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DATA, AI & SEAFOOD RETAIL

THE COMPANIES AND EXECUTIVES THAT WILL SUCCEED IN THE FUTURE ARE THOSE WHO UNDERSTAND AND USE AI.

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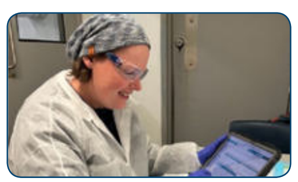

ON THE COVER

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COLUMNS

Engineered-Airlift pumps can help aquaculture systems to perform better

One method through which fish farmers can reduce power consumption while improving water quality is replacing conventional technologies used for maintaining water quality with more energy efficient devices such as airlift pumps. This article presents the results of the evaluation of the Engineered-Airlift pumps that were designed to offer a substantial reduction in total energy usage as well as an improved quality of the culture products in order to make it attractive to aquaculture industry.

*By: Josh Rosettani, Marcia Chiasson and Wael Ahmed**

Recirculating aquaculture systems (RAS) are gaining popularity as a sustainable solution amidst challenges such as the global shortage of fresh water, rising land prices, heightened environmental awareness, and concerns over water source contamination. Despite these advantages, the profitability of RAS remains hampered by the elevated cost of energy. One method through which fish farmers can reduce power consumption while improving water quality is replacing conventional technologies used for maintaining water quality with more energy efficient devices such as airlift pumps. Airlift pumps generally operate using air blowers or compressors, with the air injected at the bottom of a pipe so that the air bubbles are acting as pistons rising in this pipe by the buoyancy force effect allowing for water to be lifted while the mixing effect enhances the oxygen transfer between air and water (Figure 1). Currently, very few aquaculture operations are employing airlift pump technology for water recirculation, aeration, and waste removal. This is likely due to the poor design and lower efficiency of traditional airlift design, the limited amount of research effort that has been invested in improving performance capabilities of air lift pumps and the general lack of awareness of the industry about potential capabilities of a well-designed airlift pumps.

Utilizing expertise in multiphase flow (flow of more than one fluid together) and fluid dynamics, we have optimized the airlift design specifically for aquaculture, resulting in the development of a refined engineered-design. With a specific submergence ratio, it is possible to predict both the water volume flow rate and the amount of aeration (Figure 1). This allows for a guaranteed performance of the pump.

This technology is now commercialized by a new start-up known as *FloNergia Systems Inc.* Known as *FloMov*, this design utilizes a patented air injection method (shown in Figure 2) to regulate the air flow through the pump, producing distinct effects on the water movement. More specifically, an axial mode of air injection resulting in larger air bubbles formed underwater provides greater water flow; while a radial mode of air injection results in smaller bubbles to provide greater mass transfer between the air and the water. This occurs because larger bubbles will create so-called "slugs" which takes up a greater portion of the pipe's cross section, acting as air piston and generating the water pumping effect. Meanwhile, the smaller air bubbles involved act as a greater membrane surface area between the air and the water, allowing for more diffusion of oxygen into the water. Enhanced water circulation and aeration contribute to maintaining optimal water quality for fish health in aquaculture operations. It is important to note that the pump will be able to handle solids such as fish waste and feed, as it lacks moving parts and does not require lubrication.

Testing

Field tests were performed at the Ontario Aquaculture Research Centre (OARC) to evaluate the *FloMov* technology compared to an optimized control tank equipped with aerators designed for land-based fish production (Figure 3). Influent water is pumped from six groundwater wells to a central head tank (Table 1). From there, the groundwater undergoes degassing and oxygenation by passing through five degassing columns with plastic media before being directed the wet laboratories. Aerated water was provided to each tank at a rate of at 380 L/min. Flows were measured weekly and were adjusted as necessary to maintain the desired flow rate. Rearing tanks, approximately 70,000 L in volume, were located in an out-

The *FloMov* airlift was able to better oxygenate the water compared to the OARC control tank.

Figure 1

Theory of operation of airlift pump for moving water and aeration.

