Application of the Geyser Pump in Aquaculture and Aquaponics

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Introduction

The Geyser Pump is based on very old airlift pump technology. However, it was not until December 2000, that the concept was put to its most efficient use and the first U.S. patent for the Geyser Pump was granted. The unique aspect of the Geyser Pump is that injected air to the Geyser Pump is not released to the discharge pipe like the airlift pump. Instead, the air is accumulated to a certain volume, and then a constant amount of air is released to the discharge pipe. The water (with solids) is ejected through the discharge pipe by a large volume of air, which works like an air piston. Due to its stronger suction, the Geyser Pump has been used to replace the airlift to pump return activated sludge (transferring thick sludge from a clarifier to an aeration basin) in wastewater treatment plants.

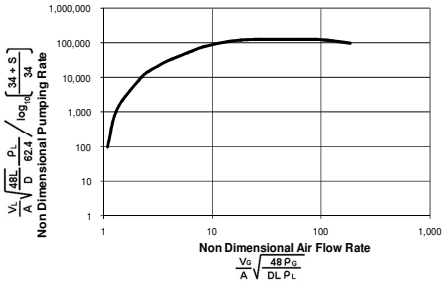
The physical phenomenon in the Geyser Pump air cylinder is now well understood. This has been the result of thorough analyses with laboratory-scale and field experiments using slow-motion video, in conjunction with numerical analyses with finite element methods. The *Geyser Pump effect* (concept of lifting water with solids by releasing a large volume of air intermittently) is now conceptually understood and several different designs have been developed for high lift and also for pumping heavy materials like grit and gravel.

This paper explains the basic concepts of the Geyser Pump family and compares it with ordinary airlift pumps and mechanical pumps. In addition, typical applications are introduced for wastewater treatment, aquaponics, and aquaculture.

Overview of Airlift Pump

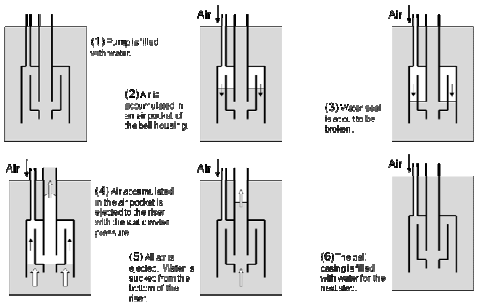
Many researchers have tried to develop a theoretical formula to calculate the required air flow for airlift pumps based on the pipe size, submergence depth , lift and pumping rate. However, there is no simple way to determine the air flow rate required. The proposal by Zenz (see Figure 1) is probably the most accurate method of airlift sizing available today (Zenz, 1993).

Zenz proposed a way to estimate the characteristics of the airlift pump from (1) pipe cross-sectional area, (2) lift height, (3) submergence, (4) pumping rate, (5) density of lifted fluid, (6) gas density, (7) liquid density, and (8) gas flow rate. Based on this information, one first calculates the ordinate of the graph in Figure 1. Then, the corresponding value of abscissa is found from the graph and finally, the gas flow rate can be calculated using information available for the specific application.



Overview of the Geyser Pump

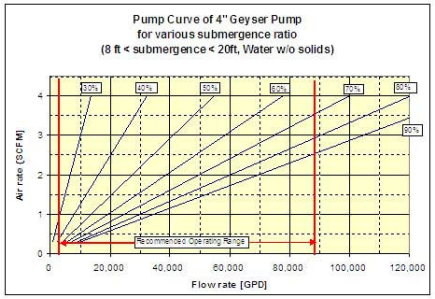
The Geyser pump which is sized according to flow requirements, may be constructed of Fiberglass, PVC, or Steel as specified. The Geyser Pump overcomes common problems characteristic of airlift pumps by allowing air to accumulate at the lower end of the riser, and to allow a large single release of air up the riser pipe. This increases the thrust up the pipe to discharge liquids and sludge. An equal volume of liquid and sludge is discharged up the riser each time the geyser releases. The rate of flow may be adjusted by the rate that air is supplied to the Geyser Pump. Air is supplied from a continuously operated air compressor or blower and airflow is adjusted by a valve in the airline. Figure 2 shows the sequence of the *Geyser Pump effect.*



Pump curves of the Geyser Pump were derived from the actual experiments and the analyses of hydrodynamics. The pump curve data are based on the assumption that pure water is pumped with various Geyser Pumps. If solids are present in the water, or the viscosity of the fluid is higher than that of water, then the pumping rate will be reduced for the same air flowrate or more air flow will be required for the same flow rate. The pumping rate of the Geyser Pump is a function of the size of discharge pipe, air flowrate, submergence and lift. The pump curves are given for various submergence ratios, which are calculated from the following formula:

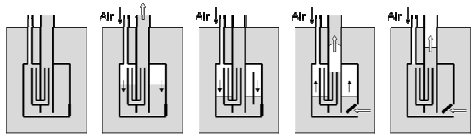
Submergence ratio = Submergence / (Submergence + Lift)

Where submergence is the distance from Geyser Pump to water level and lift is the distance from water level to the highest lifting level. Figure 3 shows a typical pump curve for the Geyser Pump.



