Evaluation of Aeration Attachments for a Crisafulli Pump

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EVALUATION OF AERATION ATTACHMENTS FOR A CRISAFULLI PUMP

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EVALUATION OF AERATORS used in fish farming (3) revealed that electric paddle wheel aerators were more efficient than other types of aerators for use in large ponds (2 to 25 acres). If electricity is unavailable at ponds, aerators driven by the power take-off (PTO) of farm tractors can provide emergency aeration. The two most common types of PTO aerators are paddle wheels and pump sprayers. Some fish farmers have PTO-powered Crisafulli pumps for transferring water between ponds, and these pumps may be fitted with aeration attachments and used as a substitute for pump-sprayer aerators.

The purpose of this research was to evaluate some simple aeration attachments used with Crisafulli pumps.

MATERIALS AND METHODS

A 12-inch Crisafulli pump (Model LH12RA-SA) was supplied by the Crisafulli Pump Company, Glendive, Montana. The pump was fitted with a standard adaptor for attaching a rubber hose for pumping, figure 1. Two aerator pipes were fabricated, figure 2: the "V" aerator pipe divided the pump discharge into two streams; the "C" aer-

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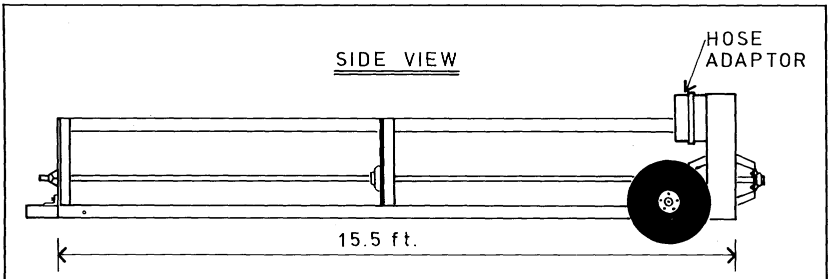

FIG. 1. Side view of Crisafulli pump showing location of hose adaptor.

