MEASUREMENT OF FLOW FIELD IN A TURBOPUMP INDUCER UNDER CAVITATING CONDITION

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ABSTRACT

Flow field near the tip region of a turbopump inducer has been measured using Particle Image Velocimetry (PIV) method in a cavitating condition. Tip leakage vortex cavitation in an inducer leads to hydraulic instabilities, thus, the effects of tip leakage vortex cavitation on a flow field near the blade need to be investigated. Using the tilted laser sheet, flow field near the tip leakage vortex cavitation has been measured. Two different sizes of tip leakage vortex cavitation has been compared. For a small cavitation region, the flow field near the inducer blade is not affected by tip leakage vortex cavitation. Thus, an incidence angle near the leading edge of the inducer blade is positive. On the other hand, for a large cavitation region, tip leakage vortex cavitation increases the axial and absolute tangential velocity near the leading edge of the inducer blade. Thus, the incidence angle becomes negative. Such measurements will give clues to understand the mechanism of hydraulic instabilities induced by tip leakage vortex cavitation.

INTRODUCTION

Turbopump inducer cavitation can cause hydraulic instabilities, or cavitation instabilities, including rotating cavitation, asymmetric attached cavitation, and cavitation surge. Especially, tip leakage vortex cavitation plays an important role in cavitation instabilities [1-3]. Until now numerical simulations for cavitation instabilities using unsteady Reynolds-Averaged Navier Stokes method cannot predict tip leakage vortex cavitation accurately. Therefore, this study aims to measure the velocity field near the leading edge of the inducer tip region to understand tip leakage vortex cavitation effects using Particle Image Velocimetry (PIV) method.

RESULTS AND DISCUSSION

PIV images near the tip region of the inducer blade have been obtained under cavitating condition. To avoid the blockage effects of cavitation region, the laser sheet has been tilted by 40° relative to the axial direction. Small and large tip leakage vortex cavitation regions have been compared, and 50 and 24 PIV images of similar tip leakage vortex cavitation regions have been phase-locked ensemble averaged, respectively. Figure 1 shows a raw image with absolute velocity vectors for a small tip leakage vortex cavitation region. Tip leakage vortex cavitation cannot be seen at the bottom of the picture because the cavitation region on the leading blade is not sufficiently large. Flow comes from left to right, and the absolute tangential velocity increases as the flow approaches the inducer blade due to the inducer rotation. Incidence angle at the leading edge of the following blade is positive at 6.7° (ranging from 4.3° to 9.4°).

Figure 2 shows a raw image with absolute velocity vectors for a large tip leakage vortex cavitation region. Axial and absolute tangential velocities are higher than the small tip leakage vortex cavitation case. The closure region of the tip leakage vortex cavitation increases axial and absolute tangential velocities. Thus, the incidence angle at the leading edge of the following blade becomes negative at -4.4° (ranging from -1.9° to -8.3°).

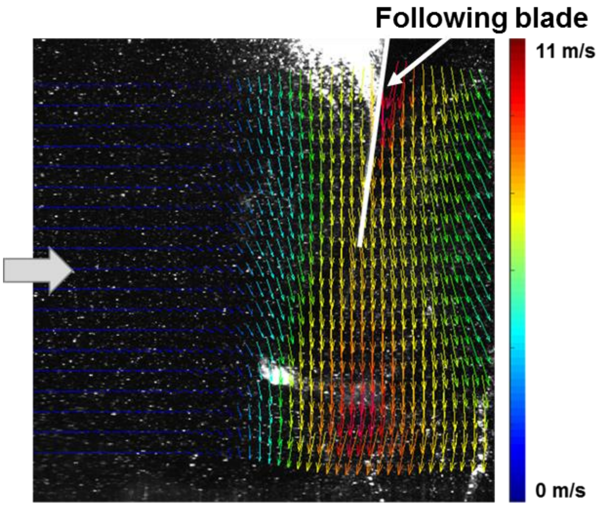

Figure 1. Raw image and velocity vector (50 frames phase-locked ensemble averaged) in case of the small cavitation region

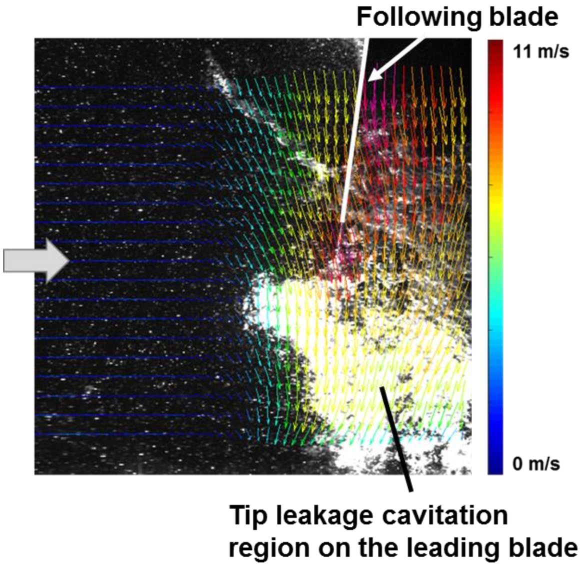

Figure 2. Raw image and velocity vector (24 frames phase-locked ensemble average) in case of the large cavitation region

REFERENCES

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