11th. World Congress on Computational Mechanics (WCCM XI)
5th. European Conference on Computational Mechanics (ECCM V)
6th. European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

VORTEX SHEDDING AND ITS SUPPRESSION FOR A SHEAR FLOW PAST A CIRCULAR CYLINDER

Kai-Wen Chang[1], and Jiahn-Horng Chen[2]

[1] National Taiwan Ocean University, 2 Pei-Ning Road, Keelung, Taiwan, gbips520@gmail.com
[2] National Taiwan Ocean University, 2 Pei-Ning Road, Keelung, Taiwan, b0105@mail.ntou.edu.tw

Key Words: *Vortex Shedding, Couette Flow, Shear Effects, Vortex Shedding Suppression*

The flow past a bluff body has been a classical problem with great challenges in fluid mechanics. It comprises a kaleidoscope of challenging fluid phenomena [1] and has been widely and voluminously investigated theoretically, experimentally, and computationally. Among them is the vortex shedding when the Reynolds number exceeds some critical value. This issue has been studied for more than a century; nevertheless, its mechanisms are still not fully understood. The fluctuating exciting forces due to the vortex shedding induce various effects such as mixing enhancement, vibration and noise production, structural system resonance, scouring and so on. In applications, some of them are beneficial, some could be harmful, and others could be even detrimental.

Vortex shedding suppression has been an important issue in the past ten years because, as indicated above, the alternating shedding of vortices can induce harmful effects. Several approaches have been proposed in the literature. They can be subdivided into two categories: boundary layer control and wake control [2]. The latter attempts to alter the wake structure in some way so that the shedding of vortices can be suppressed and has a broader range of applications. For flow past a circular cylinder, the wake can be altered by rotating the cylinder which creates Magnus effects.

The second way to suppress the vortex shedding is the rotary oscillation of the cylinder. In addition to the peak angular velocity, another control parameter is the frequency (or period) of oscillation. Taneda conducted a series of experiments for *Re* between 30 and 300 [3]. He revealed that if the frequency was high enough, the vortex shedding can be effectively suppressed. In addition, there are some new findings of the flow physics for different combinations of the two control parameters [4-5].

In the present study, we computationally investigated the laminar Couette flow past a periodically rotating circular cylinder for the purpose of observing flow phenomena behind the cylinder and controlling vortex shedding. The cylinder was placed with its center on the centerline of the channel. The Reynolds number, based on the mean velocity and diameter of cylinder, was fixed at 50. The unsteady laminar flow was computed via a finite volume method with an implicit time-marching technique. There are two main parameters which affect the flow development behind the cylinder. They are the period (T), and the peak rotation speed (A) of the cylinder under rotation. We studied the variations of vorticity distribution, lift and drag coefficients and vortex flow patterns by varying the two parameters.

Several flow patterns were identified. If the cylinder rotates at the same period as that of vortex shedding when the cylinder is fixed (T_s), our computations reveal that the suppression of vortex shedding is not possible. However, if the cylinder rotates at a period other than T_s, some interesting flow phenomena are found. For some cases, the two-sided vortex shedding is reduced to a one-sided shedding pattern (Figure 1) and the drag is also reduced, compared to those for the cylinde without rotation. For other cases with proper combinations of the two parameters, the vortex shedding can be effectively suppressed (Figure 2). In addition, the variation of drag coefficient exhibit different patterns in a period, depending on the combination of the two parameters. A possible example is shown in Figure 3.

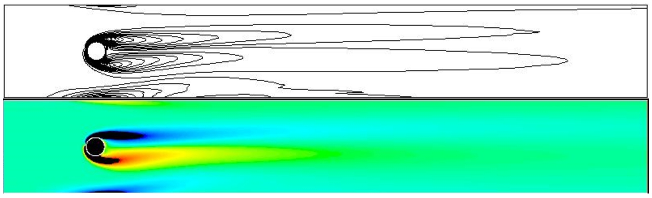

Figure 1 one-sided vortex shedding when $A = 0.2$ and $T = T_s/4$.

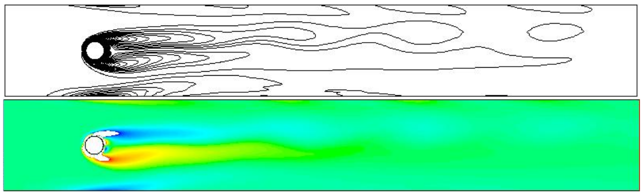

Figure 2 vortex shedding is suppressed when $A = 5$ and $T = T_s/20$.

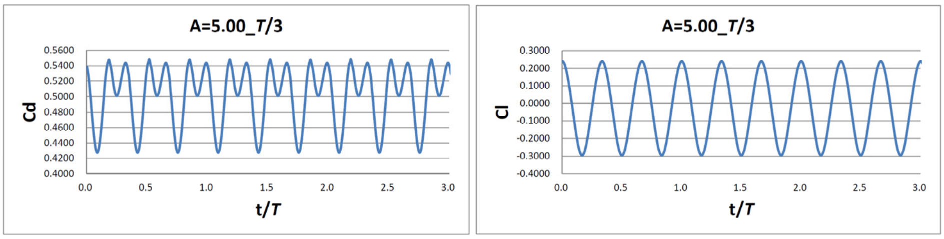

Figure 3 variations of drag and lift coefficients when $A = 5$ and $T = T_s/3$.

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