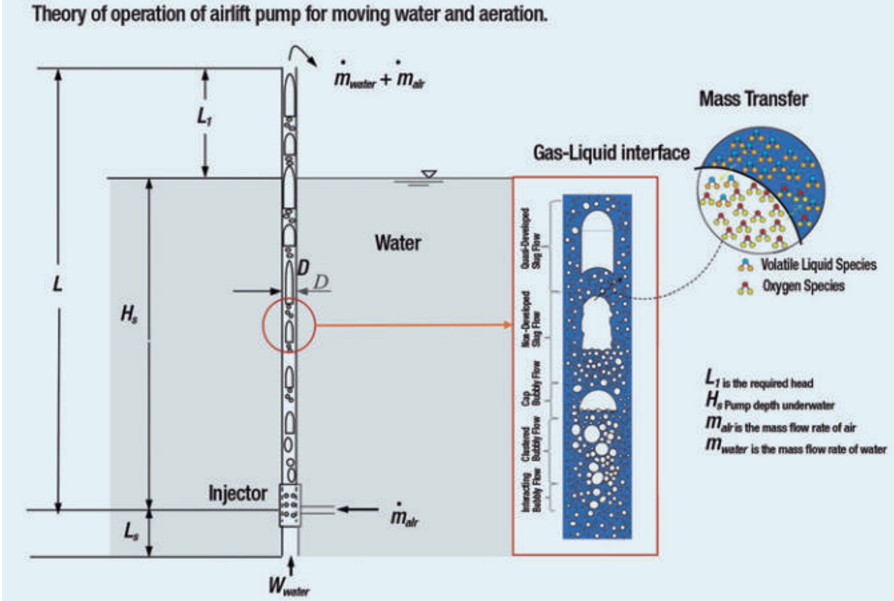
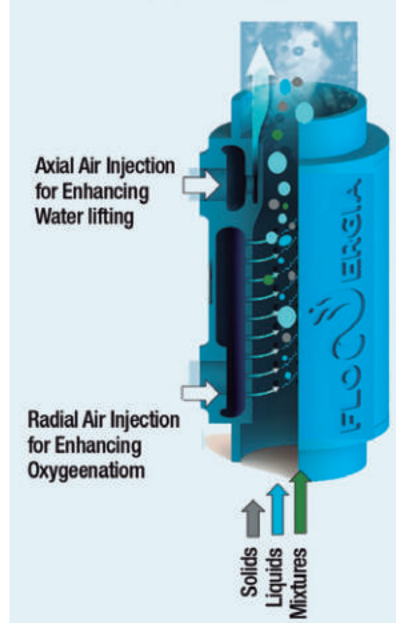


Figure 2

FloMov Airlift pump Technology.



door lab, an enclosed building with a canvas cover allowing for a natural photoperiod. Arctic char (*Salvelinus alpinus*) sourced from the OARC were selected for this study. Mixed sex Arctic char approximately 735 g were randomly distributed in two production-scale rearing tanks (1,500 fish/tank) where they were maintained using controlled tank aerators (control) or the *FloMov* (treatment). Feed rations were calculated daily using expected feed conversion and suggested feed rates for this species developed by the OARC.

Mortality was recorded daily for each tank. Dissolved oxygen (DO), total suspended solids (TTS) and Turbidity, reported as Nephelometric Turbidity Unit (NTU), were measured. The type and frequency of measurements is summarized in Table 2. In addition, the surface velocity measurements in the tanks were collected at an approximate flow rate of 200-300 L/min and 700 L/min into the controlled and *FloMov* circulation systems respectively using Sontek FlowTracker device.

Results and Discussion

Significant differences were noted in two water quality parameters, dissolved oxygen and the measurement of total suspended solids. Dissolved oxygen was greater in the treatment tank (8.68 mg/L) with the *FloMov* system compared to the control tank (8.023 mg/L; $p = 0.002$). The results of the dissolved oxygen readings as well as the saturation was plotted over the duration of the trial can be seen in Figure 4 and 5 respectively. The results clearly demonstrate that the *FloMov* airlift outperformed the OARC control tank in oxygenating the water, as evidenced by higher values for both total dissolved oxygen and saturation. Upon observing images of both tanks taken under the surface of the water, it was evident that the OARC control tank had considerably more floating solids compared to the *FloMov* tank. The measurements of total suspended solids (TSS) over the trial period further confirm this observation. Figure 6 illustrates that the *FloMov* tank, as shown in the plot of measured total suspended solids (TSS) for both tanks, maintained an average of 38.26% less TSS throughout the trial period.