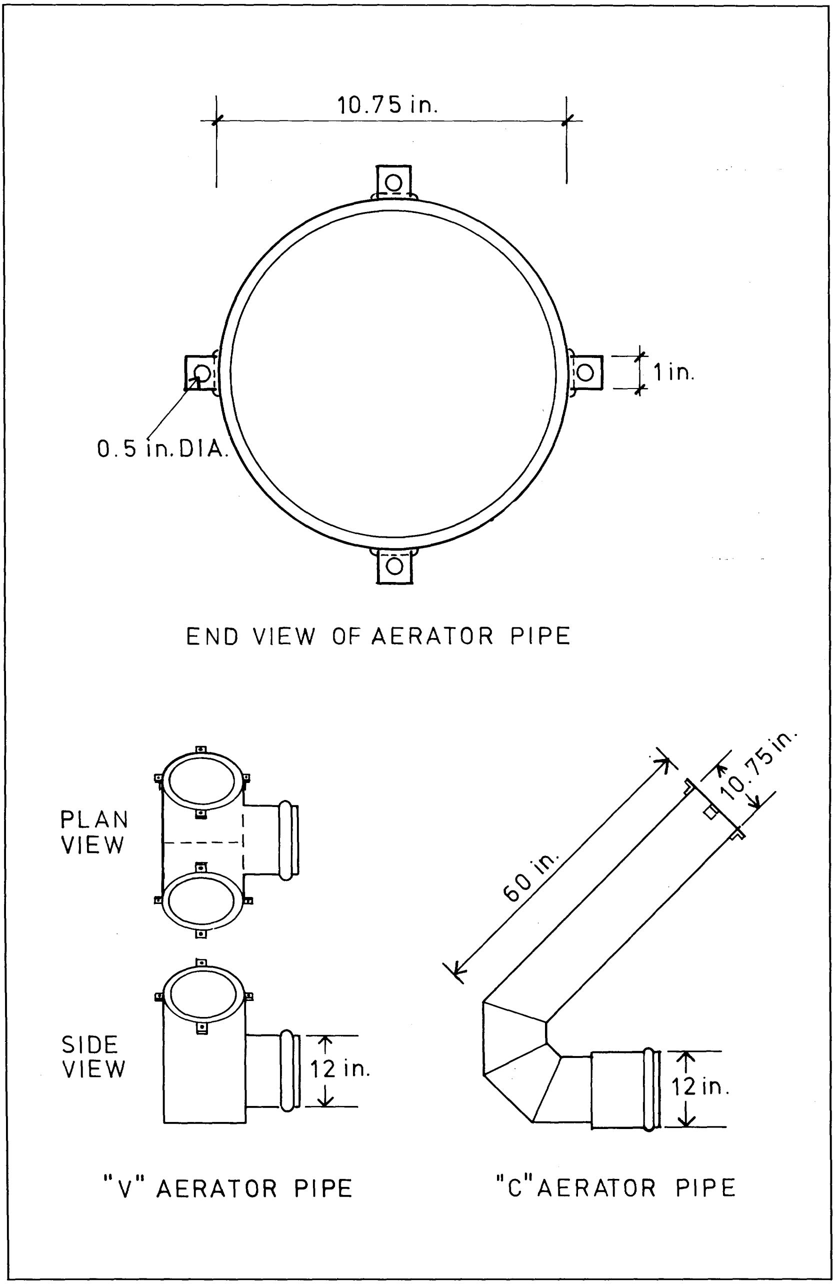

FIG. 2. "V" and "C" aerator pipes and an end view of aerator pipes.

ator pipe provided a single discharge stream. The aerator pipes attached directly to the hose adaptor with quick clamps.

Aerator pipes could be used to effect aeration by discharging water into the air and allowing it to fall onto the pond surface. However, several devices were fabricated for attachment to the discharge ends of the aerator pipes in an attempt to increase the amount of aeration. One series of attachments consisted of plates with different size holes which could be mounted over the aerator pipe to reduce area and increase discharge velocity, figure 3. Holes were 6, 7, 8, or 9 inches in diameter, with center opening areas of 28, 38, 50, and 64 square

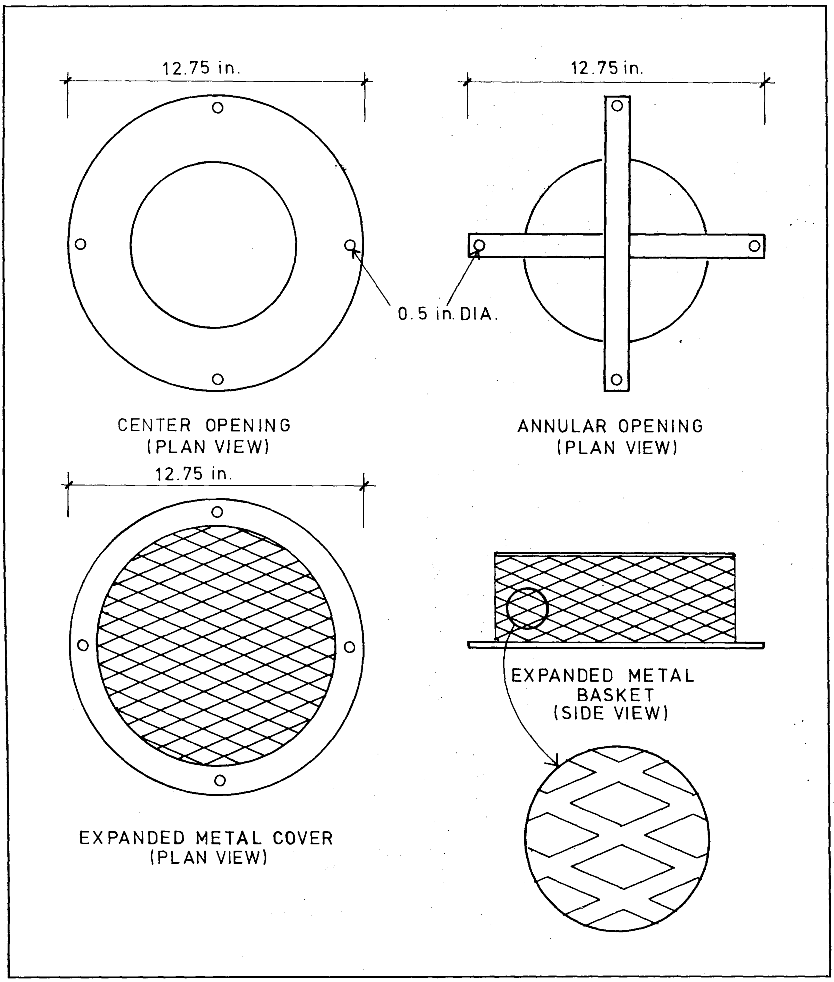

FIG. 3. Aeration attachments.

inches, respectively. Another series of plates was made by welding two metal strips to form a cross and attaching circular metal plates in the center of the crossed metal strips, figure 3. The circular metal plates were selected so that the areas of the annular openings were essentially the same as those obtained with the plates with center openings. Two expanded metal covers for aerator pipes, figure 3, also were fabricated. The open areas of the covers were approximately 64 square inches.

The Crisafulli pump was powered by a 65-hp[2] tractor (Ford Model 5000) when operated at an impeller speed of 540 rpm[2]. An 80-hp tractor (John Deere Model 2850) was used when the pump was operated at an impeller speed of 1,000 rpm.

