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Flow past a rapidly rotating elliptic cylinder

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Abstract

Previous studies have shown that the characteristics of flow over a circular cylinder can be significantly altered by introducing rotation and ellipticity. While the effect of the former has been extensively studied; the influence of the latter is less explored. In this paper, we report results of a numerical investigation on the flow past a two-dimensional (2D) elliptic cylinder that is rapidly rotating at a Reynolds number of 200, covering a narrow range of high rotational velocity where low-frequency Mode II shedding occurs for a circular cylinder. Results show that aerodynamic forces and moments acting on a rotating cylinder are highly nonlinear with respect to variation in rotational velocity and cylinder thickness. Various wake topologies are revealed, including steady, quasi-steady, periodic and aperiodic flows. At an intermediate rotation rate, a "hovering vortex" is typically formed on one side of the cylinder, and at high rotation rates, multiple vortices are generated and rotated with the cylinder. These rotating vortices are highly related to a plateau in the mean lift over a certain range of cylinder thickness, as well as a sudden force transition from a mean drag to a considerable mean thrust when the thickness exceeds a certain threshold value.

1. Introduction

Flow past a cylinder is a classical problem of bluff body aerodynamics. Research on this problem dated back to Bénard (1908) and von Kármán (1911), and extensive studies have been conducted since then (see the review articles by Williamson 1996 and Zdravkovich 1997). It is well known that a vortex street is generated in the wake of a stationary cylinder when Reynolds number (Re,

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