海氣界面之渦漩流體

Vortex Flow between Air Sea Interface

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Abstract

Flow past obstacle generate vortices. Vortex flow affects the thermal mixing and the diffusion of pollutants in the atmosphere and ocean. Ocean current produce vortices behind underwater object, then appearance on the sea surface in vortex pair form. The evolution of surface vortices is investigated by CCD and optical scanning method, especially the influence of surface winds on the sea surface vortex.

1. Introduction

Near surface turbulence controls many geophysical and environmental flow, including mixing of pollutants in rivers as well as gas and heat exchange at the air-sea interface. It also plays an important role in remote sensing of ship wakes. In this study, we aim to investigate the water surface features caused by the vortices generated from a submerged sphere under air and aqueous flow and conditions.

It is more convenient to use the slope of the water surface rather than the elevation of the mean water level as a parameter for the study of the fine structure of the water surface because high-frequency waves with low amplitude have large slopes (Cox 1958). In addition, the energy of capillary waves is proportional to the mean square of wave slope (Phillips 1977). Furthermore, the water surface slopes can be used to investigate free-surface turbulence because free-surface turbulence is related to the elevations of the near-surface flow field.

2. Experimental Methods

A scanning laser slope gauge (SLSG) was developed to visualize water-surface fine structure and to quantify the slope of those features. The underlying idea for designing such a system is to use the optical method that would not distort water flows in the process of mapping two-dimensional surface features (Li, 1993). The features of surface vortices as well as surface waves could be deduced from surface signals collecting by this system.

SLSG scans a footprint of 8.0×8.0 cm^2 on the water surface to map the surface slopes. SLSG has a 17-facet polygon mirror that rotates at 5743 rpm. Each facet is tilted at different polar angles to produce a frame scan of 17 lines during each revolution. The laser light vertically directed by the facets of a rotating polygon in an underwater-insulated box from the bottom of the water tank is incident on the water surface and then is received by a position sensor on the top of the tank. SLSG has a fast frame rate of 100 fps. Therefore, the surface vortex feature of the mapping area is supposed to be rozen Vortex propagation speed on the water surface was derived from the analysis of the vortex appeared on the SLSG image frames.

A hot-film anemometer (TSI, IFA-300) was deployed to measure fluid velocity fluctuation behind the sphere. The vortex shedding frequency was calculated from the spectrum analysis of the velocity fluctuation.

3. Experimental Setup

The experiment was conducted in a wind wave tank facility. There are two channels for the circulation of fluids; one is for the water and the other is for air. Therefore, current speeds and wind speeds are controlled for the experimental purpose. The experimental variables include current speed (U), sphere diameter (D), and sphere depth (h). Two dimensionless variables are derived for systematic analysis. One is Reynolds number $Re=UD/\nu$, the other is Froud number $Fr=U/(gh)^{1/2}$. A sphere with diameter 5 inches was rigidly supported by a rod fixed on the bottom of the tank.

The experimental setup of SLSG is as shown in the Figure 1. It is composed of three parts, the underwater optical scanning system, the part of optical sensor system above the water surface, and the third part of a computer and an electronics box which included power supplies,

4. Concluding Remarks

Vortex propagation speed on the water surface is increased with Reynolds numbers from our experimental results. For a given current speed, the vortex propagation speed is increased as the submerged depth of the sphere is increased as shown in Figure2. The vortex shedding frequency is increased with current speed as shown in Figure 3.

References

Cox, C. S. easurement of slopes of high-frequency wind waves *J. Mar. Res.* 16, 199-216, 1958.

