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INFLUENCE OF FILLING WATER ON AIR CONCENTRATION*

WU Jian-hua, MA Fei, DAI Hui-chao
College of Water Conservancy and Hydropower Engineering, Hohai University, Nanjing 210098, China,
E-mail: jhwu@hhu.edu.cn

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Abstract: The filling water inside the cavity below an aerator occurs for the flow of low Froude number or the small bottom slope of a spillway. The aerator may cease to protect against cavitation damages, and may even act as a generator of cavitation if it is fully filled by water. The experiments were conducted to investigate the influences of the geometric parameters, and then the filling water on the air concentration. The results show that the filling water, or the net cavity length, is closely related to the plunging jet length for a given aerator, and the air concentration at some section is proportional to the ratio L_n / L_j at a fixed L_j for different geometric parameters of aerators. Secondly, at the same ratio of L_n / L_j, the aerator with a larger height or a larger angle of ramp, or a larger bottom slope, would have a larger plunging jet length, and then a larger net cavity length based on the ratio of L_n / L_j. As a result, the large space of cavity, or the high air concentration of the flow could be obtained although the filling water increases also based on the fact that $L_f = L_j - L_n$. It is the space of the cavity that is the dominant factor to affect the air concentration of the flow.

Key words: aerator, air concentration, filling water, jet length, net cavity length

Introduction

Aerators on a spillway are widely used to protect the surface of structures for discharging against cavitation damages[1], due to its inexpensive cost and high efficiency[2,3]. With the development of hydropower engineering, the heights of some dams have reached and even exceeded 300 m, such as 305 m in Jinping first-cascade hydropower project and 315 m in Shuangjiangkou hydropower project, which are both in Sichuan Province, China. It is important to avoid the cavitation damages caused by high speed flows.

The air entrainment process by an aerator could be divided into four parts: nappe entrainment, including air entrainment through the upper and lower free surfaces of the jet, plunging jet entrainment at the intersection and the rollers, and air recirculation in the cavity below the jet[4].

The filling water inside the cavity below an aerator occurs for flows of low Froude number or with a small bottom slope of spillway. It was much studied since the aerator might cease to protect against cavitation damages, and even act as a generator of cavitation if it is fully filled by water. The influences of the filling water on air entrainment is complex due to the interaction between the different air entrainment processes. Generally speaking, the contributions of the filling water consist of several parts: the decrease in the volume of air cavity, thus the air entrainment capability, the change from solid to fluid boundary at the bottom position of a plunging jet, then the reduction of turbulence, and the escape of air bubbles from the filling water. The studies in the past focused mainly on the estimations of the filling water and the prevention of it.

Chanson[5], Yang et al.[6] and Xu et al.[7] obtained the expressions for calculating the filling water length (L_f) by means of hydraulics methods. Shi et al.[8] suggested that the height of a ramp instead of its angle is one of dominant factors affecting the flow pattern through an aerator for practical engineering projects,

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Biography: WU Jian-hua (1958-), Male, Ph. D., Professor