A NUMERICAL MODEL OF THE SPRAY ATOMIZED FROM FLOOD DISCHARGING BY HYDROPOWER

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Rapid economic growth has caused a significant increase in electricity consumption in China recent decades. Being a kind of cleanly, reproducible and inexpensive energy resource, hydroelectricity has been paid more attention to. As the science and technology progresses, a lot of huge dams will be constructed in the narrow gorges of southwest China. The heights of the dams will be around 300 m, flood discharging powers vary from 10 billion to 100 billion watts, and maximum unit discharge all exceed 200 $m^3/s \cdot m$. So the flood discharge characters of the dams are high head, large discharge, narrow gorges and the frequency of flood discharge. From the forms of the energy dissipators, observed of 45 dams with heights over 100 m in China, and the data indicate that the ski-jump energy dissipators (or flip buckets) were predominantly used (Xu Baichuan, 1999). The ski-jump energy dissipator has many advantages, but it also has some disadvantages, for example, spray atomized from flood discharging is a serious one of them.

In this study, a three-dimensional numerical model of the jet restricted by gravity, air resistance, and air buoyancy will be developed, and based on theoretical analysis and prototype data, a three-dimensional stochastic model using Monte Carlo method will be proposed to evaluate the range of spray and the intensity of the rainfall in the range, which are affected by complex terrain and various wind conditions. Then a feedback and verification analysis of the numerical model will be carried out to confirm the correctness of the numerical model. The prototype model data used in this work are observed from two hydropower stations. One of them is in Lantsang River, and the other is in Yellow River. The result shows that the computational solutions fit the prototype dada well. Such an analysis acquires values of some important empiric parameters in the model and highlights the ability to correctly represent the range of spray and the intensity of the rainfall in the range of the model. This numerical model can predict the spray atomized from flood discharging by hydropower in credible precision.

Taken a control volume from the nappe, and it can be seen there are five forces act on the element, which are gravity, buoyancy, resistance, surface tension, and water pressure difference. The gravity, buoyancy and resistance, are the primary forces, and other forces can be omitted. So the kinetic characteristic of the element can be described by the governing equation:

$$\frac{dv}{dt} = \frac{1}{|v|}\left(v_x \frac{dv_x}{dt} + v_y \frac{dv_y}{dt} + v_z \frac{dv_z}{dt} \right) \tag{1}$$

When two jets impinging in air, the desired points, called impinging point, P, are calculated by the equation(Sun Jian, 2002):

$$|A_iP| + |B_iP| \le b_i \tag{2}$$

Based on the mechanism of the spray and the prototype data observed from the flood discharge by hydropower, several hypotheses are proposed:

(1) The initial velocity of the water drop satisfies gamma distribution:

$$f(v'_0) = \frac{1}{b^a \Gamma(a)} {v'_0}^{a-1} e^{-\frac{v'_0}{b}} \tag{3}$$

(2) The initial vertical angle of the water drop satisfies gamma distribution:

$$f(\beta) = \frac{1}{b^a \Gamma(a)} \beta^{a-1} e^{-\frac{\beta}{b}} \tag{4}$$

(3) The initial horizontal angle of the water drop satisfies Gaussian distribution:

$$f(\phi) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(\phi-\mu)^2}{2\sigma^2}} \tag{5}$$

(4) The diameter of the water drop satisfies gamma distribution:

$$f(d) = \frac{1}{b^a \Gamma(a)} d^{a-1} e^{-\frac{d}{b}} \tag{6}$$

Using the above hypotheses, a three-dimensional stochastic model using Monte Carlo method will be proposed to evaluate the range of spray and the intensity of the rainfall in the range, which are affected by complex terrain and various wind conditions. Feedback and verification analysis of the numerical model confirms the correctness of the numerical model. And it can be used to predict the spray atomized from flood discharging by hydropower in credible precision.

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