Aeration of hydraulic turbines for increased dissolved oxygen concentrations using deflectors

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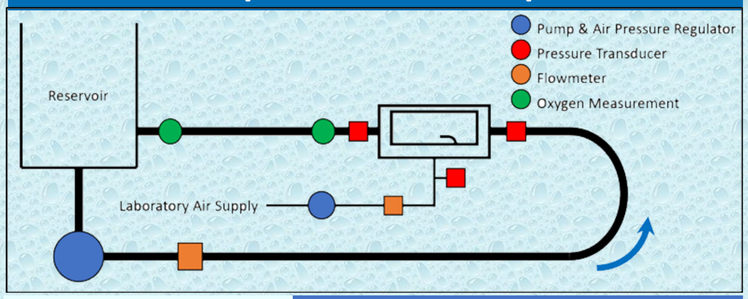
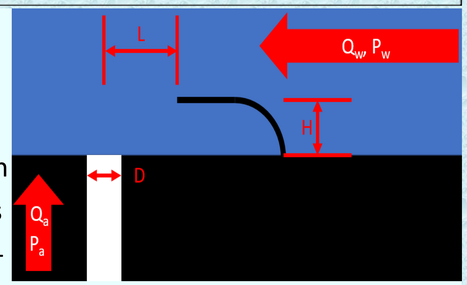
Introduction

- Deep reservoirs in warm climates are vulnerable to low dissolved oxygen (DO) levels in the hypolimnion due to thermal stratification, and hydropower power plant intakes require aeration to raise DO levels to meet environmental regulations.
- The proposed solution is to use a retrofit deflector, allowing natural peripheral aeration in the draft tube.

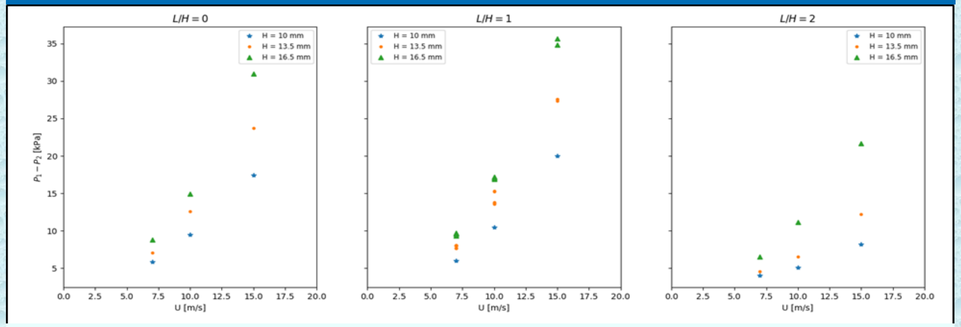
Experimental Set-Up





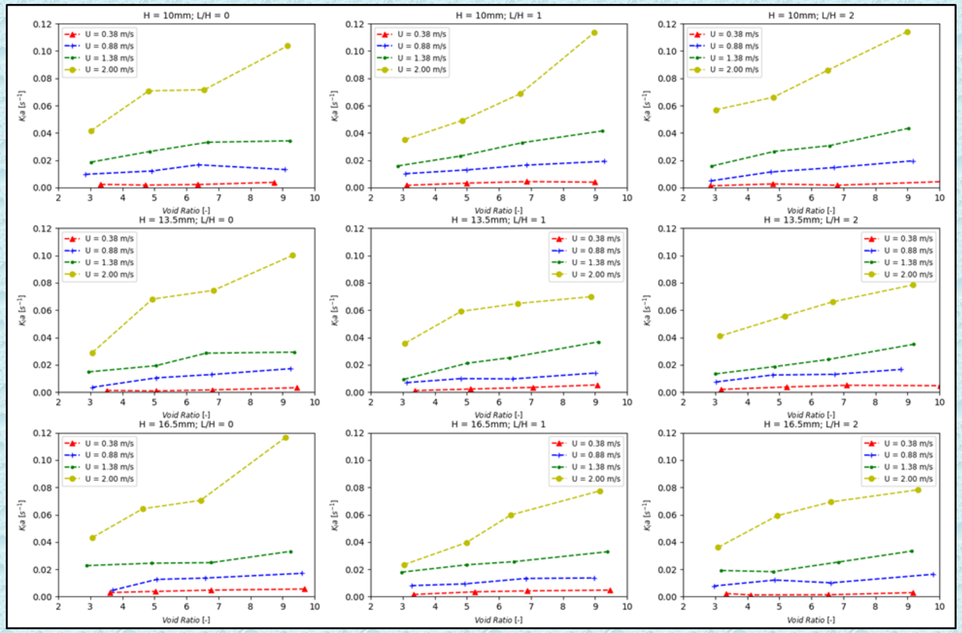
- Optimization of deflector geometry by varying L and H
- Oxygen concentration analyzed as it evolves downstream of air injection.
- Water and injection air pressures measured to quantify the aerating behaviour of each deflector configuration.

Data Analysis



- Draft tube air admission driven by pressure difference between ambient atmosphere and negative pressure at air inlet, governed by following equation

$$\frac{P_{atm}}{P_{air\ inlet}} = \left(1 + \frac{\gamma - 1}{2} * Mach^2_{air\ inlet}\right)^{\frac{\gamma}{\gamma - 1}}$$



- Analyzing oxygen exchange between injected bubbles & anoxic water through draft tube is based on mass conservation

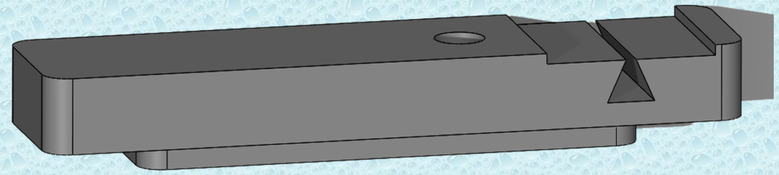
$$-ln(1-E) = K_L a \cdot t$$

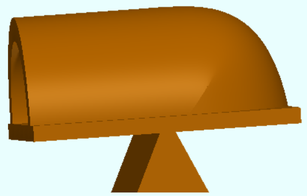
$K_L a$ = total aeration coefficient.

E = oxygen transfer efficiency

t = residence time of bubbles between two measurements

New Deflector Design





- Previously, PVC strip machined for every 3D printed deflector geometry.
- New design provides a sliding mechanism to reuse PVC strip for future experiments.

Conclusion & Future Work

- Identified optimal deflector geometry among studied dimensions
- Based on chosen geometry, different modifications are to be tested such as introducing roughness, trips, holes, etc.
- Experiment was a simplified model, possibility of introducing swirl to model turbine effect
- Use cameras to study bubble characteristics quantitively