Plasma Actuators for Aerodynamic
空気流体力学用プラズマアクチュエータ

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Due to the conjunction of a technological need in aerodynamic control to be used in aeronautic industry and new investigations on aerodynamic properties of plasma actuators, recently several researches started on applications of plasma actuators in aerodynamic control [1]. This paper deals with such researches developed in P' Institute.

1. Introduction

We will present here, the different so-called "plasma actuators" developed in our laboratory. The purpose of this overview is not to analyze and compare the efficiency of the different plasma actuators, this has already been made by Moreau in a very exhaustive review [2], but the goal here is to describe how the different actuators are made and how they are working [3].

2. The electric wind

It is known for a long time that a metallic point submitted to a high electrical potential generates a wind this is due to the so called "point effect". Indeed, near the tip of the point a corona discharge appears, thus ions are created and moved by the electric field. These ions in motion drift the air molecules creating an electric wind (Fig. 1). This is the basic process of non thermal plasma actuators.

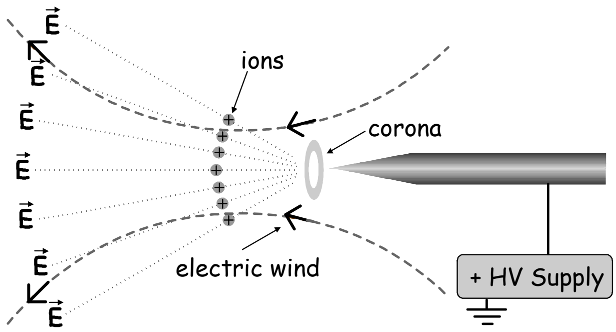

Fig. 1. Electric wind generated at a needle tip.

In the case of actuators to be used in aerodynamic applications, the process is a little more complicated as the actuator must be mounted on the body submitted to the flow and therefore the material of the body induces perturbations as well on the plasma but also on the "electric wind" created, more they need a counter electrode. Nevertheless, the fact that such device has no moving part constitutes a real advantage for use in aeronautic industry.

Plasma actuators may be classified by their geometrical configuration and the kind of high voltage applied. In this paper we are going to examine first the actuators not using a dielectric barrier, then those using a dielectric barrier.

3. Aerodynamic plasma actuators

3.1 *The DC discharge actuator*

It is composed (Fig. 2) of two wire electrodes placed in grooves made at the surface of an insulating material. One electrode, of small diameter, is connected to a positive voltage supply; the other with a greater diameter is connected to a negative voltage.

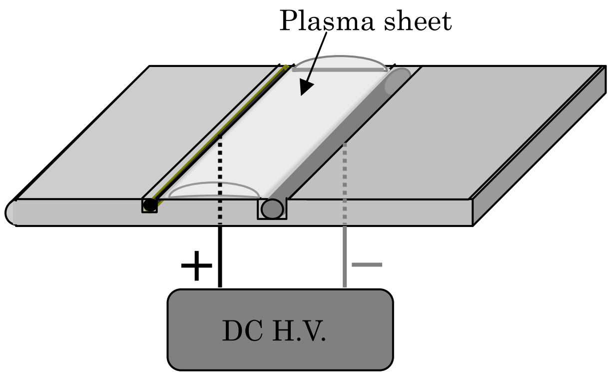

Fig. 2. Sketch of the DC discharge actuator

A corona discharge then appears in ambient air between the two electrodes. The anode diameter being smaller that the cathode one, positive ions are produced at the anode while very few negative ions are produced at the cathode. Thus the action of these negative ions on the wind generated can be neglected. Thus, under Coulombian forces, the positive ions drifted from the anode to the cathode induce the electric wind generated.

3.2 *The Dielectric Barrier Discharge (DBD) actuator*

This actuator (Fig. 3) uses a dielectric barrier discharge. Thus, one electrode is grounded, the other is connected to the output of a high voltage amplifier TREK connected to a function generator. An electrode spacing of a few millimeters allows the generation of plasma at both sides. When the lower plasma perturbs the experiment, then, the lower electrode is embedded in the material or covered by a dielectric. The flat plate is made of a dielectric material. The electrodes are made of thin metallic foil.

