SIMULATION OF A SUPER-CRITICAL BATHTUB VORTEX: COMPARISON WITH EXPERIMENTAL DATA

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Most of the sites with the largest hydropower potential in the world are already exploited. Therefore, various low head hydropower plants are now studied in order to increase the hydropower production. One of those solutions is the gravitational vortex hydropower. This system, based on a bathtub vortex, consists on a turbine placed at the centre of the vortex which allows to harvest the kinetic energy [1]. As a first step, the bathtub vortex is studied without the turbine, in the supercritical flow regime [2].

A numerical model has been performed using OpenFOAM 2.2.2. A two phases approach, using the volume of fluid method has been chosen [3]. This choice has determined the use of the solver interFoam. Simulations are mostly done without any modelling of turbulent phenomena (laminar model). Some simulations are performed using the k-ε RNG turbulent model. In order to validate the numerical approach, an experimental campaign is carried out.

The influence of different physical quantities (inlet flow rate, outlet diameter) on the vortex strength is analysed.

Water height and fluid velocities are measured on the experimental setup using respectively ultrasonic sensors and laser Doppler velocimetry [4]. These data are compared to the values extracted from the numerical models. The visual shapes of the numerical vortex and the vortex observed during the experiments are qualitatively compared (Figure 1). Furthermore, a quantitative comparison is achieved comparing water levels and velocity profiles at different positions between the numerical values and the experimental data.

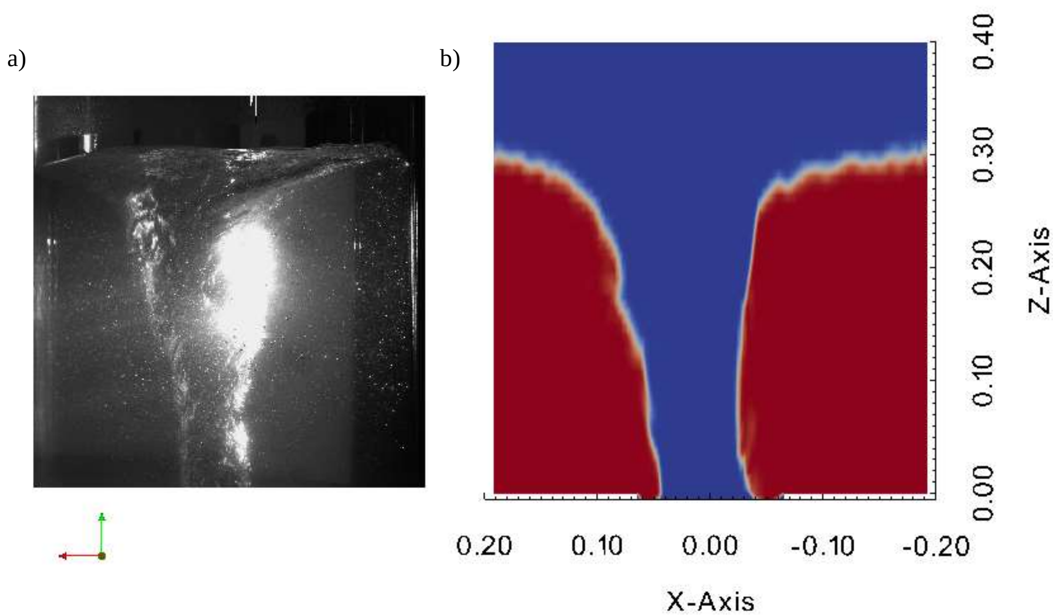

Figure 1: Qualitative comparison between the shape of the experimental vortex (a) and the numerical vortex (b).
a) Snapshot of the experimental vortex.
b) A vertical cross section of the volume fraction of water in a plane passing through the center of the geometry. Blue: water, red: air

References

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