Maintaining Dissolved Oxygen and Minimizing Oxygen Input in Land-Based Aquaculture Tanks During Power Outages

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Introduction

Land-based aquaculture is being promoted to secure sustainable fishery resources. When a power outage occurs, mechanical aeration and circulation pumps stop, and the dissolved oxygen (DO) in the tank decreases rapidly. This study proposes a control method that uses an oxygen cylinder to maintain DO during outages and demonstrates its effectiveness via numerical simulation in MATLAB. DO is modeled using a standard formulation [1], and supply from the oxygen cylinder is allowed only during outages. A PI controller adjusts the valve opening based on the difference between the tank DO and the setpoint, and oxygen usage is compared with continuous full-open operation. The results show a 51.3% reduction in oxygen usage, from 5.144 kg to 2.504 kg.

System and Control Method

Fig. 1 shows the system configuration. Under normal conditions, the tank receives oxygen via mechanical aeration and circulation pumping; during an outage, supply switches to the oxygen cylinder controlled by a valve. The change in DO is represented as the sum of oxygen transfer by aeration, transfer by circulation, consumption by fish respiration, and supply from the oxygen cylinder. The oxygen cylinder flow rate is determined by PI control of the error between the DO sensor reading and the setpoint to track the target level.

Simulation

The simulation runs for 24 hours, with a 10-hour outage from 05:00 to 15:00. Kye parameters are: tank volume 6.000 L, water temperature 28 °C, fish biomass 60 kg, respiration rate 140 mg/(kg·h), maximum oxygen cylinder flow 10 SLPM, dissolution efficiency 0.03, and target DO 5.5 mg/L. Two methods are compared: the conventional method, which fixes the valve at full open during the outage, and the proposed method, which adjusts the valve opening using a PI controller on the different between the DO setpoint and the measured DO. The evaluation metric is oxygen consumption during the outage period.

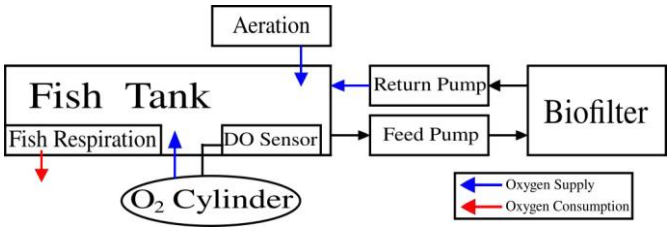

Figure 1: System configuration chart

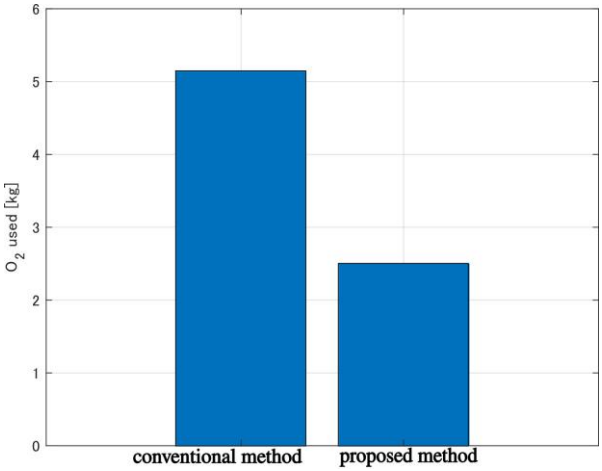

Figure 2: Comparison of oxygen consumption

Results and Discussion

Fig. 2 shows oxygen consumption during the outage. The proposed method achieves a 51.3% reduction relative to the conventional method, decreasing from 5.144 kg to 2.504 kg. This indicates that supplying only the required amount during an outage suppresses oversupply and yields substantial oxygen savings. The smaller the fish oxygen demand, the larger the difference from full-open operation and the greater the relative reduction. Therefore, PI-based valve control using the oxygen cylinder during outages effectively reduces oxygen consumption while maintaining DO near the target level.

References

[1] W. J. S. Mwegoha, M. E. Kaseva, and S. M. M. Sabai, "Mathematical modeling of dissolved oxygen in fish ponds," International Journal of Environmental Research, vol.5, no.2, pp307-320, Spring 2011.