potential installation on the upper skin of the flap.

This work is focused on the two main aspects related to the feasibility of PSJ actuators integration into the adaptive flap skin: the thermal and electromagnetic interferences of the actuators with the other electronic equipment of the flap. Both experimental and numerical studies were carried out to characterize the thermal and electromagnetic fields induced by the operating device into the surrounding structure. A simplified test mock-up [2] was designed and manufactured to support all experimental activities while being fairly representative of the actual PSJ-skin assembly. Test results allowed for a rational validation of the implemented numerical models and for a clear definition of the safety-critical areas for the installation of flap actuation, control and sensing systems.

References

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