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A smoke visualization study of the flow over a square cylinder at incidence and tandem square cylinders

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Abstract An experimental investigation of flow around a square cylinder placed at various incidence angles (0–45) with respect to the approach flow is reported (Re_d = 2,033, 6,776, 7,575, 8,246). Also flow over two square cylinders in a tandem arrangement at zero incidence is studied for different gap spacing values ranging from 1d to 6d, where d is cylinder side length (Re_d = 2,033). A low-speed vertical smoke tunnel is used to visualize flow patterns. For single cylinder, the flow patterns, stagnation and separations points, separation angle, attachment point, transient and turbulence lengths of the shear layer, wake length, frequency and Strouhal number for various incidence angles are determined quantitatively using flow visualization and image digitization process. It is found that a critical value appears around $\alpha = 15^\circ$ for aforementioned parameters due to occurrence of the reattachment of the separated shear layer on the lateral face of the cylinder.For tandem cylinders, the effect of gap spacing between cylinders on the flow patterns, separation angle, wake length, and transient and turbulence lengths of the shear layer of the upstream cylinders is investigated. The results showed that there are three flow patterns when the gap spacing values are varied from 1d to 6d. Also it is observed that the aforementioned parameters for the upstream cylinder become approximately similar to those for single cylinder due to reduction in the flow interference of the cylinders at higher gap spacing values, i.e., 5d and 6d.

Keywords Smoke visualization · Square cylinder at incidence · Tandem square cylinders · Stagnation · Separation · Attachment · Kelvin–Helmholtz structures

1 Introduction

Flow visualization is one of the most basic methods to study the flow structures over bodies. It is used to demonstrate a huge series of data in just a picture. Flow visualization is a tool in experimental fluid mechanics that renders certain properties of flow field directly accessible to visual perception. It has always been believed that observation of a process pattern facilitates the development of the understanding and the

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