Aerator tests were conducted in an aeration tank (1,400 square feet x 3 feet deep) or in an earthen pond (4,300 square feet by 3 feet average depth). Water was deoxygenated with cobalt chloride (0.075 mg/L[2]) and sodium sulfite (9 mg/L for each mg/L dissolved oxygen). Chemicals were dissolved in water, splashed over the water surface, and mixed with water by running the aerator. A polarographic dissolved oxygen (DO) meter was used to measure DO concentrations at timed intervals during aeration while DO rose from near 0 to 80 or 90 percent of saturation. Each combination of aerator pipe, aeration attachment, and impeller speed was replicated three times.

Deficits of DO were calculated for each time interval by subtracting measured DO concentrations from concentration of DO at saturation. Natural logarithms of DO deficits were plotted versus time of aeration. The line of best fit was determined by regression analysis. The oxygen transfer coefficient was calculated with the following equation:

$$(K_La)_T = \frac{\ln DOD_{10} - \ln DOD_{70}}{(t_{70} - t_{10})/60}$$

where:

$(K_La)_T$ = overall oxygen-transfer coefficient for the existing water temperature ($hour^{-1}$)

DOD_{10} = DO deficit at 10 percent saturation (mg/L)

DOD_{70} = DO deficit at 70 percent saturation (mg/L)

t_{10} = time DO reaches 10 percent saturation (minutes)

t_{70} = time DO reaches 70 percent saturation (minutes)

[2]Abbreviations used: hp = horsepower; rpm = revolutions per minute; mg/L = milligrams per liter.

The $(K_La)_T$ value was adjusted to 68°F (20°C) as follows:

$$(K_La)_{20} = (K_La)T \div 1.024^{T-20}$$

where:

$(K_La)_{20}$ = overall oxygen-transfer coefficient at 20°C ($hour^{-1}$)

T = water temperature (°C)

The standard oxygen-transfer rate was calculated by the equation:

$$SOTR = (K_La)_{20} \times 9.07 \times V \times 10^{-3} \times 2.205$$

where:

SOTR = standard oxygen-transfer rate (pounds 0_2 per hour)

V = volume of aeration tank (m^3)[3]

2.205 = pounds per kilogram.

Additional details on aerator testing are provided by Armstrong and Boyd (2) and American Public Health Association et al. (*1*).

RESULTS AND DISCUSSION

Values for SOTR were determined for four aeration attachments on both V and C aerator pipes, table 1. Values were highest for the C aerator pipe and especially for the devices with single, circular openings. All other oxygen-transfer tests were conducted with the C aerator pipe.

In tests conducted at 540 rpm with different attachments on the C aerator pipe, SOTR ranged from 14.0 to 22.1 pounds 0_2 per hour, table 2. The highest values were for the 50-square-inch center opening and the flat, expanded metal cover. These two attachments also were tested for an impeller speed of 1,000 rpm, and resulting SOTR values were roughly twice those obtained at 540 rpm.

[3]One cubic meter (m^3) = 1.3 cubic yards.

TABLE 1. AVERAGES AND STANDARD DEVIATIONS FOR STANDARD OXYGEN TRANSFER RATES FOR A CRISAFULLI PUMP OPERATED AT 540 RPM WITH DIFFERENT AERATOR PIPES AND ATTACHMENTS[1]

Attachment	Transfer rates (lb. 0_2/hr.) by aerator pipe	
	"V"	"C"
Open aerator pipe	5.8 ± 0.1	14.8 ± 0.3
Center opening, 9-inch	9.7 ± 0.7	16.2 ± 1.0
Annular opening, 9-inch	15.2 ± 0.4	15.7 ± 0.2
Expanded metal cover, flat	12.2 ± 1.0	13.5 ± 0.3

[1]Each combination of pipe and attachment was tested in triplicate.

TABLE 2. AVERAGES AND STANDARD DEVIATIONS FOR STANDARD OXYGEN TRANSFER RATES OBTAINED WITH A CRISAFULLI PUMP OPERATED AT 540 OR 1,000 RPM WITH A C AERATOR PIPE AND DIFFERENT AERATION ATTACHMENTS[1]

Attachment	Transfer rates (lb. 0_2/hr.) by speed (rpm)	
	540	1,000
Open aerator pipe	14.8 ± 0.3	
Center opening		
28 square inches	14.7 ± 0.9	
38 square inches	15.5 ± 1.2	
50 square inches	20.7 ± 0.3	36.8 ± 3.1
64 square inches	15.9 ± 1.4	
Annular opening		
28 square inches	16.7 ± 0.8	
38 square inches	16.8 ± 0.2	
50 square inches	19.0 ± 1.5	
64 square inches	15.7 ± 0.2	
Expanded metal cover		
Flat	22.1 ± 0.3	43.1 ± 1.2
Basket	14.0 ± 0.5	

[1]Tests were conducted in triplicate.

