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Pond Aeration

Types and Uses of Aeration Equipment

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No one should attempt to be a commercial fish farmer without having aeration devices and the knowledge of when and how to use them. Aerators can be used exclusively for emergencies, continuously at night, or all day and night.

Today, aeration equipment is most commonly used in emergencies to keep fish alive and minimize stress associated with oxygen concentrations lower than 3 to 4 parts per million (ppm). Aerators used in this manner are not intended to aerate the entire pond but just a portion of it. Fish move to the zone of oxygenated water found near the aerator. Enough oxygen is supplied to save fish, but not to increase oxygen levels greatly in the entire pond.

Aerators work by increasing the area of contact between air and water. Aerators also circulate water so fish can find areas with higher oxygen concentrations. Circulation reduces water layering from stratification and increases oxygen transfer efficiency by moving oxygenated water away from the aerator. Many units are electrical, so wiring should be properly protected and installed to avoid any hazards from an electrical shock.

If a pond shows a decreasing oxygen pattern that will reach 3 ppm or less before sunrise, emergency aeration should be used. In most situations, the critical time for low oxygen levels is from midnight to sunrise. If the oxygen concentration is falling quickly, however, aerators should be started when oxygen reaches 4 ppm. This creates a sufficiently large area of aerated water that fish will find and remain in until oxygen levels improve during daylight hours.

How to evaluate an aerator

Several years ago, the aquaculture industry used no standard methods for comparing or testing oxygen transfer capabilities or efficiencies of aerators. Today, aerators are tested to determine the rate at which they transfer oxygen into water. These tests are conducted in large tanks under standard conditions with clean tap water at 68° F and no initial dissolved oxygen.

Two terms are commonly used to compare the aerator performance. The **standard oxygen transfer rate** (SOTR) is the amount of oxygen that the aerator adds to the water per hour under standard conditions and is reported as lb O_2/hr. The **standard aeration efficiency** (SAE) is the standard oxygen transfer rate divided by the amount of power required and is expressed as lbs O_2/hr per horsepower (hp) or lbs O_2/hp-hr.

Ratings for tractor-powered aerators are generally given as **standard oxygen transfer ratings** (SOTR). Other, usually smaller, aerators are normally given **standard aeration efficiency** ratings (SAE). Efficiency ratings are based on the horsepower applied to the aerator shaft and not the horsepower of the power source. Most commercial aerators have ratings between 1 and 5 lbs O_2/hp-hr.

Test results of different aerators can be compared in selecting an effective and energy-efficient unit. Some manufacturers test their own equip-

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ment. When comparing test results, it is important to know if test conditions were standardized. Also, an aerator may have a high oxygen transfer rate with low efficiency rating. Cost of operation should be less for a more efficient aerator.

Types of aerators

Fish farmers have used emergency aerators powered by **tractor power takeoffs (PTOs)** for many years. With production intensification the increasing the need for aeration, these PTO aerators can be quite expensive because each aerator requires a tractor. Therefore, more electric aerators are being used than ever before. Large tractor-powered aerators are still used as back-ups during severe oxygen depletions, equipment failure, or power outages.

Each producer decides which aeration device should be purchased or built. This decision is important and should be made with the specific application and associated costs of energy and equipment in mind. Several types of aeration devices have been evaluated for use in commercial fish ponds. Most aerators are in one of the following categories: surface spray or vertical pump, pump sprayer, paddlewheel, diffused air and propeller aspirator pump.

Surface spray or vertical pump

Surface spray aerators have a submersible motor which rotates an impeller to pump surface water into the air as a spray. They float, are lightweight, portable and electrically powered. Units of 1 to 5 hp with pumping rates of 500 to 2,000 gpm are available.

They are designed to be operated continuously during nighttime, cloudy weather, or when low dissolved oxygen concentrations are expected. Surface spray aerators have prevented fish kills when used at 1.5 to 2 hp/acre. They are usually of little use in large ponds, because of relatively low oxygen transfer rates and their inability to create an adequately large area of oxygenated water.

Pump sprayer

Pump sprayer aerators are found on many fish farms. Most are powered by a tractor power takeoff or electricity. Some units are engine driven and require mounting on a trailer frame for transport. Pump sprayer aerators are equipped with either an impeller suction pump, an impeller lift pump, or a turbine pump. Some have a capped sprayer pipe or "bonnet" with outlet slits attached to the pump discharge. Others discharge directly through a manifold which has discharge slits on top and outlets at each end. Water is sprayed vertically through the discharge slits and from each end of the manifold. This type is commonly referred to as a T-pump or bankwasher and directs oxygenated water along a pond bank where distressed fish often go. Pump sprayers typically have no gear reduction which reduces mechanical failure and maintenance. These units do not erode the pond bottom, and minimum operating depth is reached when the intake is covered with water.

Paddlewheel aerators

Paddlewheel aerators have been used on catfish farms for many years. Farm-made paddlewheels are usually made from 3/4 ton truck differentials and vary with drum size and configuration, shape, number and length of paddles. Units are powered by power takeoffs or driven by self-contained diesel engines. The self-contained units are usually on floats and attached to the pond bank or held in place by steel bars secured in the bank or pond bottom.

