Manipulation of 3D Turbulent Wakes: Shear Layer Forcing and Drag Reduction

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Turbulent wakes contain complex flow mechanisms of relevance for numerous engineering applications. In particular, drag reduction of ground vehicles has become a major challenge for transport industry to reduce greenhouse gas emissions. Aerodynamic drag of buses, cars and trucks accounts for more than 50% of the rolling resistance in a highway, whose main source is the large pressure difference between the front surface and the near wake region. This justifies the huge effort pushed by researchers to reduce base drag by wake manipulation. I will discuss the physical mechanisms involved in base drag management by shear layer forcing of the separated flow behind such geometries. In order to achieve this goal, I will present a novel experimental investigation highlighting the impact of jet actuation on the wake and drag of a blunt model. Fluidic forcing is applied here with unsteady jets pulsed along the rear edges of the bluff body. Different flow regimes can be distinguished for variable actuation parameters. First, for low frequencies comprising the natural wake motions, the convection of the jet structures enhances wake turbulence, shortens the recirculating flow behind the model and increases drag. By increasing the actuation frequency, a virtual aerodynamic flow shaping is obtained together with an overall reduction of the wake fluctuating kinetic energy. The association of both mechanisms with the Coanda effect significantly decreases drag. This drag reduction would represent large oil savings towards the legislation requirements for reduction of CO_2 emissions. The physical features of such forced flows will be discussed on the basis of drag, pressure and velocity measurements at several flow conditions and forcing parameters. Eventually, I will analyze the effects of active and passive shear layer forcing on the recirculating flow asymmetry, aiming for further understanding of the symmetry breaking modes encountered in turbulent wakes with promising applications on lift and side force control.