The Seventh Asian Congress of Fluid Mechanics
Dec 8 - 12, 1997, Chennai (Madras)

# SUPPRESSION OF VORTEX SHEDDING USING CONTROL CYLINDER

**Sanjay Mittal Akhilesh Raghuvanshi**
**Department of Aerospace Engineering, IIT Kanpur, Kanpur 208 016, India.**

ABSTRACT It has been observed by researchers in the past that vortex shedding behind circular cylinders can be altered, and in some cases suppressed, over a limited range of Reynolds numbers, by proper placement of a second, much smaller, *control* cylinder in the near wake of the main cylinder. Results are presented for numerical computation of some of such situations. Stabilized finite-element method is employed to solve the incompressible Navier-Stokes equations in the primitive variables formulation. At low Reynolds numbers, for certain relative positions of the main and control cylinder, the vortex shedding from the main cylinder is completely suppressed. Excellent agreement is observed between the present computations and experimental findings of other researchers.

## 1. Introduction

The phenomenon of vortex shedding from bluff bodies is very important in various engineering situations. Control of vortex shedding leads to reduction in the unsteady forces acting on the bluff body and can significantly reduce its vibrations. Strykowski and Sreenivasan [1] have reported that there exists a finite spatial domain within which the placement of a control cylinder can suppress the vortex street. The actual extent of the domain depends on the Reynolds number of the flow and the ratio of the diameter of the two cylinders. In this article, results are presented for numerical computations of some of the cases reported in [1].

## 2. Formulation

Stabilized finite-element method [2] is employed to solve the incompressible Navier-Stokes equations in the primitive variables formulation. The SUPG (streamline-upwind/Petrov-Galerkin) and PSPG (pressure-stabilizing/Petrov-Galerkin) stabilization technique is employed to stabilize the computations against spurious numerical oscillations and to enable one to use equal-order-interpolation velocity-pressure elements. The equation systems, resulting from the finite element discretization, are solved iteratively by using the preconditioned GMRES technique.

## 3. Results & Discussion

The main cylinder of diameter D, and control cylinder of diameter d=D/7 reside in a rectangular computational domain whose upstream boundary is located at 5 cylinder diameters from the center of the main cylinder. The downstream boundary is located at 15 cylinder diameters from the center of the second cylinder. The upper and lower boundaries are placed at 5 diameters from the center of the main cylinder. The no-slip condition is specified for the velocity on the cylinder wall and free-stream values are assigned for the velocity at the upstream boundary. At the downstream boundary the viscous stress vector is set to zero. On the upper and lower boundaries, the component of velocity normal to and the component of stress vector along these boundaries is prescribed zero value. Reynolds number is based on the diameter of the main cylinder, free-stream velocity and the viscosity of the fluid. The finite element mesh consists of, approximately, 10,000 quadrilateral elements. Results are reported for two relative locations of the two cylinders. Figure 1 shows the time histories of the drag and lift coefficients for the main cylinder when the control cylinder is located at x/D=2, y/D=1. The Reynolds number is changed to 80, 70 and 60 at t=272.6, 458 and 1081.7, respectively. The vorticity and pressure fields for various Reynolds number are shown in Figure 2. Complete suppression of the vortex shedding is observed at Re=60. Figures 3 and 4 show the solutions for x/D=2, y/D=0.7. The Reynolds number is changed to 80 at t=634.1. In this case, suppression of vortex shedding takes place for Re=80. In both the cases, the solution at Re=100 is significantly different than that for a single cylinder at the same Re [2]. In all the computations no vortex shedding is observed for the control cylinder. TheStrouhal number corresponding to the variation of lift coefficient for the main cylinder for the Re=100 flow is 0.17 for the first case and 0.16 for the second. These observations are consistent with those reported in [1].

References
[1]Strykowski, PJ & Sreenivasan, KR, J. Fluid Mech., 218, 71-107, (1990).
[2]Tezduyar, TE & Mittal, S & Ray, SE & Shih, R, Comput. Meth. in App. Mech. & Engg., 95, 221-242, (1992).

