

Available online at www.sciencedirect.com



Journal of Hydrodynamics

2011,23(1):55-64 DOI: 10.1016/S1001-6058(10)60088-1



www.sciencedirect.com/ science/journal/10016058

FLOW PATTERNS AND FORCE CHARACTERISTICS OF LAMINAR FLOW PAST FOUR CYLINDERS IN DIAMOND ARRANGEMENT *

ZOU Lin

School of Mechanical and Electronic Engineering, Wuhan University of Technology, Wuhan 430070, China, E-mail: l.zou@163.com LIN Yu-feng Department of Mechanical Engineering, The Hong Kong Polytechnic University, Hong Kong, China

LU Hong

School of Mechanical and Electronic Engineering, Wuhan University of Technology, Wuhan 430070, China

(Received April 26, 2010, Revised November 15, 2010)

Abstract: A three-dimensional numerical investigation of cross-flow past four circular cylinders in a diamond arrangement at Reynolds number of 200 is carried out. With the spacing ratios (L/D) ranging from 1.2 to 5.0, the flow patterns can be classified into three basic regimes. The critical spacing ratio for the transition from narrow gap flow pattern to vortex impingement flow pattern around the cylinders is found to be L/D = 3.0, while a single bluff-body flow pattern is observed at L/D = 1.2. The relationship between the three-dimensional flow patterns and force characteristics around the four cylinders shows that the variation of forces and Strouhal numbers against L/D are generally governed by these three kinds of flow patterns. It is concluded that the spacing ratio has important effects on the development of the free shear layers about the cylinders and hence has significant effects on the force and pressure characteristics of the four cylinders with different spacing ratios.

Key words: four cylinders, spacing ratio, flow pattern, force characteristics

Introduction

A cylinder array is a basic unit in multi-cylinder arrays and tube banks, with many direct practical applications, such as in heat exchanges, offshore structures, and even micro electro-mechanical systems. The complexity of flow separation and free shear layer interference generated by the cylinder arrays has attracted considerable attention in the past. Some insight is gained by previous studies about the vortex dynamics in the flow around single or two circular

Corresponding author: LIN Yu-feng, E-mail: mmyflin@gmail.com

cylinders. For the flow around a single cylinder, the vortex dynamics of wake about the cylinder were systematically studied by using different methods^[1,2], even with a consideration of the effects of flow-induced structural deformation for a circular cylinder^[3]. For flow around the two cylinders, the flow interference between two circular cylinders and forces on the cylinders in tandem^[4,5], side-by-side^[6,7] and in staggered arrangements^[8,9] was extensively studied. As a result, a greal deal is known about the flow around single and two cylinders. It is shown that the steady and fluctuating fluid forces acting on structures are mainly governed by the characteristics of the flow around the single or two cylinders.

In practice, the flow around four cylinders is more important than that around the single or two cylinders because of its more complicated nature, depending on the angle of incidence (α) between incident flow and the line through the cylinders centres, as well as on the spacing ratio (L/D),

^{*} Project supported by Open Research Foundation of State Key Laboratory of Digital Manufacturing Equipment and Technology, Huazhong University of Science and Technology (Grant No. DMETKF2009016), the Fundamental Research Funds for the Central Universities (Grant No. 2010-Ia-030). **Biography:** ZOU Lin (1970-), Female, Ph. D., Associate

Professor