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ORIGINAL ARTICLE

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A LES study of the flow interference between tandem square cylinder pairs

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Abstract The results of an investigation on the interference effects of the tandem square cylinders exposed to a uniform flow are presented in this paper. Time-dependent and three-dimensional flow simulations are carried out using large eddy simulation with a one-equation subgrid model. An incompressible three-dimensional finite volume code with a collocated grid arrangement is used for solving filtered Navier–Stokes equations. These equations are solved with an implicit fractional two-step method. Simulations are conducted with different Reynolds numbers between 10^3 and 10^5. The longitudinal spacing between the cylinders is selected 4D for the chosen Reynolds numbers, where D is the side of the cylinders. Also the effect of the spacing between cylinders, ranging from 1D to 12D, is studied for the selected Reynolds numbers. The instantaneous flow field is studied by analyzing the vortices, pressure, streamlines and Q-criterion to assist understanding of the various flow patterns, vortical structures and Kelvin–Helmholtz vortices in the separating shear layers. The hysteresis is observed in a certain range of the gap spacing, which this range depends on the selected Reynolds number. The global results are also computed and compared with available experimental results. The results indicate that there is a satisfactory agreement between the predictions and available experimental data considering the fine grid adopted.

Keywords Tandem square cylinders · Unsteady flow · Flow structure · Large eddy simulation · One-equation subgrid model · Hysteresis

1 Introduction

The flow over cylinders in tandem, side-by-side or staggered arrangements represents an importance and complex configuration that is of interest for many engineering applications such as tall buildings, adjacent skyscrapers, groups of chimney stacks, tubes bundles in heat exchangers, overhead power-line bundles, bridge piers, stays, masts, chemical reaction towers, off-shore platforms and electronic systems especially in computer equipment. For these configurations, the flow interference has an essential role for several changes in the characteristics of the flow. Thus, the dynamic interaction between the structure and the fluid is one of the most fascinating problems in engineering mechanics. The behavior of flow over cylinders is dependent on the shape of the cylinders, the number of cylinders involved, the distance between the cylinders and the Reynolds number employed. Except perhaps for the circular section [1–7], the detailed knowledge on the unsteady flow field around square cylinders in tandem, side-by-side or staggered arrangements is rather limited in spite of the efforts involved in taking unsteady measurements and calculations in such flows. Consequently, there is a considerable gap of knowledge concerning the non-circular cylinders at various Reynolds number. From

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