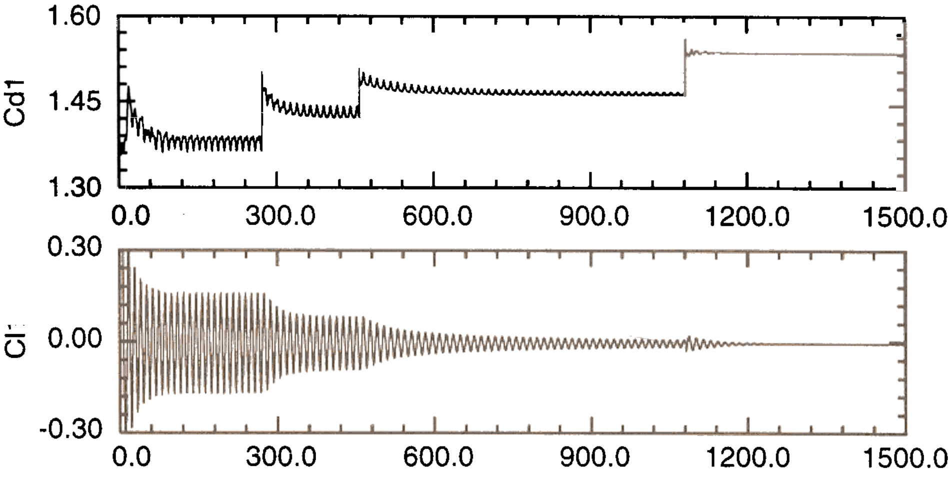

Fig. 1. $x/D = 2$, $y/D = 1$ flow past main and control cylinders: time histories of the drag and lift coefficients for the main cylinder. $Re = 100$ for $0 < t \leq 272.6$, $Re = 80$ for $272.6 < t \leq 458$, $Re = 70$ for $458 < t \leq 1081.7$ and $Re = 60$ for $1081.7 < t$.

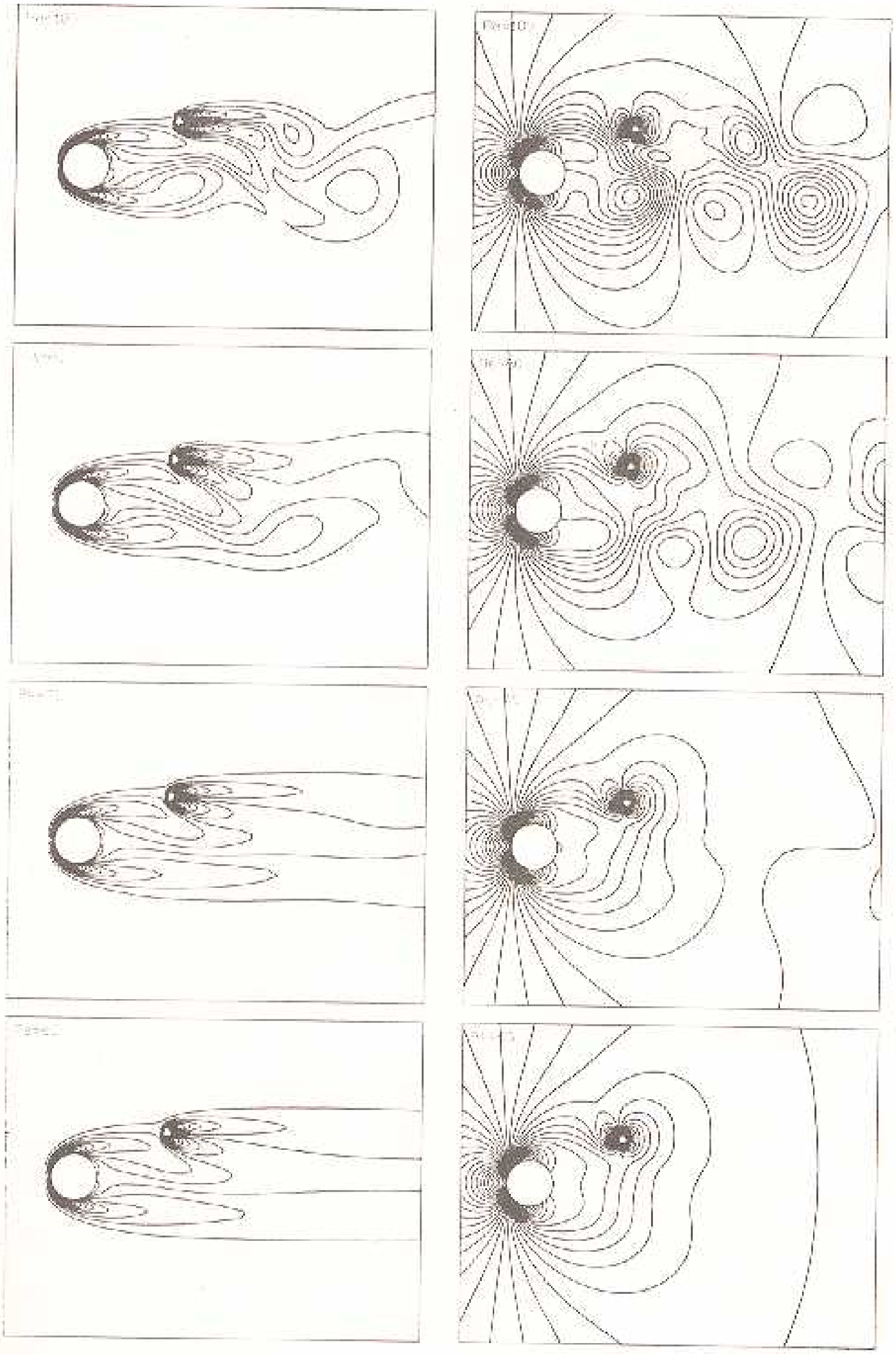

Fig. 2. $x/D = 2$, $y/D = 1$ flow past main and control cylinders: vorticity and pressure fields for $Re = 100, 80, 70, 60$.