Studies have demonstrated that increasing either the speed of the drum rotation (rpm) or paddle depth generally increases aeration capacity. Paddle depth affects oxygen transfer rates more than does the speed of rotation. This increase in capacity is not cost free, because horsepower requirements increase and oxygen transfer efficiency may decrease. The maximum rotational speed of a tractor-powered paddlewheel aerator for extended operation is limited by the tractor, its recommended power takeoff speed under load, and the gear reduction of the paddlewheel.

The shape of the paddles is also important; for example, U, V, or cup shapes are more efficient designs than flat paddles. Paddlewheels create vibrations that can be reduced when paddles are arranged in a spiral pattern.

The oxygen transfer rate and power requirement increase with paddle immersion depth and the diameter of the paddlewheel drum. The size of the spray pattern likewise increases. The power required to operate a paddlewheel aerator at any given speed and paddle depth is constant. Fuel consumption and operating costs depend on the power source.

Most producers do not have enough paddlewheel aerators for all ponds and move these units from pond to pond. A paddlewheel, though mobile, can be difficult to situate in the pond properly so that it is effective without damaging itself or the tractor. Before emergencies occur, their locations should be selected and several trial runs should be conducted so that situating becomes more or less routine.

Paddlewheels can erode a hole in the pond bottom during operation. If the aerator settles into a hole while running, the load increases and reduction gears can break. Weld a metal plate under the paddlewheel to reduce erosion of the pond bottom. It is also important to block the tractor to prevent it from slipping back and increasing the load on the tractor. Table 1 summarize the performance results for several types of paddlewheel aerators powered by farm tractors.

Table 1. Test results of two sizes of paddlewheels. The power source was an 87 hp tractor.

PTO shaft speed (rpm)	Paddle depth (inches)	Tractor engine speed (rpm)	Power reqmt. (hp)	SOTR (lb O_2 /hr)	Fuel consumption (gal/hr)	lb O_2/gal fral	SAE lb O_2/hp-hr
			PTO Paddlewheel, 4-inch drum				
540	4	1800	4.9	15.2	1.6	9.5	3.1
1000	4	950	4.8	15.2	0.7	21.7	3.2
540	14	1800	16.9	45.1	2.0	22.6	2.7
1000	14	950	16.7	45.1	1.2	37.6	2.7
			PTO Paddlewheel, 20-inch drum				
540	4	1800	12.4	26.0	1.8	14.4	2.1
1000	4	950	12.0	26.0	1.0	26.0	2.2
540	14	1800	40.2	90.0	3.0	30.0	2.2
1000	14	950	39.0	90.0	2.3	39.1	2.3

When fish are stressed with low dissolved oxygen, they often go to shallow areas of the pond near the banks. The type and design of the paddlewheel aerator may affect the ability to direct the water along the pond bank where the fish tend to congregate. Another consideration is the ground clearance under the frame of the aerator. A paddlewheel aerator with limited ground clearance may get caught on high spots, such as a levee crown, while high clearance models can traverse these areas with ease, but may operate too shallowly to be effective.

Electric paddlewheel

Electric paddlewheel units are 4 to 12 feet long with paddles of triangular cross section and a total drum diameter of about 28 to 36 inches. Paddlewheel speed is usually 80 to 90 rpm with a paddle depth of about 4 inches, enough to load the motor. The correct paddle depth can be determined in the field as the depth needed to draw the rated amperes of the motor. To extend the service life of the motor, the motor should draw only 90 percent of full load amperes rating, unless the manufacturer recommends differently. Motor sizes range from 1/2 hp to 19 hp and larger. Motors operating on single- or three-phase current are available.

Methods used to reduce the motor speed to the desired aerator shaft speed include v-belts and pulleys, chain drive and gears and gearboxes. Shafts of most electric motors run at 1,750 rpm and most units are mounted on floats.

Diffused air systems

Diffuser aerators operated by low pressure air blowers or compressors forcing air through weighted aeration lines or diffuser stones release air bubbles at the pond bottom or several feet below the water surface. Efficiency of oxygen transfer is related to the size of air bubbles released and water depth. The smaller the bubble and the deeper it is released, the more efficient this type aerator becomes. When tested at normal catfish pond depths, these aerators were found to be inefficient compared to other devices.

Limited studies in commercial catfish ponds showed no improvement in fish production when a diffused aeration system was used. One of the biggest problems with diffused-air systems is clogging of the air lines and diffusers so that periodic cleaning is required. Also, the air lines interfere with harvesting.

Propeller-aspirator pump

These aerators consist of a rotating, hollow shaft attached to a motor shaft. The submerged end of the rotating, hollow shaft is fitted with an impeller which accelerates the water to a velocity high enough to cause a drop in pressure over the diffusing surface which pulls air down the hollow shaft. Air passes through a diffuser and enters the water as fine bubbles that are mixed into the pond water by the turbulence created by the propeller. They are electrically powered, and models range from 0.125 to 25 hp. Table 2 summarizes the performance results of units of various sizes.

Table 2. Performance data on propeller-aspirator pump aerators.

Power at Aerator Shaft (hp)	Approximate SOTR (lb O_2/hr)	Approximate SAE (lb O_2/hp-hr)
1	2.2	2.2
5	11.0	2.2
10	23.2	2.3
15	45	3.0

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