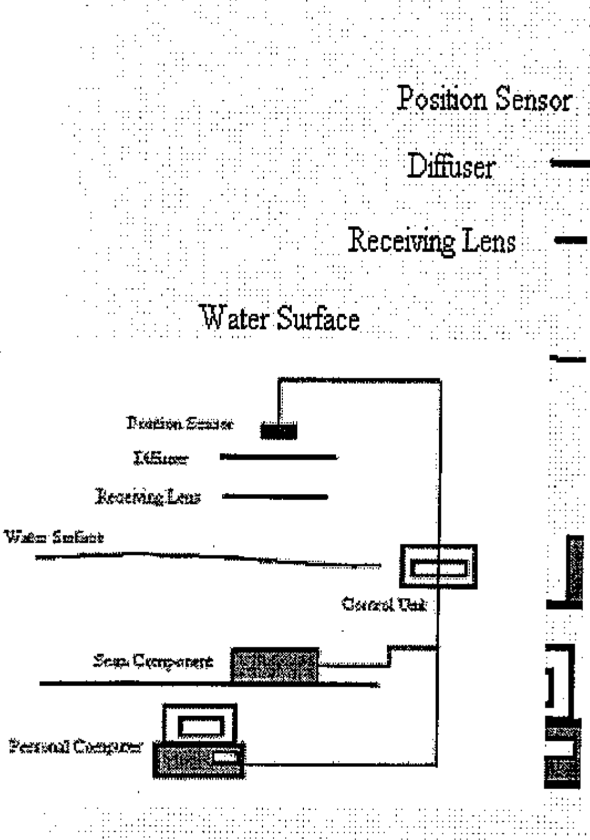

Figure 1. The setup of surface vortex experiment.

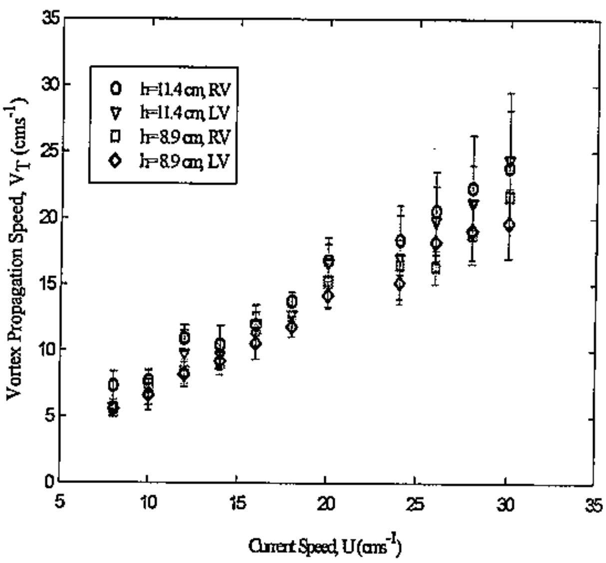

Figure 2. Vortex propagation speeds increase with current speed.

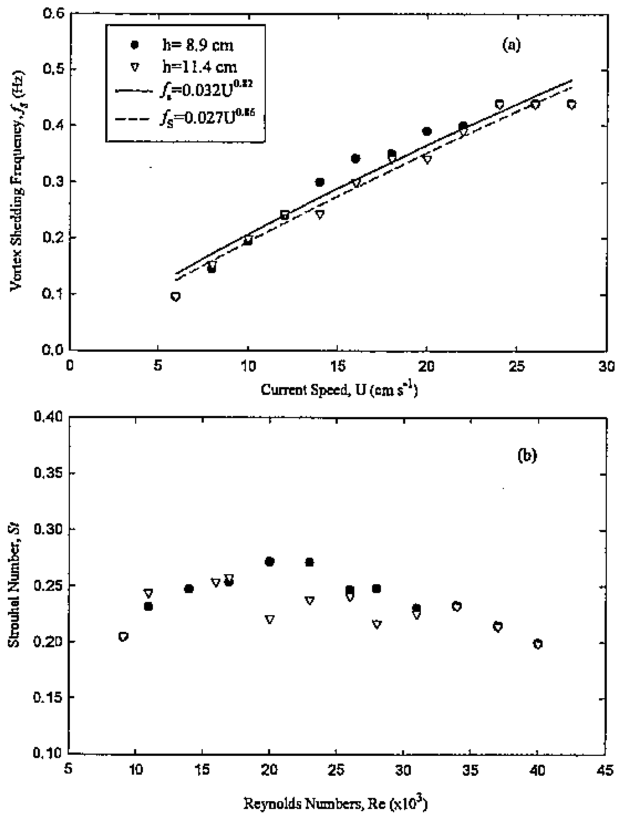

Figure 3. Vortex shedding frequency increases with increasing current speed.