Experimental and computational investigation of the intermittent nature of laminar separation bubble in flow past bluff bodies

Abstract

The phenomenon of drag crisis for flow past bluff bodies is investigated both experimentally as well as computationally. Drag crisis is associated with a significant decrease in drag experienced by the body as the Reynolds number (Re) is increased in the critical flow regime. This regime is characterized by the transition of the boundary layer from a laminar to turbulent state, leading to a delay in the flow separation. The formation of a laminar separation bubble (LSB) on the bluff body surface is a crucial part of the mechanism behind the boundary layer transition. It is found that the formation of the LSB is intermittent during the critical regime. The frequency of the appearance of the LSB and the duration of its stay increases with increase in Re. By the end of the regime, an LSB is observed at all times. The intermittency is utilized to explain the mechanism for decrease in drag during drag crisis. An intermittency factor $I_f$, defined as the fraction of time during which the LSB exists in the flow, is estimated to highlight the same. The experiments are carried out in a low-turbulence wind tunnel. Unsteady force, surface-pressure measurements, hotwire anemometry and oil-flow visualization techniques are implemented. The $I_f$ is calculated by a statistical analysis if the instantaneous surface-pressure and force coefficients. Computations are carried out using a stabilized finite element method which is used to solve the incompressible Navier-Stokes equations. The $I_f$, in this case, is estimated by analyzing the rms of high-pass filtered fluctuations in the surface-pressure and flow close to the cylinder.

Bio Sketch

Sanjay Mittal is a professor of Aerospace Engineering at IIT Kanpur. After completing his BTech from IIT Kanpur in 1988, and MS & PhD from the University of Minnesota in 1990 and 1992, respectively, he joined the Army High Performance Computing Research Center, University of Minnesota as a Research Associate. He returned to India in 1994 as an Assistant Professor. He has served as the Chair of the Aerospace Engineering Department as well as the Dean of Academic Affairs. Presently, he is the Head of the National Wind Tunnel Facility at IIT Kanpur. He is interested in Unsteady Aerodynamics, Transition, Experimental Aerodynamics, Finite Element Methods, Aerodynamic Shape Optimization, Fluid-Structure Interactions and modeling of Traffic Flow.

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