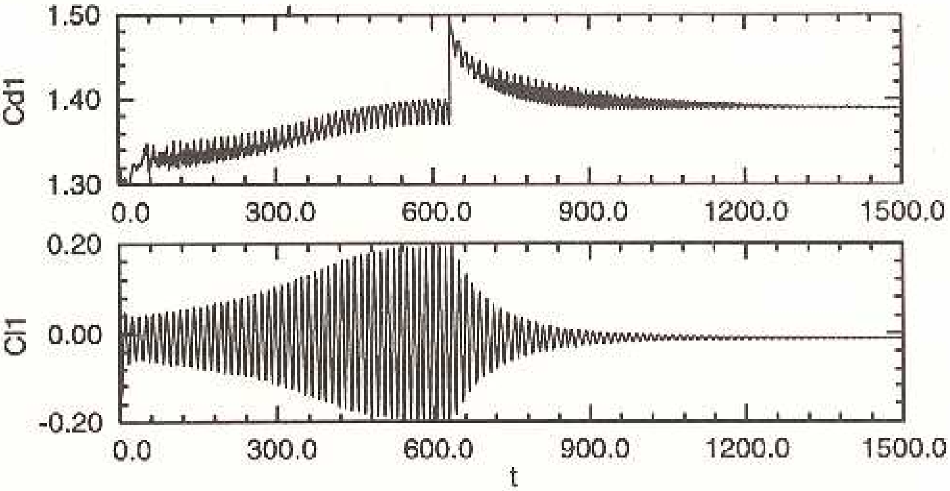

Fig. 3. $x/D = 2$, $y/D = 0.7$ flow past main and control cylinders: time histories of the drag and lift coefficients for the main cylinder. $Re = 100$ for $0 < t \leq 634.1$ and $Re = 80$ for $634.1 < t$.

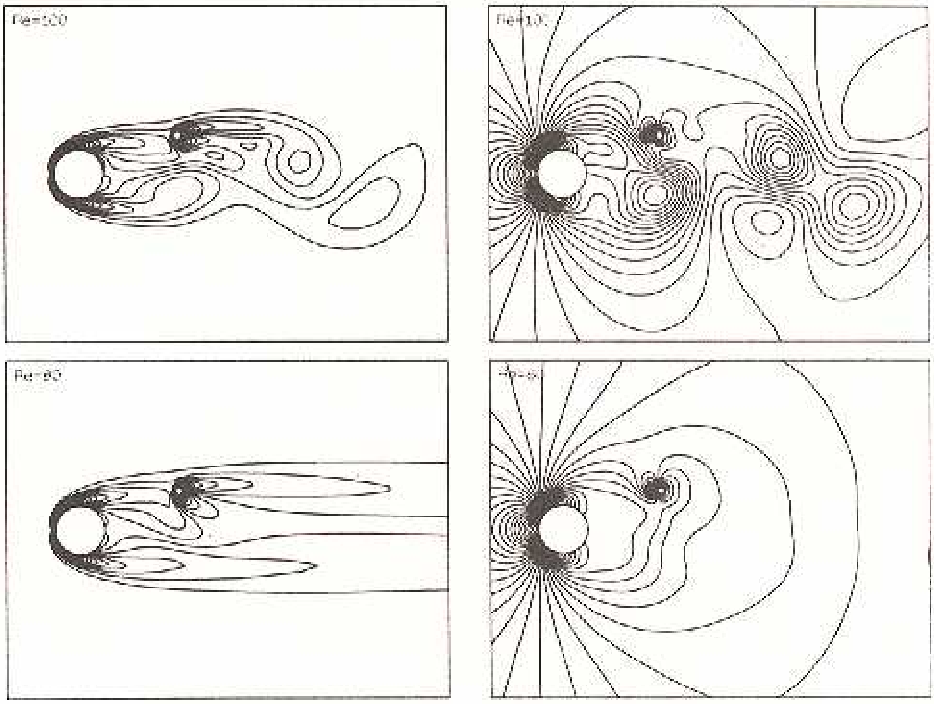

Fig. 4. $x/D = 2$, $y/D = 0.7$ flow past main and control cylinders: vorticity and pressure fields for $Re = 100, 80$.