DIELECTRIC SURFACE TEMPERATURE MEASUREMENTS IN A DBD PLASMA ACTUATOR USING INFRARED THERMOGRAPHY

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Abstract: Active flow control by plasma actuators, usually called ElectroHydroDynamic actuators, is currently under investigation in order to improve vehicles aerodynamic performances. One of these actuators consists in using surface dielectric barrier discharge. To realize such an electric discharge, two metallic electrodes are placed on each side of a dielectric material, the upper one being connected to a high voltage (typically a 20 kV peak-to-peak sinusoidal waveform of several kHz in frequency), the lower one to the ground. Such devices working at atmospheric pressure create a non-thermal plasma at the dielectric surface spreading over 10 mm in our specific conditions. This plasma induces a low-velocity airflow, the so-called “ionic wind”, which can be used to modify external flow under specific conditions.

Our team has been studying such devices (DBD actuators) to perform airflow control for three years. In order to quantify possible thermal effects on the laminar-to-turbulent transition, measurements of the surface temperature were carried out by infrared thermography which is a non-intrusive technique. The dielectric temperature was determined with plasma on and after plasma switch-off; the measurements were also carried out with and without an external boundary layer flow over the discharge (velocity range from 5 m/s up to 25 m/s) in order to observe external flow influence on the dielectric temperature.

Measurements and main results firstly show that, similar to the ionic wind velocity evolution, temperature increases with the voltage amplitude and the frequency of the supply power. Then, the most effective way to combine the highest ionic wind velocities with the lowest surface temperature is by increasing the amplitude voltage rather than the frequency. Finally, plasma induces a temperature gradient on the dielectric surface along the gap separating the two electrodes. The maximum of temperature is observed near the high voltage electrode, whereas the maximum of ionic wind velocity is usually located farther above the grounded electrode.

These observations remain valid with an external boundary layer flow. In addition, under specific free-stream velocities, the temperature is observed to be higher than in quiescent air. This can be explained by the influence of the boundary layer nature (laminar or turbulent) on the heat transfer or by a modification of the plasma properties with the external flow.

In conclusion, measurements of dielectric surface temperatures by infrared thermography enable the dielectric heating to be characterized in relation with the plasma actuation and the high voltage ranges. Results on laminar-to-turbulent transition when plasma acting might be interpreted with temperature measurements performed with an external airflow.

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