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DETACHED EDDY SIMULATION OF HYDRAULIC CHARACTERISTICS ALONG THE SIDE-WALL AFTER A NEW ARRANGEMENT-SCHEME OF THE SUDDEN LATERAL ENLARGEMENT AND THE VERTICAL DROP*

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Abstract: In order to study the cavitation damage in a side-wall when a sudden lateral enlargement and a vertical drop are imposed at the radial gate, a new arrangement-scheme is proposed, where the sudden lateral enlargement and the vertical drop can be imposed at the outlet of the gate chamber. The hydraulic characteristics along the side-wall are simulated by the detached eddy simulation and the Volume Of Fluid (VOF) method. The numerical results agree well with those of experiment. The experimental and numerical results show that the flow condition is smooth with only a weak water-wing appearing behind the lateral cavity, and the length of the lateral cavity becomes longer and is mainly affected by the size of the lateral enlargement and the zone of negative pressure after the water impacts the side-wall would disappear. The hydraulic characteristics of the new arrangement-scheme are beneficial to the prevention of the cavitation damage in the side-wall and the Detached Eddy Simulation (DES) with the VOF method can well predict the hydraulic characteristics after the new arrangement-scheme of the sudden lateral enlargement and the vertical drop.

Key words: model test, aeration to prevent cavitation damage, realizable $k-\varepsilon$ turbulent model, Detached Eddy Simulation (DES), Volume Of Fluid (VOF) method

Introduction

A sudden lateral enlargement and a vertical drop are usually imposed at a radial gate to prevent the cavitation damage of discharge structures, but the cavitation damage in a side-wall also occurs in some hydraulic engineering, for instance, Tarbela dam (Pakistan), Longyangxia (China) and Krasnoyarsk (Soviet Union). After the sudden lateral enlargement and the vertical drop at a radial gate, the high water-wing would create an unfavorable flow condition[1], with a very short lateral cavity (of only 3 m in length)[2-4], and a zone of negative pressure appears on the side-wall after the water impacts the side-wall with the maximum pressure at the place of impact[5], which all would cause cavitation damages in the side-wall.

So far, the model test is the main method in selecting the aeration types and studying the hydraulic characteristics, but the model making takes a long time and a high cost, requires a large area of experiment and one has to solve the problem of scale effect. On the other hand, the numerical simulation is gradually becoming a new important method with the development of computer technology[6-10]. Most engineering flows are turbulent and in geometrically complex domains with a free surface, affected by large scale eddies. In a turbulent model, the Unsteady Reynolds-Averaged Navier-Stokes (URANS) simulation averages eddies of all scales, so it cannot be used to simulate the main features of large scale eddies in time and space[11]. On the other hand, the Large Eddy Simulation (LES) can serve as an effective tool for studying main features of large scale eddies in time and space. To simulate three-dimensional turbulent flows by using the large eddy simulation, the computational cost and time are critical issues. Much effort has been

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