Proceedings of the Eighth (1998) International Offshore and Polar Engineering Conference
Montréal, Canada, May 24-29, 1998

ISBN 1-880653-34-6 (Set); ISBN 1-880653-37-0 (Vol. III)

The Three Dimensional Flow Features of Interaction Between Two Vortex Streets

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ABSTRACT

Interaction between two vortex streets with difference in shedding frequency, generated from instability of 2–D wake-type flows is investigated numerically. A hybrid method for solving Navier-Stokes equations combining the compact finite difference in streamwise and Fourier spectral method in spanwise is adopted. The Reynolds number in present calculation is 200. Typical characteristics of the vortex street interaction, such as vortex splitting and reconnection, formation of streamwise vortices and the connection with the spanwise vortices, the generation of spanwise velocity and "climbing" phenomenon are presented and analyzed. In the downstream a kind of large scale "spot-like" coherent structures is found which is called vortex dislocation phenomena found by Williamson and other experimentalists. Correspondingly flow field features are shown in detail. The present results show that the interaction of vortex streets plays a basic role for flow transition to turbulence.

KEY WORDS: Interaction of vortex streets, flow transition

INTRODUCTION

In many offshore structures some small scale structures are always located in wake flows of their neighbouring cylindrical structures. The wake flows basically consist of multiple three-dimensional vortex streets with different direction, various phases and frequencies. Strong interaction between the vortex streets occurs and results in a very complex turbulent flow field. To understand the details of the flow is of significant important not only for predicting the fluid force and dynamics response of the small structures, but also for studing the mechanism leading to flow transition to turbulence. It is believed that as a first step to approach the complex problem study the flow features of two vortex street interaction is helpful to both engineering and basic research purposes.

Recently Williamson[1], among others, reported a new mechanism on the transition of cylinder wake flow, which associates with the generation of a large-scale spot-like, 'vortex dislocations' due to difference in phase and vortex shedding frequency. Similar phenomenon can be found in boundary layer transition and in many other practical flows, such as shear flows past a cylinder, uniform flow past a cylinder with a local discontinuity in diameter and free shear flows etc. The basic characteristics of these complex vortex dislocation phenomena may be related to the development of vortex street interaction and by now only a few of theoretical studies have been undertaken. Based on above viewpoints, in present paper a numerical study on the 3–D flow features of the interaction between two vortex streets with difference in phase and frequency is performed. The temporal and spatial evolution of the vortex street interaction and some typical characteristics, such as vortex splitting and reconnection, formation of streamwise vortices and a kind of large-scale spot-like coherent structure are introduced. The calculated global features are comparable with experimental results.

METHOD

For solving 3–D incompressible open space flow to provide not only high numerical accuracy and wave number reso-