Drag Reduction by Active Control for Flow Past Cylinders

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The main objective of this talk is to investigate computational methods for the active control and drag optimization of incompressible viscous flow past cylinders, using the two-dimensional Navier-Stokes equations as the flow model. The computational methodology relies on the following ingredients: space discretization of the Navier-Stokes equations by finite element approximations, time discretization by a second order accurate two step implicit/explicit finite difference scheme, calculation of the cost function gradient by the adjoint equation approach, minimization of the cost function by a quasi-Newton method à la BFGS. The above methods have been applied to predict the optimal forcing-control strategies in reducing drag for flow around a circular cylinder using either an oscillatory rotation or blowing and suction. In the case of oscillatory forcing, a drag reduction of 31% at Reynolds number 200 and 61% at Reynolds number 1000 was demonstrated. Using only two blowing-suction slots, we have been able to stabilize the flow for Reynolds numbers up to 85. Without using any extra control energy, except to prevent the instabilities in the flow, we have been able to maintain the stabilized steady state, whose drag should be the best value one can achieve. When an additional slot was used, we have been able to completely suppress the formation of the Von-Karman vortex street up to Reynolds number 200 with a significant net drag reduction.