Large Eddy Simulation of Flow Past an Infinite Span Circular Cylinder at Re = 3900

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The flow past a circular cylinder has been extensively studied due to its fundamental significance in fluid mechanics and engineering applications. At a diameter based Reynolds number of $Re_D = 3900$, the wake dynamics transition from laminar vortex shedding to turbulent flow structures, making it an ideal benchmark for numerical simulations. In this study, Large Eddy Simulations (LES) were performed to investigate the unsteady flow characteristics around an infinite-span circular cylinder. The simulation is performed using OpenFOAM V1912, utilizing a structured mesh with near-wall refinement to accurately resolve boundary layer dynamics.

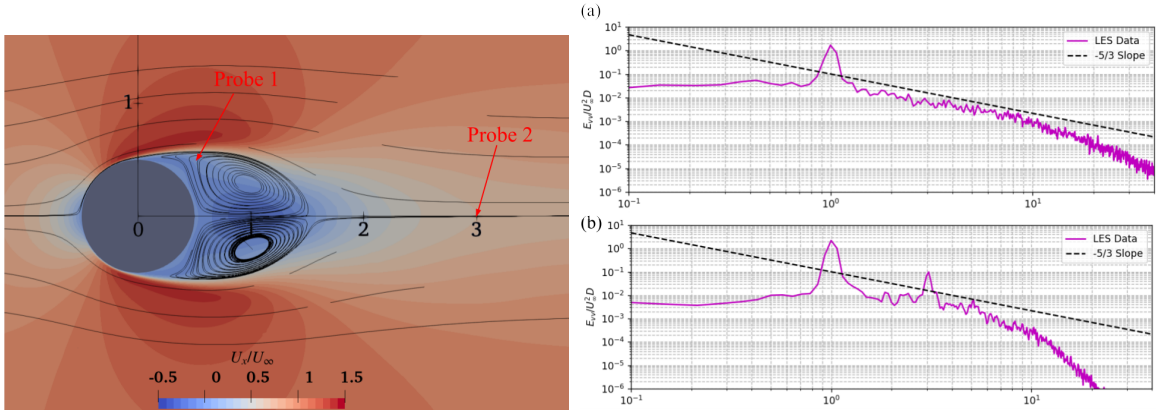

Figure 1: Left: Time averaged streamwise velocity contours. Overall figure caption describing both images; Right: Turbulent energy cascade at (a) Shear Layer - Probe 1; (b) Wake - Probe 2.

Key flow features, including vortex shedding frequency, turbulence statistics, and pressure distribution, are analyzed and compared against experimental and Direct Numerical Simulation (DNS) data. The Strouhal number and drag coefficient are examined to validate the computational model. Furthermore, the study explores the coherent structures in the wake to gain insights into the dominant modes of vortex dynamics.

The results demonstrate good agreement with existing literature, capturing key flow phenomena such as vortex shedding, turbulent kinetic energy distribution, and wake asymmetry. The findings contribute to a deeper understanding of turbulent wake flows and provide a foundation for future studies in flow control and bluff body aerodynamics. Potential applications include aerodynamic shape optimization and flow-induced vibration mitigation in engineering structures.

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