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ON THE WAKE TRANSITION IN THE FLOW PAST A CIRCULAR CYLINDER AT CRITICAL REYNOLDS NUMBERS

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It is well known that the wake topology in the flow past a circular cylinder remains almost unchanged up to Reynolds number 2×10^5 [1]. Then, at $Re \sim 2 \times 10^5$ major changes take place entailing flow separation, turbulence transition in the detached shear layer, a reattachment of the flow and a further separation of the boundary layer. Furthermore, a dramatic decrease in the drag coefficient occurs between Reynolds numbers 2×10^5 and 5×10^5. In this regime, named critical regime by Roshko [2], there are two discontinuous drops in the drag and the existence of asymmetric forces on the cylinder surface [3, 4]. Another transition later occurs in the range $10^6 < Re < 3.5 \times 10^6$, with the drag increasing again [2, 4], whereas at higher Reynolds numbers beyond 3.5×10^6, the boundary layer at the cylinder becomes turbulent before separation (see for instance [2]).

The aim of this work is to carry out large-eddy simulations of the flow at critical and super-critical Reynolds numbers in the range of $Re = U_{ref} D/\nu = 1.4 \times 10^5 - 8.5 \times 10^5$. The cases have been solved in a computational domain of $x \equiv [-16D, 16D]$; $y \equiv [-10D, 10D]$; $z \equiv [0, 0.5\pi D]$ in the stream-, cross- and span-wise directions, respectively, with a circular cylinder at (0,0,0). Different unstructured grids up $\sim$ 90 million control volumes have been used. The boundary layer at the cylinder surface is well resolved, i.e. no wall function is used. Thus, the meshes are designed so as to keep the non-dimensional wall distance $y^+ \leq 2$. To do this, a prism layer is constructed around the cylinder surface. All simulations have been performed on Marenostrum III Supercomputer.

Preliminary results of the variation of the drag coefficient with the Reynolds number and the pressure distribution on the cylinder surface are shown in Figure 1. In spite of the large scattering in the data measured in this regime, a reasonable agreement with experimental data is observed. An interesting feature captured by the present computations is a plateau

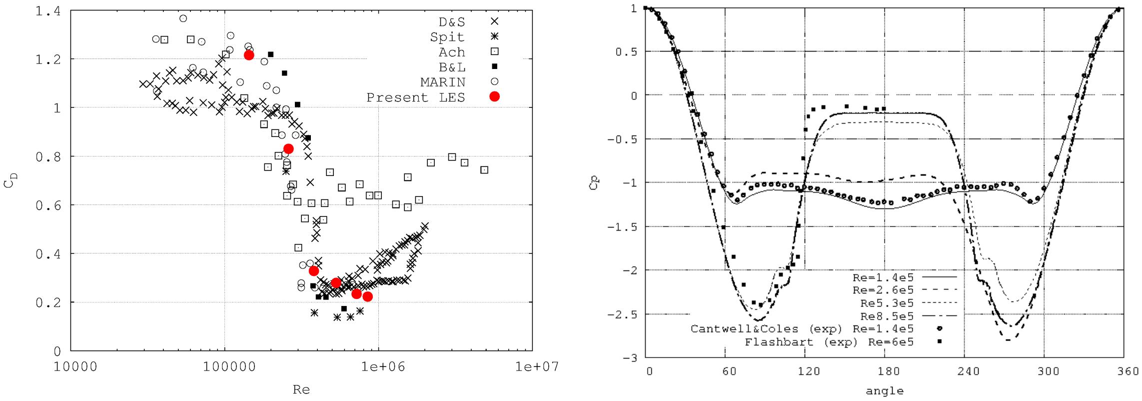

Figure 1: (left)Drag coefficient vs. Reynolds number. (right) Pressure coefficient on the cylinder surface

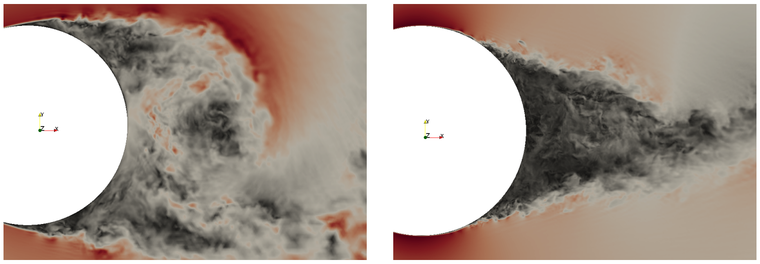

Figure 2: Wake topology. (left) Sub-critical regime at $Re = 1.4 \times 10^5$. (right) Supercritical regime at $Re = 7.2 \times 10^5$.

in the pressure distribution indicating the presence of a laminar separation bubble (see Figure 1 (right)). The change in the wake topology is also evident in Figure 2, where the flow behind the cylinder at $Re = 1.4 \times 10^5$ and $Re = 7.2 \times 10^5$ is depicted.

One of the major outcomes of the present computations is to shed some light on the shear layer instability mechanisms and their role on the drag crisis phenomena. In addition, changes in the wake topology which occurs from sub-critical to super-critical regimes are study in detail.

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