According to pump affinity laws (5), the discharge of a pump is related to impeller speed by the equation

$$\frac{Q_1}{Q_2} = \frac{n_1}{n_2}$$

where:

Q_1 and Q_2 = pump discharges at impeller speeds n_1 and n_2. Thus, discharge increases in direct proportion to impeller speed, and it is not surprising that SOTR at 1,000 rpm was roughly twice SOTR at 540 rpm. Power requirements of a pump increase according to the formula

$$\frac{P_1}{P_2} = \frac{(n_1)^3}{(n_2)^3}$$

where:

P_1 and P_2 = power requirements at impeller speeds n_1 and n_2. For impeller speeds of 540 and 1,000 rpm, the formula becomes:

$$P_{1,000} = P_{540} \times (6.37)$$

Therefore, to double the SOTR by increasing impeller speed from 540 to 1,000 rpm would raise power requirement about sixfold.

Of the several attachments for aerators, the C aerator pipe with the 50-square-inch (8-inch diameter) center opening was the most suitable. Although the flat expanded metal cover had a high SOTR at both 540 and 1,000 rpm, the small opening in the expanded metal cover will clog easily in ponds with infestations of aquatic weeds.

A PTO-driven pump sprayer aerator operated at 1,000 rpm by an 80-hp tractor had a SOTR of 46.9 pounds 0_2 per hour, while another pump-sprayer aerator operated at 540 rpm by a 65-hp tractor had a SOTR of 26.6 pounds 0_2 per hour (*3*). Both of these pump-sprayer aerators were designed specifically for aeration and could not be used for pumping water. The Crisafulli pump fitted with attachments tested in this study aerated approximately 80 percent as efficiently as the pump-sprayer aerators manufactured specifically for aeration. Pump sprayer aerators are not as efficient as paddle wheel aerators. Values of SOTR for PTO-driven paddle wheel aerators operated by a 65-hp tractor ranged from 43.3 to 65.7 pounds 0_2 per hour (*3*). Busch et al. (*4*) reported an SOTR of 90.4 pounds 0_2 per hour for a paddle wheel aerator powered by an 85-hp tractor. The Crisafulli pump with aeration attachments is not a practical alternative to paddle wheel aerators and conventional pump-sprayer aerators, but a Crisafulli pump may be converted to a useful emergency aerator if other types of aeration equipment are not available.

REFERENCES

(1) American Public Health Association, American Water Works Association, and Water Pollution Control Federation. 1980. Standard Methods for the Examination of Water and Wastewater. Amer. Public Health Assoc., Washington, D.C.

(2) Armstrong, M.S. and C.E. Boyd. 1982. Oxygen-transfer Calculations for a Tractor-powered Paddle Wheel Aerator. Trans. Amer. Fish. Soc. 111:361-366.

(3) Boyd, C.E. and T. Ahmad. 1987. Evaluation of Aerators for Channel Catfish Farming. Ala. Agr. Exp. Sta. Bull. 584.

(4) Busch, R.L., C.S. Tucker, J.A. Steeby, and J.E. Reames. 1984. An Evaluation of Three Paddle Wheel Aerators Used for Emergency Aeration of Channel Catfish Ponds. Aquacultural Eng. 3: 59-69.

(5) Stepanoff, A.J. 1957. Centrifugal and Axial Flow Pumps. John Wiley, New York, N.Y.

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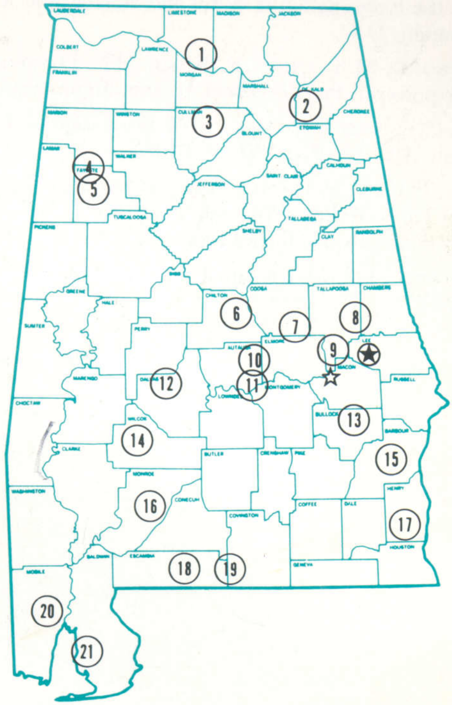

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