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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 Flow Research on Advanced and Novel Control Efficiency (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.