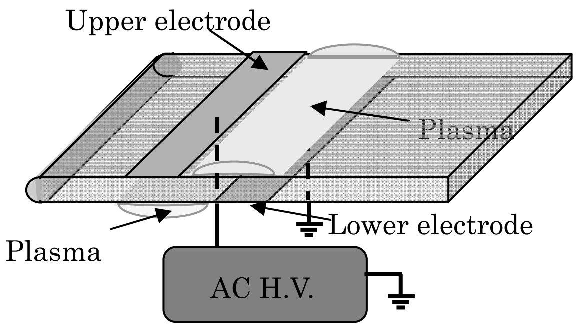

Fig. 3. Sketch of the DBD actuator

3.3 The sliding discharge actuator

The sliding discharge has been first performed for other applications (lasers). In the laboratory we perfected different devices producing sliding discharge, but, for airflow control, the sketch of the actuator mainly used is shown in Fig. 4. The upper upstream electrode is connected to a DC+AC power supplies; this means that the potential applied to this electrode has two components: an AC one added to a DC one. It is in fact a periodic voltage which has a non null time-averaged value. The lower electrode and the upper downstream electrode are connected together and grounded. Sometimes only an alternative potential is applied to the upper left electrode while a DC voltage is applied to the set composed by the upper right electrode and the lower electrode. In both configurations the results obtained are similar. This actuator can produce a large plasma sheet but the electric wind configuration and magnitude remain quasi similar to those produced by the two previous actuators.

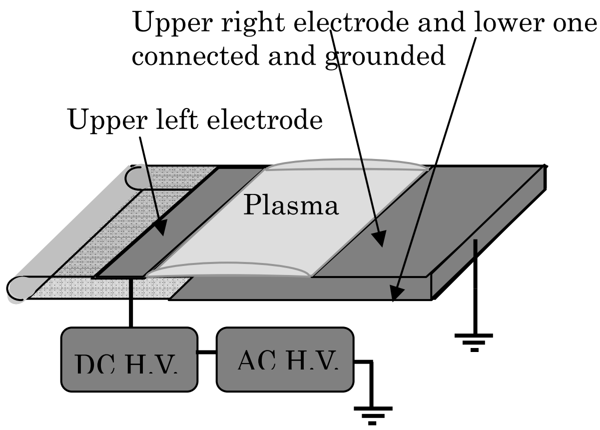

Fig. 4. Sketch of the sliding discharge actuator

4. Example of plasma actuation

We can see on Fig.5 an example of plasma actuation on a Naca profile

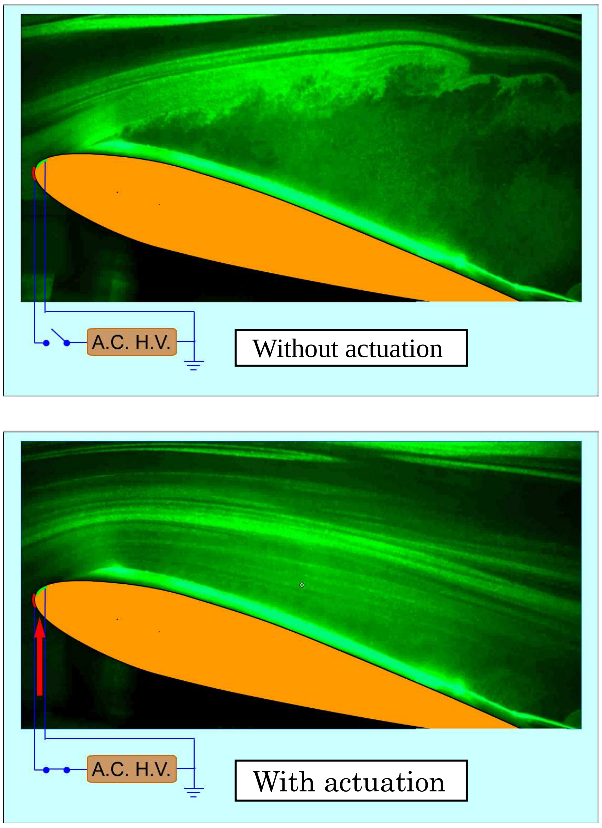

Fig. 5 Example of plasma actuation on a NACA profile

References

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