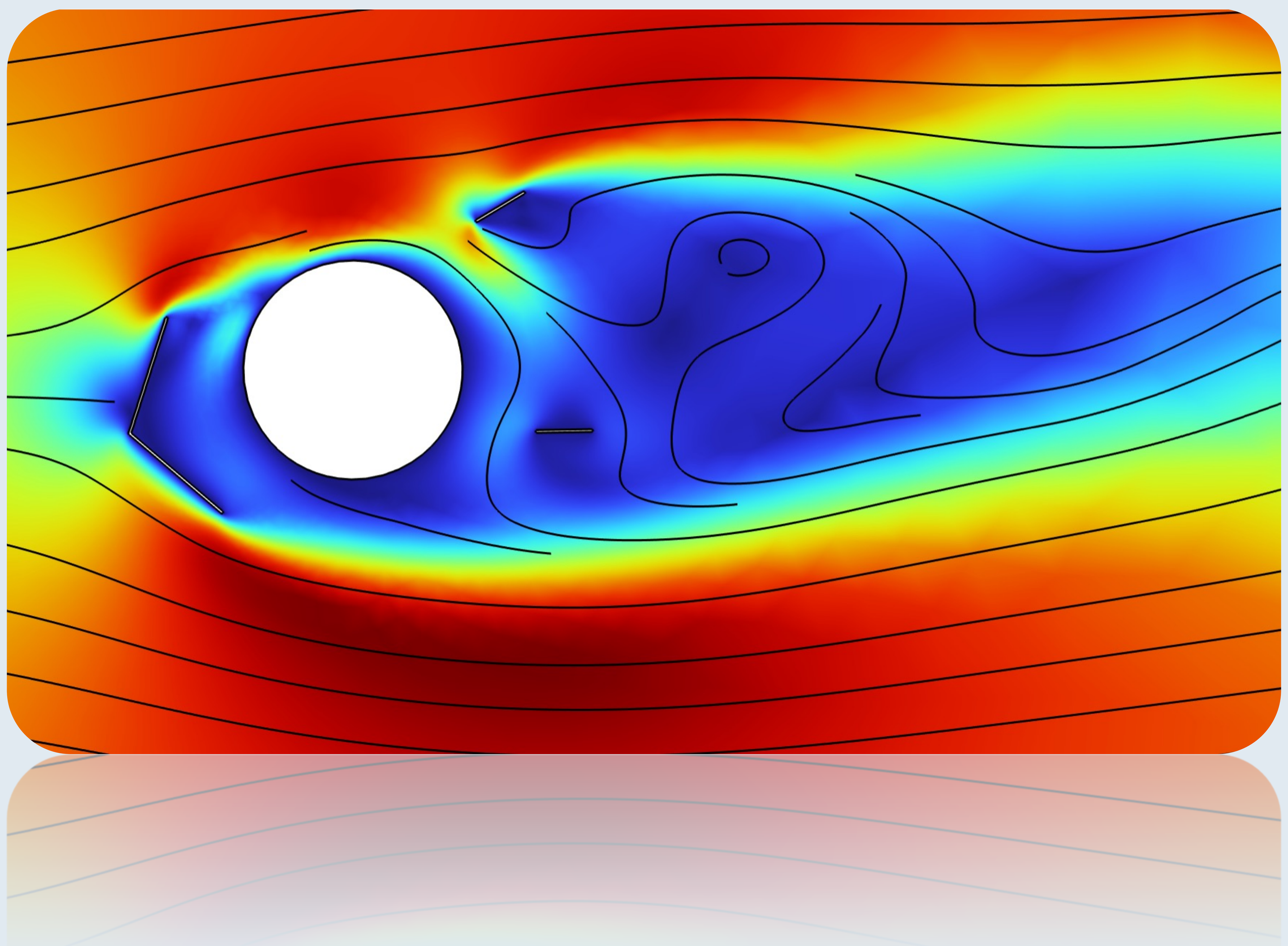

Drag Reduction and Vortex-Induced Vibration Mitigation via Optimizing Aerodynamic Characteristics

The optimum ‘free-to-rotate’ components that shield the main structure from VIV and dissipate the energy into periodic rotational oscillations.

R. I. Bourisli, A. E. Alshayji
Mechanical Engineering Department, Kuwait University, Kuwait.

Introduction and Aim

Vortex-induced vibrations (VIV) can result in a range of problem from structural fatigue and resonance to performance degradation and increased drag. Potential dangers include severe consequences like structural collapse, pipeline ruptures, and various accidents in different industries. The problem of reducing VIV for a cylinder in crossflow is addressed here by proposing an collection of objects strategically placed account the cylinder and allowed to rotate freely.

The collection (assembly) is composed or an upstream arrowhead and two flaps downstream of the cylinder. The idea is for the assembly to endure a large portion of the kinetic energy of the flow and divert it away from the cylinder and/or dissipate it rotationally. The arrowhead helps divert the flow while the flaps help keep the structure aligned. The total drag on the entire structure (assembly + cylinder) can also be reduced in the process.

