“Control of three-dimensional wakes behind simplified models of blunt-based vehicles”

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The flow around heavy vehicles, such as trucks is mainly characterized by a massive separation that induces the development of a strong wake behind the body and the periodic shedding of vortices. Such features result into the appearance of major fluctuating aerodynamic forces and a large drag coefficient that hinders the fuel consumption and renders such type of vehicles a major source of greenhouse gases emission. Consequently, these kinds of wakes have been extensively studied in the last decades [1] with the aim at developing new, more efficient flow-control methods or to improve the existing ones in terms of drag and flow-induced loads. Due to the geometrical complexity of vehicles, these analyses focus generally on simplified models, such as the square-back Ahmed body [2], whose wake retains the main features of three-dimensional wakes. In that sense, it has been recently shown [3] that the turbulent wake behind square-back models sustain, aside from the periodic shedding (periodic mode), a bi-stable random dynamics characterized by the intermittent switching between two horizontally deflected mirror positions (steady Reflectional Symmetry Breaking, RSB, modes). The control of such bi-stable wake asymmetry may lead to considerable drag reduction and decrease of lateral force fluctuations. Following this goal, we present experimental results from our studies on control strategies for the turbulent wake behind the Ahmed body. In particular, we first apply steady perimetric blowing at the base, focusing on the effect of increasing values of the dimensionless base flow parameter, C_m , on the periodic and steady RSB modes for different perimetric blowing configurations. Thus, two general types of behaviors have been identified in terms of the drag coefficient, as the value of Cm increases. For weak blowing rates, a mass injection mechanism acts filling the recirculation bubble and increasing its length, leading to the subsequent decrease of the drag force. Eventually, at higher blowing rates, such effect is reversed and the recirculation region size reduces, leading to an increase of drag. The latter behavior, which will be denoted as momentum regime, produces important changes on steady RSB modes, translating the wake deflected position from horizontal to vertical directions for some blowing configurations. The effect of the blowing density on the aforementioned mechanisms will be also discussed, showing that a light gas reduces more efficiently the drag coefficient than heavier gases. Besides, a second passive strategy is presented, whereby curved rear cavities, designed by means of topological optimization processes, are tested on the Ahmed body for different yaw angles, showing a larger drag reduction and bi-stable dynamics mitigation than classical solutions consisting of straight cavities or flaps.

[1] H. Choi, et al. Annual Review of Fluid Mechanics 46:44-68, 2014.
[2] S. R. Ahmed et al. SAE Tech. Rep. No. 840300, 1984.
[3] M. Grandemange et al. Journal of Fluid Mechanics, 722:51-84, 2013.