Two-Dimensional Vortex Shedding from a Circular Cylinder near a Moving Wall

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ABSTRACT

In vehicle aerodynamics, understanding of the flow over a bluff body near a moving wall is important in some situations, such as flow over a road wheel [1] and ground effect type racing cars [2]. Although many investigations have been performed on stationary wall case at various Reynolds numbers in the sub-critical regime [3-6], only a small number of literatures are available concerning the flow over a bluff body near a moving wall. In the present study, we carry out two-dimensional numerical simulations of flow over a circular cylinder near a moving wall, as shown in Fig.1.

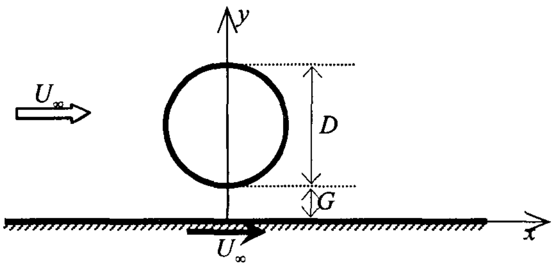

Fig.1 Schematic diagram of the computational configuration and coordinate system

Due to the kinematic condition of the wall, the gap flow rate is much larger than the stationary wall. Thus vortex shedding is observed even in the smallest gap distance simulated, contrary to the stationary wall case. However, the alternative vortex shedding is disappeared as the cylinder aproaches the wall. The intrinsic mechanism is explain using the inviscid instability theory. The stability of the mean velocity profile at the gap is consistent with the status of vortex shedding from the lower side of the cylinder. The stability mechanism may also explain the suppression of vortex shedding for the stationary wall case.

The critical gap ratio $(G/D)_C$ is defined as the value at which the alternative vortex shedding disappears, which is corresponding to the critical gap ratio for the stationary wall case at which the vortex shedding is suppressed at the lower side of the cylinder. It is found that the critical gap ratio corresponds to a local minimum of the streamwise maximum mean velocity in the gap. Using this feature the critical gap ratio is determined precisely. It shown that the critical gap ratio decreases with Reynolds number and becomes constant for $Re > 500$, as shown in Fig.2.

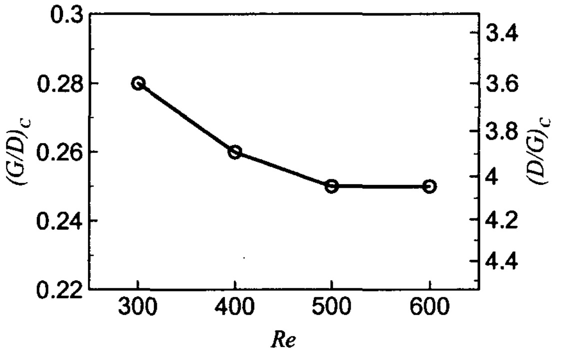

Fig.2 The critical gap ratio at different Reynolds numbers

The variations of the drag and lift forces with Re and D/G are presented. It is interesting to find that the rotation of the force vector agrees well with the averaged displacement of the front stagnation point and the bisector of the two separation points, as shown in Fig.3. Inspection of this feature in the three-dimensional flow regime is necessary.

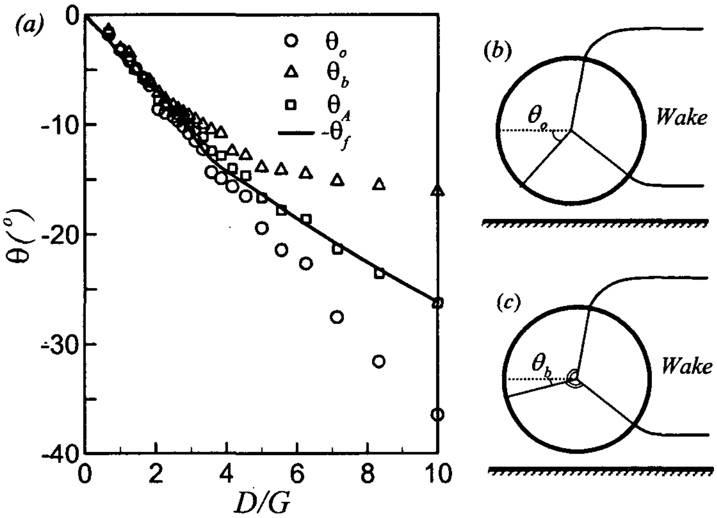

Fig.3 Comparison among various angles (a): $-\theta_f$, minus force angle; θ_o, angular position of the front stagnation point; θ_b, angular position of the bisector of the upper- and lower-side separation points and $\theta_A = (\theta_o + \theta_b)/2$; (b) Schematic of θ_o and (c) schematic of θ_b.

The selection of the velocity scale in the definition of the Strouhal number is discussed. The uniform free stream velocity and the separation velocity [7] are examined. As shown in Fig.4, the Strouhal number is collapsed into a single curve for different Reynolds numbers when it is defined in terms of the separation velocity.

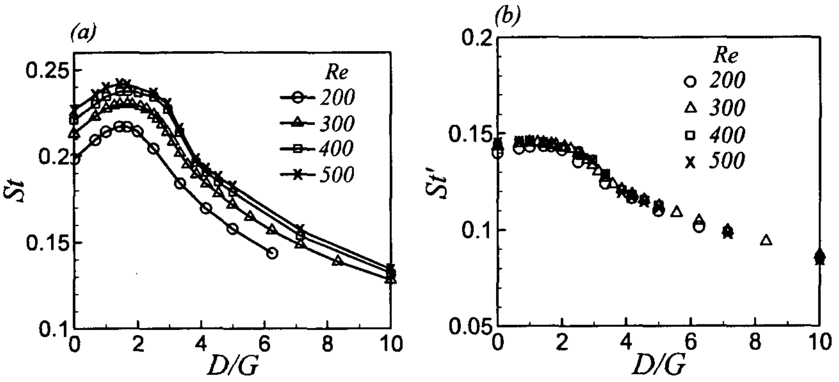

Fig.4 Strouhal number defined in terms of (a) freestream velocity and (b) separation velocity at Re = 200, 300, 400, 500

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