Figure 3

Field testing of the *FloMov* airlifts at the Ontario Aquaculture Research Center (OARC).

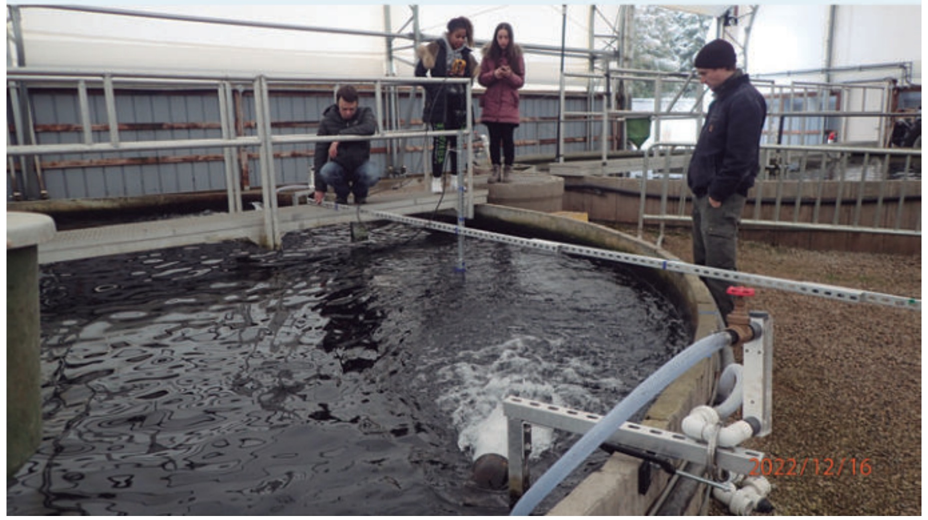


Table 2

Type and frequency of measurements.

Parameter	Type	Frequency	Timing
Dissolved Oxygen	Oxyguard	3x / Week	Monday, Wednesday, Friday at 9:00 am
Inflow Measure	Velocimeter	Weekly	Monday 9:00 am
Total Suspended Solids	Grab Sample	2x / Week	Monday 9:00 am; Friday 2:00 pm
Turbidity	Grab Sample	6x / Week	Monday, Wednesday, Friday at 9:00 am and 3:00 pm

Table 1

Water quality characteristics of influent groundwater.

Parameter	Value
Temperature	8.5 ± 0.2 °C
Dissolved Oxygen	10.6 mg/L
pH	8.2
Hardness	241 mg/L
Total Suspended Solids	0.29 mg/L
Total Organic Carbon	1.45 mg/L
Chemical Oxygen Demand	<10 mg/L

Figure 4

Total dissolved oxygen (DO) results.

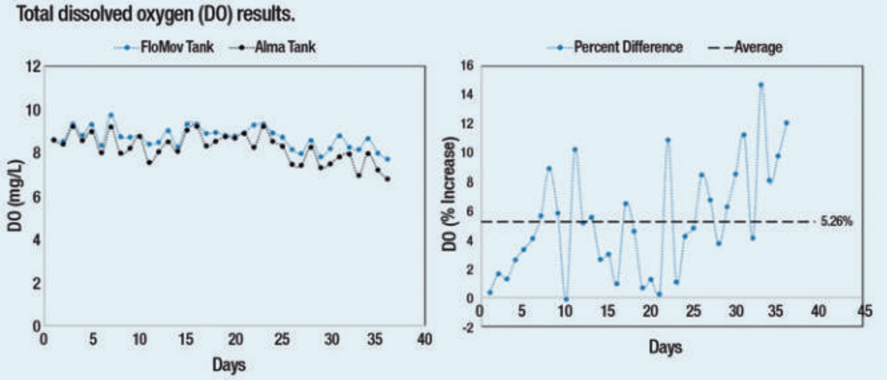


Figure 5

Dissolved oxygen (DO) saturation results.

