

# Fluttering and Drag reduction in wakes

Juan D’Adamo<sup>1</sup>, Verónica Raspa<sup>2</sup>  
Ramiro Godoy-Diana<sup>3</sup>

<sup>1</sup> Universidad de Buenos Aires, Facultad de Ingeniería,  
LFD, CONICET, Buenos Aires, Argentina

<sup>2</sup> Universidad de Buenos Aires, Facultad de Ciencias Exactas y Naturales,  
IFIBA, CONICET, Buenos Aires, Argentina.

<sup>3</sup> Physique et Mécanique des Milieux Hétérogènes,  
ESPCI Paris-PSL (PMMH, UMR 7636), France

Drag forces in wake flows account for a significant portion of energy consumption in many industrial applications, particularly in transportation. Effective flow control strategies require a thorough understanding of the physical mechanisms that characterize wake flows. Active control methods involve introducing energy into the flow (e.g., through mobile parts, blowing, or suction), while passive control methods modify the flow by altering geometry, material, or surface properties.

Wake flows are typically characterized by the well-known Bénard-Von Kármán (BvK) instability, which generates a periodic vortex street pattern. We propose to modify this flow pattern through a special configuration of flexible foils attached to the surface of a bluff body producing significant drag reductions. On a recent work, [García-Baena et al. \(2021\)](#) obtained drag reductions that can be applied to a better aerodynamical design of trucks using a similar configuration. These reductions are attributed to foil reconfiguration [Gosselin et al. \(2010\)](#) and changes in the hydrodynamic stability properties ([Giannetti and Luchini, 2007](#); [Strykowski and Sreenivasan, 1990](#); [Thiria et al., 2009](#)). However, flutter instability may also arise, increasing fluid inertial forces and potentially restraining drag reduction as discussed by [Leclercq et al. \(2018\)](#).

In the present work, we experimentally study the strong fluid-structure interaction (FSI) for a D-shaped body in a wind tunnel. We characterize the modifications to the BvK vortex street caused by foil reconfiguration and wake-induced vibrations. Specifically, we examine whether small-amplitude fluttering can enhance drag reduction by altering the wake dynamics. With these results, we aim to contribute to the development of efficient aerodynamic designs, ultimately reducing energy consumption.

## References

- C García-Baena, JI Jiménez-González, and C Martínez-Bazán. Drag reduction of a blunt body through reconfiguration of rear flexible plates. *Physics of Fluids*, 33(4):045102, 2021.
- F Giannetti and P Luchini. Structural sensitivity of the first instability of the cylinder wake. *Journal of Fluid Mechanics*, 581:167–197, 2007.
- F Gosselin, E De Langre, and B A Machado-Almeida. Drag reduction of flexible plates by reconfiguration. *Journal of Fluid Mechanics*, 650:319–341, 2010.

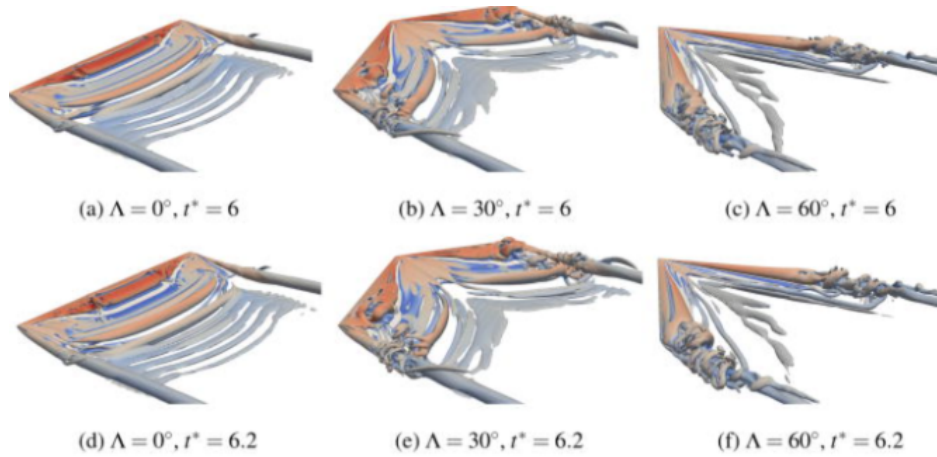


Figure 1: Isosurfaces of  $Q = 1$  colored by normalized velocity magnitude for all wing geometries at reduced frequency  $k = 0.05$ ; from: [Cavanagh et al. \(2024\)](#).

T Leclercq, N Peake, and E De Langre. Does flutter prevent drag reduction by reconfiguration? *Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 474(2209):20170678, 2018.

PJ Strykowski and KR Sreenivasan. On the formation and suppression of vortex ‘shedding’ at low reynolds numbers. *Journal of Fluid Mechanics*, 218:71–107, 1990.

Benjamin Thiria, Olivier Cadot, and J-F Beaudoin. Passive drag control of a blunt trailing edge cylinder. *Journal of fluids and structures*, 25(5):766–776, 2009.

## References

Cavanagh, A., Bose, C., & Ramesh, K. (2024). Effect of sweep angle on three-dimensional vortex dynamics over plunging wings. *Physics of Fluids*, 36(11).