Overview of Geyser Ejection Pump for High Lift

Based on the *Geyser Pump Effect*, the Geyser Ejection Pump was developed to supply a constant flow pumping rate for very high lift. The Geyser Ejection Pump has one or two check valves. If needed, aerated fine screens are equipped to the pump to protect the check valve, so that no large solids flow into the pump to assure a steady performance for a long period and for easier maintenance. Figure 4 shows the conceptual design of the Geyser Ejection Pump and how the pump transfers liquid.



Step 1 (Fill Period)
Step 2 (Ejection Period)
Step 3 (End of Ejection Period)
Step 4 (Air Release + Fill Period)
Step 5 (Fill Period)

Applications – Improvement of Wastewater Treatment Plant Performance

Package plants usually provide the operator with limited aeration and wasting capabilities. The Geyser Pump can provide the operator a wide range of control over the RAS flow rates and reduce the clogging events of standard airlift designs. The ability to reduce the RAS flow rate with strong suction will create following advantages:

The oxidative treatment capability of the system is increased by increasing hydraulic detention time in the aeration basin.

The performance of the clarifiers is increased by increasing the hydraulic and solid detention time in the clarifier. The layer of sludge blanket is reduced and the supernatant layer is increased with improved clarity.

The RAS line connected to the Geyser Pump seldom clogs, based on the experience of over 2,000 applications of Geyser Pumps. After the power failure, an airlift pump requires a valve operation to start up the operation again. However, even after the power failure, the Geyser Pump regains the performance automatically.

Bridge formation of sludge in the clarifier does not occur as the Geyser Pump gives frequent pulsated suction to accumulated sludge.

The thickest sludge pumped by the Geyser Pump is 6% solids (60,000 mg/l) in the sewage treatment plant. When the Geyser Pump is properly installed, no pop-up sludge is observed in the clarifier.

Increasing the solids concentration of the solids. This is very significant when a slow settling, filamentous sludge condition exists. Filamentous sludge conditions are common with package plants and often are the reason for excessive loss of solids from the treatment system.

Reduction in the amount of extraneous water pumped to the digester. This will reduce the amount of staff time required for decanting of holding tanks, thus increasing holding capacity.

Applications – Solids Removal for Aquaponics and Aquaculture

Significant improvement in solids control was observed in an aquaponics system set up in San Diego. In September of 2007, a 150 gallon stock tank (in a 6' x 8' Portable Farms greenhouse) was installed to hold the 80+ Tilapia in an aquaponics system. An air lift pump made from a ½" PVC pipe was used to move the water to a settling tank. The air lift was mounted in a modified 3" PVC end cap with four arches cut to function as legs. This old style air lift pump was capable of lifting water approximately 5 inches above the surface of the water. The air lift pipe assembly was on the bottom of the stock tank in order to draw fish waste and debris from the bottom of the tank. The water in the tank was never clear. Even the lightest feeding schedule produced turbid water and feeding the Tilapia at the recommend level produced very dirty water. The discharge pipe required cleaning every two weeks as it became clogged with a slimy growth and fish waste. The settling tank required cleaning every two weeks.

In March a ½" outlet Geyser Pump was installed and a noticeable difference in water quality was observed. Within four hours the water was so clear that the bottom of the stock tank can be seen. The fish were visible and so was the Geyser Pump. Even the pebbles that had fallen from the Growth Trays were visible. The best part was the fact that the Geyser Pump could easily lift the water over 16" above the stock tank water surface.

The secondary effects were just as pronounced. The discharge pipe never requires cleaning. It remains clean and clear with no growth or accumulation of any kind. The other effects noted include the fact that the settling tank now needed to be cleaned on a weekly basis because the feeding of the fish was back up to the recommended level. The water would occasionally become cloudy after the fish are fed. After about an hour, the water becomes clear again and the pebbles may be seen on the bottom.

Applications – Water Pumping for Aquaponics and Aquaculture

Typical aquaponics for hobby use requires a pump that has a capacity of between 60 and 150 gallon per hour with 5 to 6 feet of lift. Mechanical pumps like centrifugal pumps, submersible pumps and magnetic drive pumps requires frequent maintenance due to problems associated with debris in the water. For this application, a 1" Geyser Ejection Pump was developed and used in a Portable Farms greenhouse in San Diego. Figure 5 shows a pump curve of this special model. The required air flow is less than 0.2 cfm at 2 psi (for 5 feet lift). Wastes can be eliminated effectively using the Geyser Ejection Pump since the suction force is the same as that of the Geyser Pump.