**Numerical Analysis of Circular Cylinder in Combination of Uniform Flow and Oscillating Flow at Low-Reynolds Number**

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**ABSTRACT**

The dynamic mesh technique and User-Defined Function (UDF) are used to simulate the cylinder motion. A transversely oscillating circular cylinder in combination of uniform flow and oscillating flow at low Reynolds number is simulated. The uniform flow and oscillating flow both are x direction. SIMPLE algorithm is used to solve the Navier-Stokes equations. In this paper, we compute the lift and drag coefficient changing with time and draw the map of vorticity isolines at phase angle \( \phi = 3\pi/2 \). Force time histories are shown for uniform flow at Reynolds number (Re) of 200 and for the combination of uniform and oscillating flow.

**KEY WORDS:** Transversely oscillating cylinder; circular cylinder; uniform flow; oscillating flow; vorticity isolines.

**INTRODUCTION**

In recent years, increasingly more and more exploration and production have shifted to deeper waters. Marine risers remain to be technically challenging in deep sea. More and more pivotal components of the circular cylinder shape represented by marine risers are widely used in the offshore platform and subsea pipeline systems. Many works focus on the research of circular cylinder in uniform flow and oscillating flow. Many excellent experiments and numerical simulations had been done in the fields of flow around circular cylinder. Gu et al. (1994) found that vortex from one side of the cylinder to the other reach to a high degree of concentration of vorticity next to cylinder when the \( f/f_s \) increased ( \( f \) is the oscillating frequency of cylinder, \( f_s \) is the shedding frequency for the fixed cylinder). Lu and Dalton (1996) studied the vortex shedding from a transversely oscillating circular cylinder in a uniform flow by numerical solutions. The impact of increasing the amplitude of oscillating cylinder and Reynolds number are shown to lower the value of \( f/f_s \) at which vortex switching.

Wang and Zhou (2005) studied a circular cylinder oscillating transversely in a uniform flow and verified the conclusion of Lu & Dalton. Meneghini and Bearman (1995) obtained the boundary of lock-in for small amplitudes of oscillations. The \( f/f_s \) varied from 0.7 to 1.15 and for \( A/D \) from 0.025 to 0.6 in the simulation. Williamson and Roshko (1988) carried out experiments for large amplitudes of oscillation. Anagnostopoulos and Bearman (1992) conducted experiments about the vortex induced transverse oscillations of a circular cylinder at low Reynolds number ranging between 90 and 150. The amplitude of the lift force in phase with the circular cylinder velocity is maximum at the lower limit of the lock-in region. Zhao and Chen (2006) reproduced these results by Lagrangian–Eulerian (ALE) method.

There are seldom papers and research works in combination of uniform flow and oscillating flow at present. The numerical simulation considering combination of uniform flow and oscillating flow is more practical. This paper deals with transversely oscillating circular cylinder in combination of uniform flow and oscillating flow at low Reynolds number by the dynamic mesh technique and User-Defined Function (UDF). The uniform flow and oscillating flow both are x direction. Lift coefficient and drag coefficient changing with time have been simulated. Fixed cylinder in uniform flow have been simulated to test and verify the model and Strouhal number (\( f_s D/U \)).

**NUMERICAL COMPUTATIONS**

Control equations are the two-dimensional incompressible viscous flow Navier-Stokes equations, continuity equation and momentum equation for cartesian coordinates are

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\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0
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