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NUMERICAL SIMULATION OF FLOW OVER TWO CIRCULAR CYLINDERS IN TANDEM ARRANGEMENT*

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Abstract: In this article, the 2-D unsteady viscous flow around two circular cylinders in a tandem arrangement is numerically simulated in order to study the characteristics of the flow in both laminar and turbulent regimes. The method applied alternatively is based on the finite volume method on a Cartesian-staggered grid. The great source term technique is employed to identify the cylinders placed in the flow field. To apply the boundary conditions, the ghost-cell technique is used. The implemented computational method is firstly validated through simulation of laminar and turbulent flows around a fixed circular cylinder. Finally, the flow around two circular cylinders in a tandem arrangement is simulated and analyzed. The flow visualization parameters, the Strouhal numbers, and drag and lift coefficients are comprehensively presented and compared for different cases in order to reveal the effect of the Reynolds number and gap spacing on the behavior of the flow. The obtained results have shown two completely distinct flow characteristics in laminar and turbulent regimes.

Key words: circular cylinders, tandem arrangement, vortex shedding, hydrodynamic forces

Introduction

The study of a group of circular cylinders in cross-flow has attracted a great attention in the recent decades. Examples of its various applications in practical engineering areas include: offshore platforms, transmission cables, cooling towers, heat exchanger tubes, chimney stacks and marine risers. The mentioned structures are subjected to air or water flows and therefore, experience flow-induced forces which can lead to their failure in a long time. Basically, with respect to the free stream direction, the configuration of two cylinders can be classified as tandem, side-by-side and staggered arrangements. These configurations have been the subject of a lot of numerical and experimental studies by different researchers.

In this respect, wake interaction between two circular cylinders in tandem and side-by-side arrangements was studied experimentally by some researchers such as Zhang and Melbourn[1], Bearman and Wadcock[2], Liu et al.[3] and Ryu et al.[4]. In the meantime, the flow pattern for tandem arrangement was recently studied numerically by Mittal et al.[5], Meneghini et al.[6], Mahir and Altac [7], Singha and Sinhamahapatra[8], Ding et al.[9] and Kitagawa and Ohta[10] for both laminar and turbulent regimes. Zhang and Melbourne[1] investigated experimentally he interference between two tandem cylinders in turbulent flow at $Re = 1.1\times10^5$ and for cylinder spacing up to 10 diameters. They observed that at subcritical Reynolds numbers, the reattachment of separated flow from the upstream cylinder to the downstream one occurred in the critical spacing range of $3 < L/D < 4$.

In addition, many researchers such as Bearman and Wadcock[2], Liu et al.[3], Roy et al.[4], have contributed their study to the investigation of flow around two fixed side-by-side cylinders. In their experimental work, Bearman and Wadcock[2] applied a flow visualization method to study the effect of interference between two circular cylinders in side-by-side arrangement at $Re = 2.5\times10^4$. At low

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