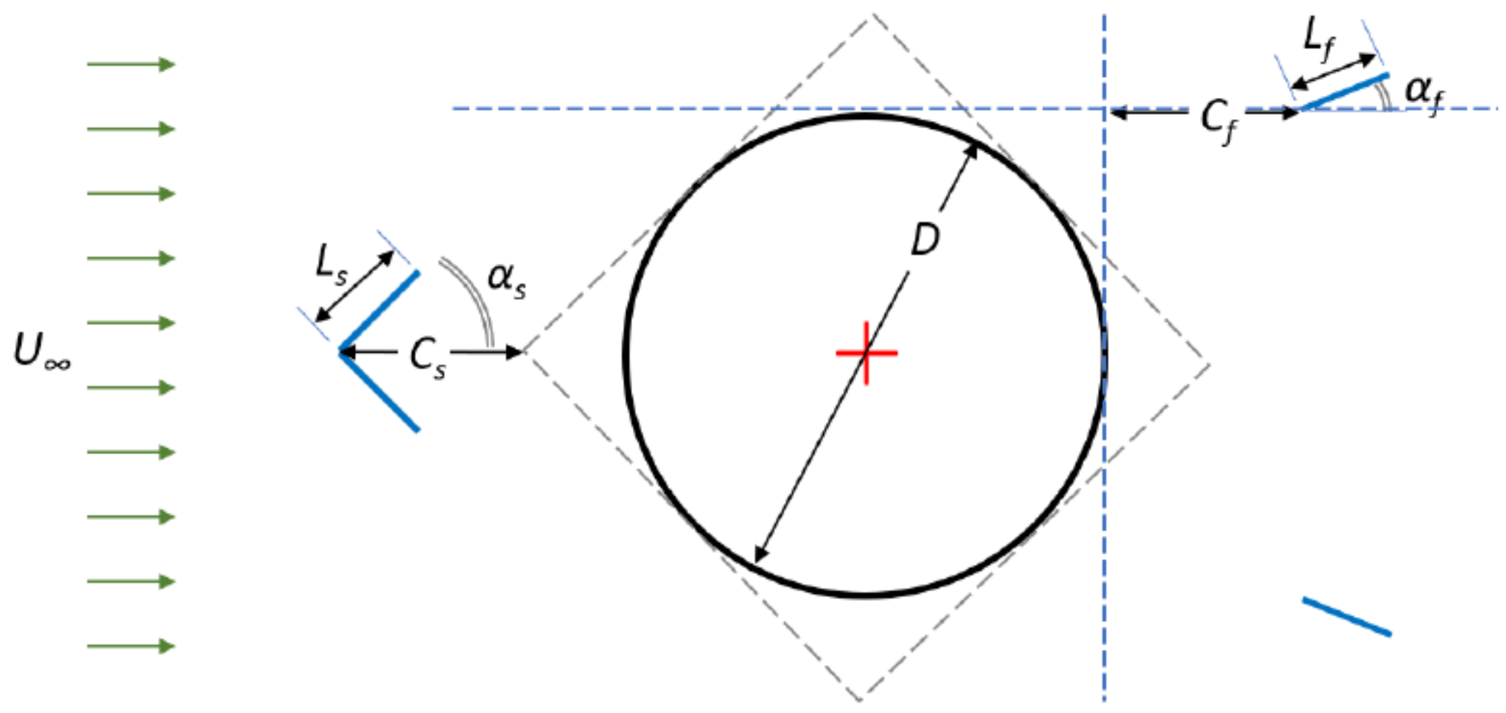

FIGURE 1. Schematic of the *free-to-rotate* assembly around a stationary circular cylinder, with all the design parameters.

Methodology

A wide range of laminar Reynolds number were tested and the drag on a bare cylinder is noted. In addition to the *Laminar Flow* and *Solid Mechanics* physics, a number of COMSOL nodes were utilized such as the *Fluid-Structure Interaction*, the *Moving Mesh*, and the *Optimization* node in the Solver. An initial “*Stationary*” solver step was first used so that the *Time Dependent* simulation can start from the steady-state conditions. The six design parameters were optimized separately at first and their optimum values were combined and tested against a bare cylinder in crossflow. The reduction in total drag over the entire assembly reached 70%. The study then used the built-in BOBYQA algorithm to optimize all six variable concurrently. The only constraint was that the steady-state angle of rotation is within ±2.5°.

Preliminary Results

It is observed that the optimum values of the six parameters, when used collectively, can reduce the overall drag on the entire structure (cylinder + assembly), across all Reynolds numbers. Furthermore, when the stationary condition on the assembly was released, and the assembly was *free-to-rotate*, the rotational oscillation can bear a large portion of the kinetic energy of the flow. This reduces the intensity of the vortex shedding and thus the resulting VIV. Lastly, preliminary results show that optimizing all the six variables concurrently guarantees the optimum configuration and minimum drag coefficient. The condition of perfect alignment of the assembly with the flow at all times was maintained up to a certain Reynolds number and is the subject of ongoing research.

