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NUMERICAL SIMULATIONS OF THE HYDRAULIC CHARACTERISTICS OF SIDE INLET/OUTLETS*

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Abstract: The hydraulic characteristics at the side inlet/outlet of pumped storage plants is studied by numerical simulations, covering the flow distribution, head loss, vortex, and others. Based on the physical model test, the realizable $k-\varepsilon$ turbulence model is used in the 3-D simulation of the side inlet/outlet. A new scheme is suggested to obtain the uneven flow distribution over three branch orifices. The variation of the free surface with the reservoir water level under the pumped condition is simulated, with results consistent with the experimental results.

Key words: hydraulic characteristics, side inlet/outlet, pumped storage plant, numerical simulation, realizable $k-\varepsilon$ turbulence model

Introduction

The flow in the inlet/outlet of a pumped storage plant is bidirectional, with frequent variations of reservoir level and flow head, which poses a very comlex hydraulic problem. For example, vortexes may be generated under the pumped condition to create problems of reduced flow rate, noises, cavitation, vibration and so on. Separation flow and reverse current may be generated under the power condition to create problems of vibration or destruction of the trashracks[1]. Cai et al.[2] studied the effects of guide piers on the flow characteristics at water inlet/outlet with two flow directions as in pumped storage plants, indicating that there is a great difference in the flow state between pumped and power conditions. Cai et al.[3] studied the flow characteristics at the trashracks of a pumped power station by physical model tests, to show that the flow distribution is uneven at the trashracks in the inlet/outlet. Jain et al.[4] studied the vortex formation at vertical pipe intake and Anwar et al.[5] studied the similarity of vortex at horizontal intake. It is concluded in the studies based on the observation data of 29 prototype inlets of Gordon et al.[6] that the generation of vortexes is related to the velocity, inlet dimension and submergence depth. Chen et al.[7] deduced the velocity field with the free surface vortex. Li et al.[8] measured the flow field with the free surface vortex using the particle image velocitmetry. Li et al.[9] simulated the flow field and vortex in a barrel with a central orifice outlet at its bottom by the Finite Volume Method. In this article, the hydraulic characteristics of the side inlet/outlet under pumped and power conditions, including flow distribution, head loss, and vortexes, are studied by numerical simulations using the realizable $k-\varepsilon$ turbulence model.

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1. Numerical model

1.1 *Control equations*

The realizable $k-\varepsilon$ turbulence model is based on transient N-S equations[10]. Compared with the standard $k-\varepsilon$ turbulence model, a new eddy