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# A ROTARY CONTROL OF THE CIRCULAR CYLINDER WAKE: AN ANALYTIC APPROACH

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Abstract. *In this paper, we establish some quantity relationships between the dynamics of circular cylinder wakes and the rotation speed of the cylinder. It has been shown analytically that rotating the cylinder can regularize the flow behavior, and delay the transition from steady flow to turbulent flow. The work needed to overcome the drag exerted on the cylinder is provided.*
**Keywords:** Navier-Stokes equations, Incompressible fluid, Circular cylinder wakes

1. **Introduction.** Study of the circular cylinder wake flow has received more and more attention in recent years. This configuration appears in a wide range of aeronautical, civil, mechanical and chemical engineering applications (see, e.g., [3], [9], [11], [27], [26], and references therein). In practice, the circular cylinder wake flows tend to be unstable and become turbulent at rather low Reynolds number, hence it represents a typical archetypal unstable flow in fluid dynamics. Moreover it is the reduction of more complex configuration to a simple model which can be treated mathematically yet exhibits the nature of complex flow behavior. For example, a simplified wake, created by a circular cylinder in compressible cross flow, has been used to model the energy separation and base pressure fluctuation [1]. It was recently found that studying the flow past a cylinder can help in understanding two oceanographic phenomena: separation of the Gulf Stream from the North American coastline at Cap Hatteras and the interaction of the Antarctic Circumpolar Current with topographic obstacles [25].

Let us describe the flow behavior when it passes a cylinder. Let $\mathbf{u}(t)$ denote the velocity field of the wake flow (here $\mathbf{u}(t)$ is the symbolic notation for a function of the space variable $\xi$). When $Re$ based on cylinder diameter and free stream velocity is small ($Re < 40$), the velocity field is stable and attracts all of the orbits. In this case the flow is fully laminar. When $40 < Re < 50$, steady vortices form behind the cylinder (see Figure 1). Typically, for $t \to \infty$, $\mathbf{u}(t)$ will converge to a stationary solution

$$\mathbf{u}(t) \to \mathbf{u}^s, \qquad \text{as} \quad t \to \infty,$$