Accepted Manuscript

Revisiting the drag reduction problem using adjoint-based distributed forcing of laminar and turbulent flows over a circular cylinder

P. Meliga, E. Boujo, M. Meldi, F. Gallaire

PII: S0997-7546(17)30613-1
DOI: https://doi.org/10.1016/j.euromechflu.2018.03.009
Reference: EJMFLU 3274

To appear in: *European Journal of Mechanics / B Fluids*

Received date : 3 November 2017
Revised date : 4 March 2018
Accepted date : 20 March 2018

Please cite this article as: P. Meliga, E. Boujo, M. Meldi, F. Gallaire, Revisiting the drag reduction problem using adjoint-based distributed forcing of laminar and turbulent flows over a circular cylinder, *European Journal of Mechanics / B Fluids* (2018), https://doi.org/10.1016/j.euromechflu.2018.03.009

Revisiting the drag reduction problem using adjoint-based distributed forcing of laminar and turbulent flows over a circular cylinder

P. Meliga[a,*], E. Boujo[b], M. Meldi[c], F. Gallaire[d]

[a] *Aix-Marseille Univ., CNRS, Centrale Marseille, M2P2, Marseille, France*
[b] *CAPS, ETH Zurich, Zurich, Switzerland*
[c] *Université de Poitiers, CNRS, ISAE-ENSMA, Institut PPrime UPR 3346, 86962, Poitiers, France*
[d] *LFMI École Polytechnique Fédérale de Lausanne, Lausanne, Switzerland*

Abstract

This study assesses the ability of a sensitivity-based, span-wise homogeneous control velocity distributed at the surface of a circular cylinder to cut down the cost of reducing drag by more classical techniques, e.g., base bleed and lateral suction. At Reynolds number $Re = 100$, achieving the linear optimal reduction requires a time-dependent control velocity, set at each time instant against the sensitivity of the instantaneous drag. This approach however fails against even small control amplitudes because the system does not have time to adjust to the rapid change in the value of the wall velocity, and drag essentially increases. An efficient (albeit linearly suboptimal) reduction is however achieved using a steady control velocity set against the time averaged sensitivity. By doing so, drag decreases monotonically with the control momentum coefficient, and the sensitivity-based design exhibits a significant advantage over base bleed and lateral suction, that both reduce drag to a far lesser extent. Similar results are reported using various levels of modeling to compute approximations to the exact, time averaged sensitivity. The mean flow approach, that requires knowledge of the sole time averaged cylinder flow, yields especially promising results given the marginal computational effort. This approach is thus extended to the turbulent case at $Re = 3900$, where it achieves similar efficiency in the frame of both 2-D and 3-D RANS modeling. The study concludes with a discussion about the feasibility to extend the scope to span-wise periodic

*Corresponding author
Email address: philippe.meliga[@]univ-amu.fr (P. Meliga)