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Flow control by means of plasma actuation - a separation control and drag reduction study

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Reducing the aerodynamic drag on heavy vehicles is the mission of the **F**low **R**esearch on **A**dvanced and **N**ovel **C**ontrol **E**fficiency (FRANCE) project. The ability of Dielectric Barrier Discharge (DBD) plasma actuators to actively delay separation of the flow around the front corners of a truck cabin is the ultimate goal of the project. DBD plasma actuators are made of two electrodes asymmetrically placed on each side of a dielectric material. Plasma actuators present, among others, the advantage of not having any moving parts making them more robust than other types of actuators. By applying a high alternating voltage between the electrodes a plasma region is formed on the surface of the dielectric. This plasma is a consequence of accelerated electrons which ionize the surrounding medium: repulsion of ions during the ionization process induces momentum similar to a wall-jet, the so-called electric wind. The later was investigated during the first part of this project: our in-house built plasma actuators can produce electric wind with velocities up to 5 m/s.

In the present investigation, the capability of the DBD plasma actuators to delay flow separation created by a strong adverse pressure gradient behind a half-cylinder has been studied. The separation control experiments were conducted in the NT2011 open-circuit wind tunnel at the Fluid Physics laboratory, at KTH Mechanics. A tripped boundary layer develops upstream a half-cylinder embedded in the flat plate, separates on the cylinder and reattaches on the plate downstream the cylinder. A double actuator made of two DBD plasma actuators mounted in a row producing an electric wind oriented in the streamwise direction was used to reduce the separation bubble. A parametric study on the position of the actuator was conducted to optimize the control effect. Hot-wire measurements were performed to study the baseline case at different Reynolds numbers. The effects of the plasma actuation was investigated by comparing pressure measurements at the wall and wall-normal velocity profiles measured downstream the reattachment point for the uncontrolled and controlled cases as can be seen in Fig. 1. This study showed that a drag reduction of 30% could be achieved using this double actuator and carefully placing the actuator. A new study with DBD plasma actuators placed in a row with the electric wind oriented in the spanwise direction is now being conducted to investigate the capacity of plasma actuators to control separation in a similar way to passive vortex generators.

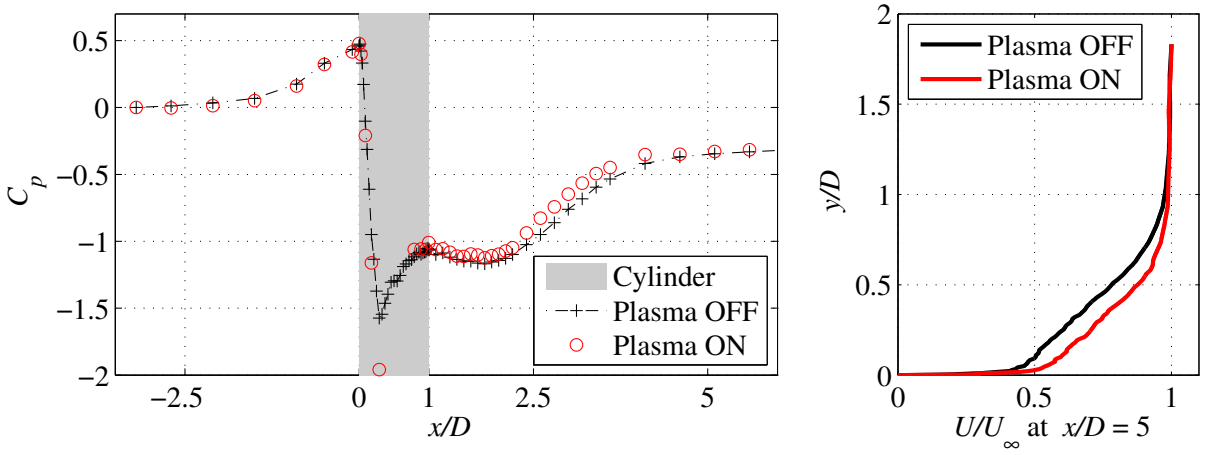

Figure 1: Static pressure at the wall on the left and boundary layer velocity profile downstream the cylinder on the right.