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# Numerical study of unsteady flows past a rotating wavy cylinder

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**ABSTRACT**

In the present paper, three-dimensional unsteady flows past a rotating wavy cylinder have been studied through numerically simulations. The behavior of the lift forces acting on a rotating wavy cylinder and a rotating straight cylinder is compared, respectively. The results suggest that the rotation rate of the wavy cylinder has to be about two times that of a straight rotating cylinder in order to obtain the same value of the mean lift. The pressure distribution and the vortex structures in the wake of the rotating wavy cylinder at various rotation rates are also demonstrated and analyzed in this work. As rotation rate of the cylinder increases, the vortex formation length increases and the periodic shedding of the Karman vortex is suppressed. Three-dimensional vortex structures in the wavy cylinder wake are visualized at various rotation rates. Due to the surface rotation effect, a distinct difference exists in the vortex structures between a rotating wavy cylinder and a stationary wavy cylinder.

*Keywords*: Magnus-Robins effect; rotating wavy cylinder; vortex shedding

## 1. Introduction

Investigations of incompressible flow past a rotating circular cylinder at subcritical Reynolds numbers have been conducted by many researchers. The study of flow around a spinning cylinder are a subject of significant importance in aerodynamics and design of engineering structures. Rotating cylinders are also a kind of devices well recognized for the control of boundary layer flows. However, more complex scenarios prevail when an additional effect of spanwise wavy wall are taken into account. Therefore, the purpose of the present investigation is to address the force behaviors and wake flow structures affected by a combined effect of rotating cylinder and its spanwise wavy wall.

The lift force experienced by a rotating cylinder is called Magnus-Robins effect [1-2]. Prandtl[3] proposed that the maximum lift produced by a rotating cylinder in a uniform flow was limited to $4\pi$ (~ 12.6) when the streamlines were closed around the cylinder. However, Glauert[4] argued that Prandtl's limit can be exceeded as the circulation around the cylinder can be further increased by shedding the vortex through the closed streamline in the wake under the effect of centrifugal force. An early attempt of engineering application of the Magnus-Robins effect on the spinning cylinder had been conducted by a German engineer Anton Flettner, who was the first to build a ship which