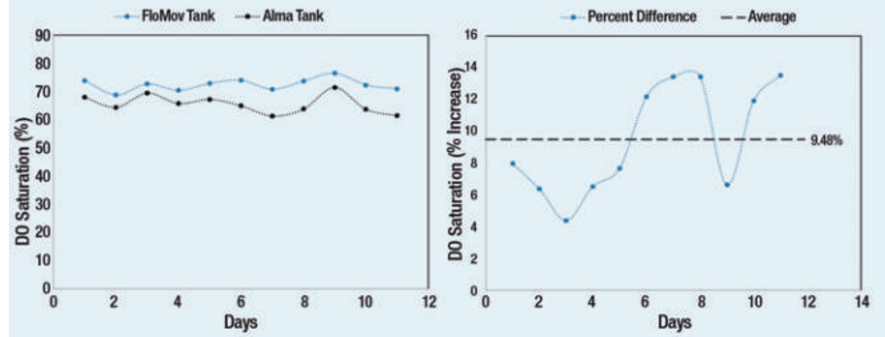
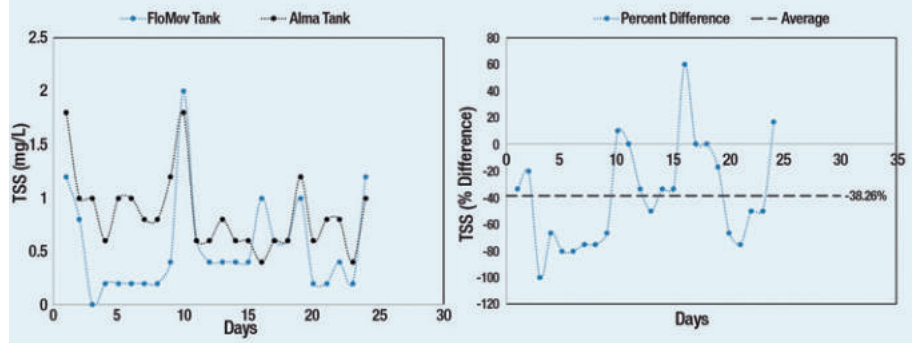


Figure 6

Total suspended solids (TSS) results.



Conclusion

This study tested the effect of *FloMov* airlift on water quality parameters and fish productivity in a commercial aquaculture setting compared to a more expensive aeration system optimized for land-based fish production. The *FloMov* were simple to install and operate. Additionally, the *FloMov* pumps did not experience much biofouling during the trial and required no maintenance during the whole operation. This study found that the *FloMov* system significantly improved some water quality parameters, such as velocity, dissolved oxygen and total suspended solids measured in the morning.

The airlift design is optimized for aquaculture and now an engineered design is developed.

Acknowledgement

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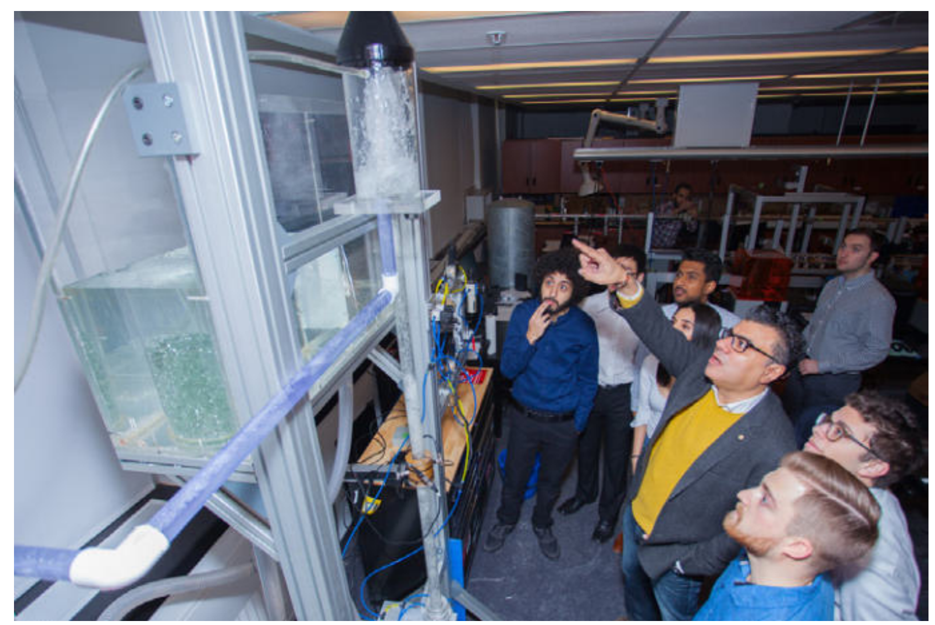

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