# Airfoil flow control using DBD plasma actuators

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The technology of plasma active flow control is a new active control technology. A high-voltage input supplied to the electrodes arranged on the aircraft surface causes the ambient air to weakly ionize. The ionized air (plasma) induces disturbance in the flow. In this way, it can effectively control boundary layer transition and separation, significantly improve lift-to-drag ratio and stall angle of the aircraft.The technology has an important application foreground in the developing aircraft industry in the future due to the advantages of no moving parts, quick response, very low mass, low input power etc.

Experiments were carried out to study the effect of plasma flow control on airfoil in an open-circuit low-speed wind tunnel. Lift and drag were measured by a five-component strain gauge balance. Particle Image Velocimetry (PIV) technology was applied to visualize the modification of the flow structure over the airfoil by the plasma actuators. Influence of plasma actuator voltage, excitation frequency, electrode position, free-stream velocity and control evolution was investigated. In additional, the mechanism of plasma flow control was preliminary analyzed and lift enhancement validation experiment was carried out.

The lift coefficient versus angle of attack and drag polar for the airfoil controlled by the plasma actuator are presented in Fig. 1. The results show that the leading-edge plasma actuators are effective in controlling the flow separation over the airfoil at low wind speeds. The maximum lift coefficient and stall angle are increased by 11% and 6 deg respectively at free-stream velocity of 20m/s.

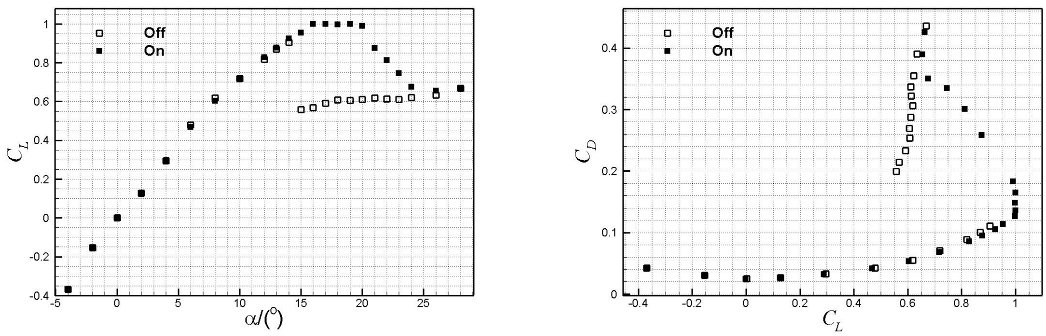


Fig.1 Lift coefficient versus angle of attack (a) and drag polar for the airfoil(b) at the velocity of 20m/s

At a given flow state, there exists threshold values for both the actuator voltage and excitation frequency on the actuators as seen in Fig.2. The threshold values are different with the changing attack angles. At the higher attack angles, the plasma actuator’s authority must be increased due to the much stronger flow separation on the airfoil.

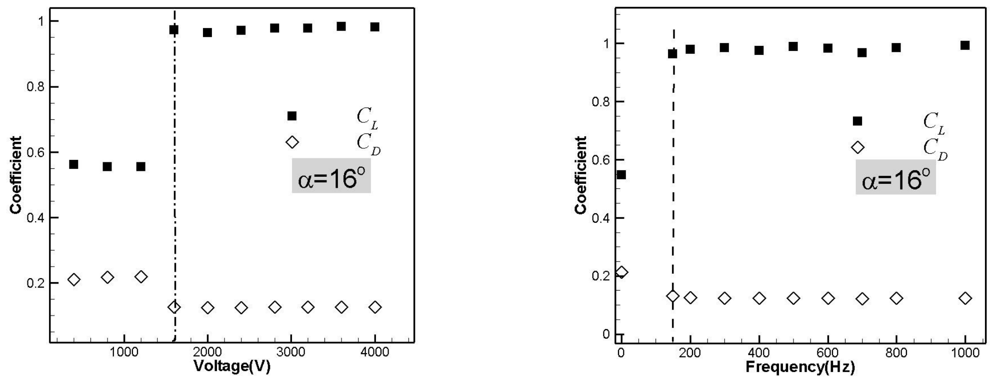


Fig.2 Effect of the actuator voltages and excitation frequencies on the lift and drag coefficient at the angle of 16 deg

The PIV results also show that there is threshold value of forcing voltage. When the voltage is lower than the threshold value, the control is effectless or the control is not visible. When the voltage is near the threshold value, the control effect is unsteady and finally goes steady. When the voltage is higher than the threshold value, the control is prominent and steady and flow separation can reattach to the airfoil suction surface very well.

Lift enhancement validation experiment on the NACA23018 two-element airfoil was carried out. The force test results show that the plasma actuator can efficiently increase the maximum lift and stall angle on the two-element airfoil. The maximum lift coefficient increases 52% and stall angle increases 12.4° at free-stream velocity of 20m/s. Plasma actuator has the same function as leading edge slat, and it can be used with other trailing edge high-lift system, so it has a potential application foreground in the design of transport aircraft.

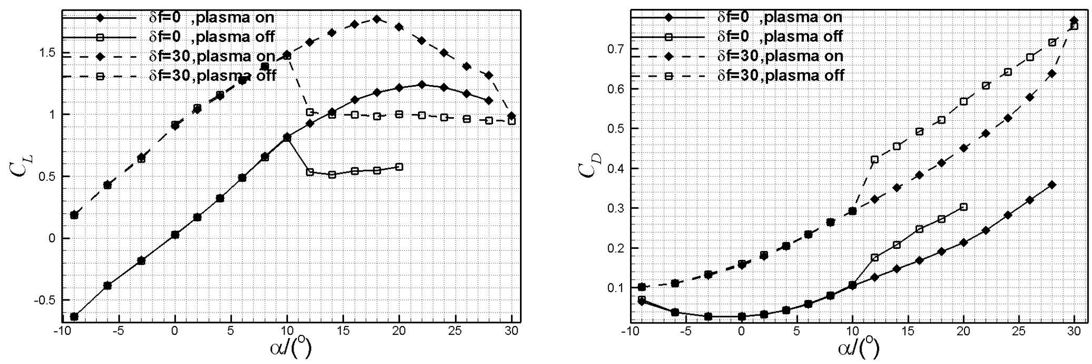


Fig.3 Lift and drag coefficient vs. angle of attack for the airfoil