

Velocity Field Measurements Using Bubble Tracers in a Cavitation Tunnel

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ABSTRACT

As the tracers for PIV (Particle Image Velocimetry) can cause damages on the inner equipment's sensors or tough cleaning works after experiments, PIV measurements have been excluded, especially in a cavitation tunnel containing too much water, even though they have efficient potentials on the quantitative visualization and analysis of flows around the underwater body. The objective of present study is to investigate the possibility of PIV using tracers of bubbles naturally generated in a cavitation tunnel. The bubble can be grown from the nuclei melted in the water of tunnel and the size of bubbles is changed by varying the tunnel pressure. Since the trace ability and appropriate size of tracer are so important for PIV techniques, the characteristics of bubbles as tracer should be found out in the viewpoint of trace ability and bubble size with the variation of flow speed and tunnel pressure..

KEY WORDS: PIV; tracer, bubble, cavitation tunnel, pressure

INTRODUCTION

The flow velocity can be measured with the PIV technique if there are tracers in the flow field, which is similar to the LDV (laser Doppler velocimetry) technique. In the case of LDV, the measurement volume is about a few mm³ and the measurement of average velocity is available even though there is small number of tracers in the flow field. On the other hand, the PIV technique, not a point-wise measurement but a field measurement, needs uniformly distributed tracers in the flow for the appropriate measurements since it can have the measurement range of a few μm to a few m. In addition, the tracer has the size of from a few nm to a few mm with the variation of the experimental conditions and the size of measurement plane. As the size of tracer is getting larger, the light intensity scattered from the tracer within the laser light sheet is also getting larger and this can provide some merits to the PIV measurements. However, larger tracers may play a role of additional nuclei in the cavitation tunnel and affect the cavitation patterns to some degree. As a result, the PIV measurements can not be

conducted together with the cavitation observation tests in a tunnel and lead to some harsh works to clean the whole cavitation tunnel after them. MOERI(Maritime and Ocean Engineering Research Institute)'s mid-size cavitation tunnel holds water of about 50 tons and the cleaning works to remove tracer particles were possible after PIV measurements. Recently, MOERI has constructed another cavitation tunnel, which will have large test section of 2.8 x 1.8 x 12.5 m³ and contain about 2100 tons of water. In this new cavitation tunnel, the cleaning works is considered to be nearly impossible because they will require too much cost and time. Therefore, serious considerations would be necessary for the effective employment of the PIV measurements in the large cavitation tunnel as well as the mid-size cavitation tunnel.

The experiments carried out in the MOERI's mid-size cavitation tunnel were the reproduction of the hull wake, propeller cavitation tests, rudder cavitation test(Paik et al, 2008) and so on. For the realization of the hull wake equipment called the wake screen made of several meshes is used to simulate the wake flows behind the bare hull. Since this wake screen has quite fine and dense meshes, lots of tiny bubbles can be generated additionally. Although the large cavitation tunnel does not need the wake screen, it would be meaningful to investigate the trace ability of the bubbles in the presence of the wake screen. The tunnel pressure should be controlled to match the propeller operation condition and lots of bubbles appeared when it is decreased under the water vapor pressure.

The PIV for two-phase flow has been done to obtain velocity fields in the bubbly flows. Lindken at al(2002) performed the studies to separate each velocity component of the liquid or the vapor in the bubbly flow state. Although Jansen et al.(1986) investigated the breaking wave containing bubbles using the fluorescent particles and ultraviolet rays, they showed not good spatial resolution of velocity field. Govender et al.(2002) showed insufficient explanation of the PIV technique itself though he tried to get some information on the two-phase flow. It is necessary to study the details about the light source because the intensity of the scattered light from the particles is small in the bubbly flow with low void fraction and small-size bubbles. Ryu et al.(2005) have conducted PIV measurements based on the silhouette technique considering the bubbles as the tracer to visualize the green water over the head deck of a ship. Although they tracked successfully the bubbles using the white source of 600W instead of laser light source, the reliability of experimental results of the flows with highly velocity