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Aerodynamic forces and wake structure on a 2D model of a vehicle in ground effect

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In this research we perform numerical simulations and wind tunnel experiments of a D-shaped bluff body. Different flow conditions and ground-body distances are considered to analyse the ground effect on aerodynamic forces and wake structure.

1 Introduction

Terrestrial transportation of goods and people grow daily and, consequently, CO_2 and other polluting gas emissions. The reduction of the transportation volume would imply a change in the logistic model unapproachable in the short term. However, technical solutions can be implemented to reduce fuel consumption and, at the same time, emissions. At high velocities, flow separation is the main responsible of drag forces in bluff bodies, as those of terrestrial vehicles. In this sense, many technical solutions proposed in the last decades have focused on wake control to improve aerodynamic performance.

In recent years there has been a growing interest in the creation of devices that allow the control of the wake of simplified ground vehicle models, either by passive methods, such as the use of rigid Lorite-Díez *et al.* (2018) or flexible flaps Lorite-Díez *et al.* (2017), or by active methods such as blowing in the rear side of the object (Lorite-Díez *et al.* , 2019). In order to determine the best choice for this type of control devices, it is necessary to have precise knowledge of the wake created behind the object.

In this research, a numerical study of the aerodynamic coefficients and wake structure for high Reynolds numbers is performed on a simplified 2D vehicle model that has been widely used in recent works. In particular, the effect of proximity to the ground on the parameters studied is analyzed.

2 Numerical setup and results

The vehicle is modeled as a bluff body of height H with a rounded front and rectangular rear (Lorite-Díez *et al.* (2017)) in an incompressible free-stream of velocity U_∞, density ρ and viscosity μ (figure 1). The front of the body is designed as an ellipsoidal nose with a major-minor axes aspect ratio of 2 to avoid flow separation. To avoid edge effects during the experiments, the body is fixed to lateral plates. Numerical simulations are performed solving incompressible Navier-Stokes equations in the computational domain of figure 1. The Reynolds number of the problem is defined as $Re = \rho U_\infty H/\mu$.

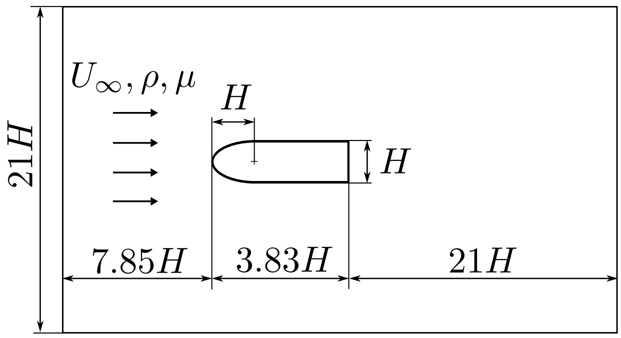
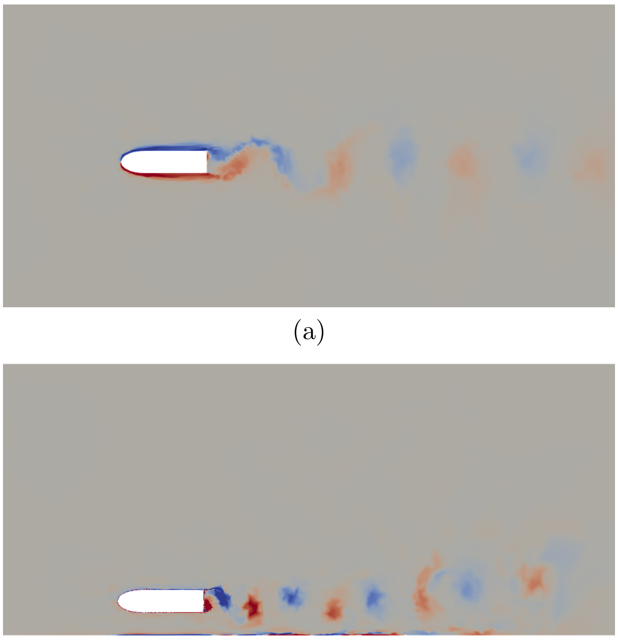


Figure 1: Scheme of the problem configuration and computational domain.

Experiments and numerical simulations are performed for different ground-body distances and Reynolds numbers. The distance d between the ground and the lower surface of the body is varied from $d = H$ to $d = 10H$. In figure 2, we show the structure of the wake from a numerical simulation for $Re = 40000$ and $d = 10H$ (figure 2a) and $d = 10H$ (figure 2b). The effect of the ground can be clearly appreciated, affecting the flow around the body, the structure of the wake, and, hence, the aerodynamic forces on the body.

3 Conclusions

We have generated a database of numerical and experimental results of aerodynamic forces and wake



(a)

(b)

Figure 2: Wake structure for $Re = 40000$ and (a) $d = 10H$ and (b) $d = H$.

structure of a 2D model of a vehicle for different ground-body distances and flow conditions. We have analyzed these results to characterize the effect of proximity to the ground and better understanding the behaviour of the wake. These results will be used to design a control device to improve aerodynamic performance of the body.

Acknowledgements

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References

Lorite-Díez, M., Jiménez-González, J.I., Gutiérrez-Montes, C. & Martínez-Bazán, C. (2017) "Drag reduction of slender blunt-based bodies using optimized rear cavities". *Journal of Fluids and Structures*, **74**, 158–177.

Lorite-Díez, M., Jiménez-González, J. I., Gutiérrez-Montes, C. & Martínez-Bazán, C. (2018) "Effects of rear cavities on the wake behind an accelerating D-shaped bluff bod", *Physics of Fluids* 30, 044103

García-Baena, C., Camacho-Sánchez, J.M., Lorite-Díez, M., Gutiérrez-Montes, C. & Jiménez-González, J.I. (2023) "Drag reduction on a blunt body by self-adaption of rear flexibly hinged flaps",*Journal of Fluids and Structures* 118, 103854.

Lorite-Díez, M., Jiménez-González, J., Martínez-Bazán, C., Cadot, O. and Pastur, L. (2019), Perimetric blowing at the rear of a bluff body: consequences on the wake dynamics and drag reduction. *Proc. Appl. Math. Mech.*, 19, e201900044.