A fundamental study of disappearance phenomenon of partial cavitation on the NACA 16012 hydrofoil

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Long Abstract

1. Introduction

For the purpose of understanding of the basic characteristics of cavitation, a number of studies have been conducted using the single hydrofoil which is a basic element of fluid machinery. Experimental study using NACA16012 hydrofoil was conducted in order to investigate the relationship between cavitaiton and boundary layer. Generally, the cavity grows as the cavitation number decreases, however Franc et al.[1] reported that, when the cavitation number decreases on a condition of constant angle of attack at 4 deg., cavitation pattern changes as non-cavitation, partial cavitaiton, non-cavitation and finally, super-cavitation. Details of the disappearance phenomenon have not been described in the article, and research related to this phenomenon has never carried out and clarified by other researchers

The authors have reproduced the disappearance phenomenon in NACA16012 hydrofoil in the previous study at Tohoku university [2],the disappearance phenomenon can be seen in a region of sheet-cloud cavitation at angle of attack from 5 deg to 7 deg. However, it is necessary to consider the influence of the tunnel because the desappearance condition is different from that by Franc et al. Therefore in this study, the experiment is conducted for the reproduction of the disapearance phenomenon by using the cavitation tunnel at Kyusyu University which size is larger than that in our tunnel. And, in order to investigate the disappearance mechanism, lift and drag force and pressure distribution on the hydrofoil are measured in the non-cavitation condition and the disappearance condition. In addition, by analyzing the pressure fluctuation at the downstream of the hydrofoil, relationship between the unsteady characteristics of sheet-cloud cavitation and the disappearance mechanism is discussed.

2. Experimental Set up

In this study, the experiment is conducted by using the cavitation tunnel in Kyusyu University. It is composed of upper tank, test section and pump. The cross section of the test part is 200 mm high and 81.5 mm width. NACA16012 hydrofoil with chord length 100 mm and span width 81 mm is used in this study. The pressure in the upper tank is pressurized and depressurized by using a compressor and a vacuum pump, whereby the pressure of the whole tunnel is adjusted. A pressure transducer is furnished 200 mm upstream from the center of the hydrofoil for measuring hydrostatic pressure of the test section. Lift and drag force is measured by 2 gauges method using a cantilever beam with 4 strain gauges attached to each sides of a rectangular cross section. The pressure distribution on the hydrofoil surface is measured by making pressure holes in the hydrofoil surface (18 holes at the suction surface and 7 holes at the pressure surface) and connected to a pressure transducer. In this experiment, the flow velocity is kept fixed at 5.4 m/s (Re=4.8×10^5), 9.2

m/s (Re=1.0×10^6), and at the angle of attack 2.5 to 4 deg., the pressure is reduced gradually from non-cavitation condition to bubble cavitation condition. The change of the cavitation patterns is observed, and at that time, cavitation number is measured.

3. Results and Discussion

Figure 1 shows the cavitation patterns observed in this study. Cavitation disappearance phenomenon is seen at the angle of attack of 3° and 4° at Re=1.0×10^6, although that is not seen at Re=4.8×10^5. Even though the condition of the phenomenon is different from previous studies, the disappearance phenomenon is seen at three cavitation tunnels. Therefore it is considered that cavitation disappearance phenomenon is not caused by the influence of the tunnel but is the characteristic of NACA16012 hydrofoil.

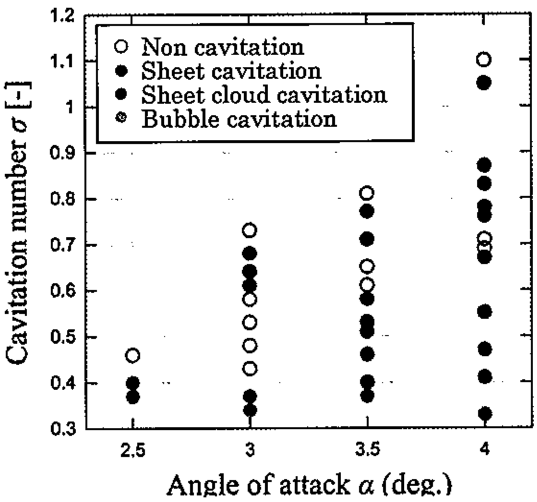

Figure 1. Observed cavitation patterns at Re=1.0×10^6

As the result of the measurement of lift and drag force and pressure distribution around the hydrofoil with non-cavitation condition, the change of the gradient of lift force is observed at the angle of attack 3.5 deg. at which the cavitation disappearance occurred and as shown Figure 2, at the same angle of attack, a local pressure rise is also observed in mid chord region in pressure distribution on suction surface of the hydrofoil. Compared to the results of the visualization experiment of the boundary layer by Franc, it is considered to be due to the exsistence of the steady reattachment point of the separation bubbles. It is considered the cavitation disappearance phenomenon is coused by the characteristics of the peculiar boundary layer on the hydrofoil's suction surface. In addition, by measurement of the pressure fluctuation at the downstream of the hydrofoil, it was found that the disappearance phenomenon is observed in a certain frequency bands of cloud shedding.According these results, it can be inferred that the cavitation disappearance phenomenon may be affected by the peculiar boundary layer characteristics and frequency characteristics.

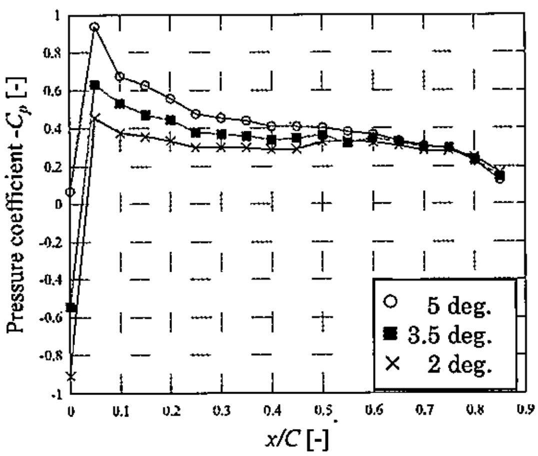

Figure 2. Time averaged pressure distribution on suction surface in non-cavitation condition (σ = 1.6, Re=1.0×10^6)

Reference

[1]J. P. Franc," Attached cavitation and the boundary layer: experimental investigation and numerical treatment", J. Fluid Mech. (1985), vol.154.

[2]Iga, Y., and Furusawa, T., "Experimental study of appearance of thermodynamic effect on cavitation in hot water" , JSME, vol.83, No.845 (2017.1), p.16-00377