Oxygenation of flowing water with an elbow deflector: physical model

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Hydropower is a renewable energy source, but minimizing its environmental impacts is important. Ensuring adequate dissolved oxygen levels downstream of turbines can be achieved using draft tube aeration, a low-impact retrofit option. To optimize this process, we investigate parameters governing oxygen diffusion from air to water, primarily driven by the air-water interface area. Creating a large interfacial area is allows for high air mass-transfer rates, and is achievable by generating small bubbles. Our experimental approach uses a physical model to observe and model the oxygenation efficiency of air injection into the lee of a deflector. The parametric study examines the effects of flow velocity and void ratio (air/water volume ratio).

Understanding the main physical processes contributing to oxygenation, including the flow past the deflector, self-aspiration, and the bubble dynamics of formation and shedding from the air pocket, is required to predict aeration rates in draft tube aeration for hydropower plants. An experimental test rig was built to examine the oxygenation potential of an air stream introduced into the lee of a deflector in a vertical conduit under a range of flow velocities and air-water void ratios. Along the conduit, four dissolved oxygen measuring stations are positioned to monitor the time evolution of dissolved oxygen concentration downstream of the deflector. In addition, observations are made of the dynamics of the flow in terms of the formation of the primary air cavity in the flow, subsequent bubble shedding from the air cavity, and the distribution of bubble sizes within the flow. To prepare water with low dissolved oxygen content for the test rig receives, both a vacuum pressure and ultrasonic irradiation (with a specialized ultrasonic probe, QSonica) is employed. The deoxygenation conditions require maintaining a water temperature of 28 ºC and applying a vacuum pressure of 16 kPa, effectively reducing the dissolved oxygen concentration from 8 mg/l to 2 mg/l within a 30-minute time frame.

The objective of this research is to analyse the experimental data obtained to investigating the bubble dynamics due to air injection at a deflector, quantify the oxygenation rates of the flow, and measure the self-aspiration potential of the elbow deflector. The result of this research study contributes to hydropower's development as a sustainable clean energy source.

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