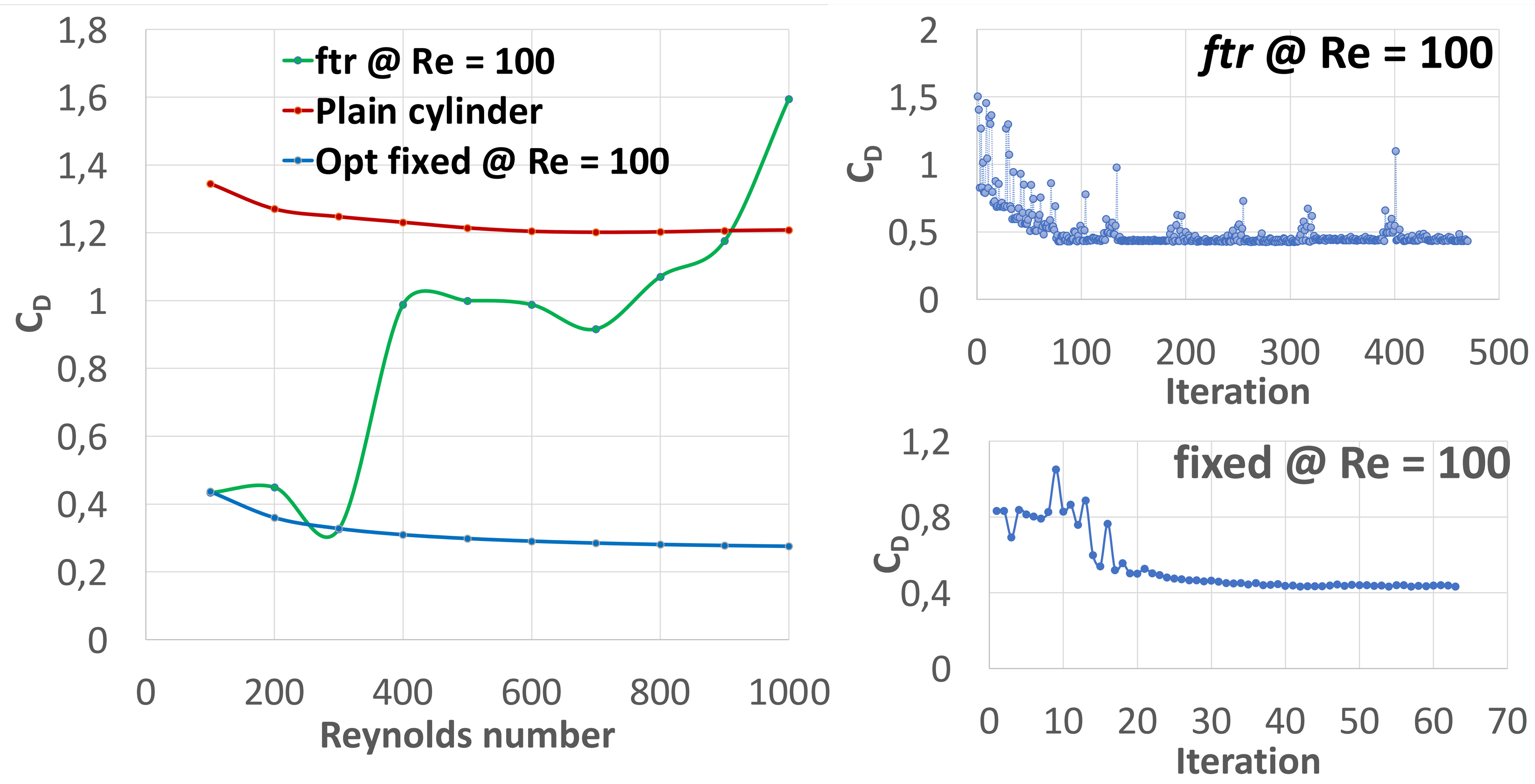

FIGURE 2. LEFT: Cd vs. Re for three types of cylinders. TOPRIGHT: C_D vs. iteration for free-to-rotate assembly at different Re values. BOTTOM RIGHT: same for fixed assembly.

REFERENCES

1. Dehkordi, E.K., Goodarzi, M., Nourbakhsh, S.H., 2018. Optimal active control of laminar flow over a circular cylinder using Taguchi and ANN. European Journal of Mechanics / B Fluids 67, 104–115.
2. Silva-Ortega, M., Assi, G.R.S., 2017. Suppression of the vortex-induced vibration of a circular cylinder surrounded by eight rotating wake-control cylinders. Journal of Fluids and Structures 74, 401–412.

جامعة الكويت
KUWAIT UNIVERSITY