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Design of Pond Water Aeration Systems: A Review

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ABSTRACT

During the past decade, pond/lake aeration systems have been developed which will sustain large quantities of fish and water impurities. Aeration-performance testing is an important procedure in selecting design features to provide a cost effective system without affecting the performance of the aeration system. Paddlewheel aerators and propeller-aspirator-pumps are widely used for aeration system. Aerators usually are placed in ponds to provide maximum air circulation in water. Supply of DO (dissolved oxygen) is necessary in water. This method includes designing of the system using mechanical components and renewable source of energy that is solar energy to operate the system. With the recent increases in awareness of energy depletion, energy cost and the requirements of Biological Nutrient Removal (BNR), the design of an aeration systems has become the most important parts of the design of the activated sludge process. A well designed system can significantly save energy, cost and perform better operation.

KEYWORDS: Fine bubble generator dissolved oxygen, water oxygenation, Aeration system, compressor for aeration system.

INTRODUCTION

Aeration (also called aerification) is the process by which air is circulated through, mixed with or dissolved in a liquid or substance[1].Water aeration is the process of increasing the oxygen saturation of the water.With the recent increasing cost of energy, operating the water treatment plant efficiently has become one of the most important factor the managers are facing. An aeration system is divided into three parts: Airflow generation, Airflow distribution, and Aeration control[2]. Aeration generation consists of aeration blowers. Distribution of airflow consists of air piping, air control valves, and diffusers. Control of aeration consists of blower control, air flow calculations, airflow meters, and dissolved oxygen meters. For an aeration system to be good all the three part should work properly. If one aspect of design is needing improvement, the other two aspects will be affected and will likely cause the DO set point to be missed, the permit to be violated and energy to be wasted [3].With the increasing cost of energy, instead of using non-renewable source of energy, renewable energy like solar energy can be used to operate the system.

Using solar energy, compressor will be activated which will absorb air from atmosphere and then release it into the water. A diffuser will be installed at the bottom of the lake. The diffuser will be designed in such a way that it will generate fine bubbles. Fine bubbles are a key component in improving the performance of gas-liquid reactors, particularly in situations where reactions are mass transfer limited. Many aerator types exist for different reactor applications; however conventional aerators are mostly suited to coarse bubble generation [4].

TYPE OF AERATION

1) Diffused Aeration
i) Plate diffuser
ii) Tube diffuser
2) Mechanical Aeration
i) Vertical Aeriation
ii) Horizontal Aeration
3) Combined Aerator

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1.**Diffused Air Aeration**

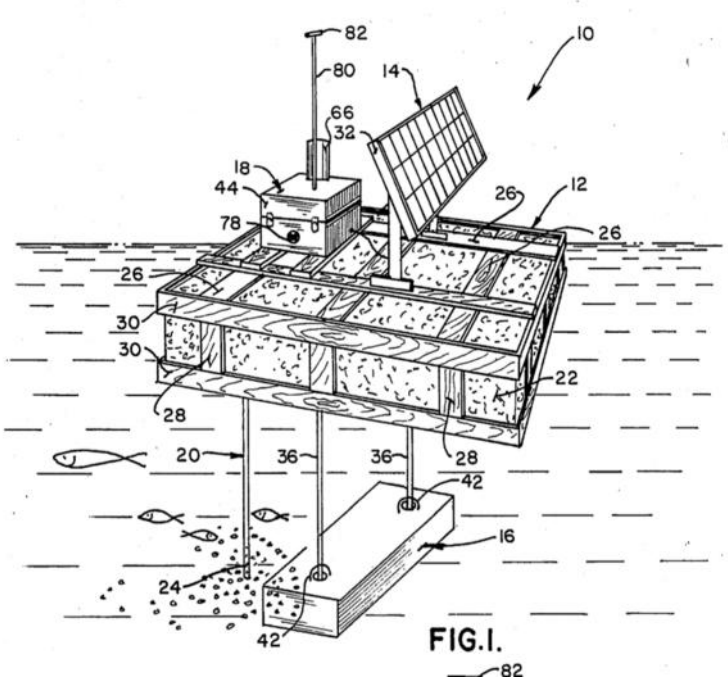
In this method compressed air is blown with the help of compressor and then released through diffuser water. Diffusers are divided two types: Plate diffuser and Tube diffuser[2].

i. Plate Diffuser

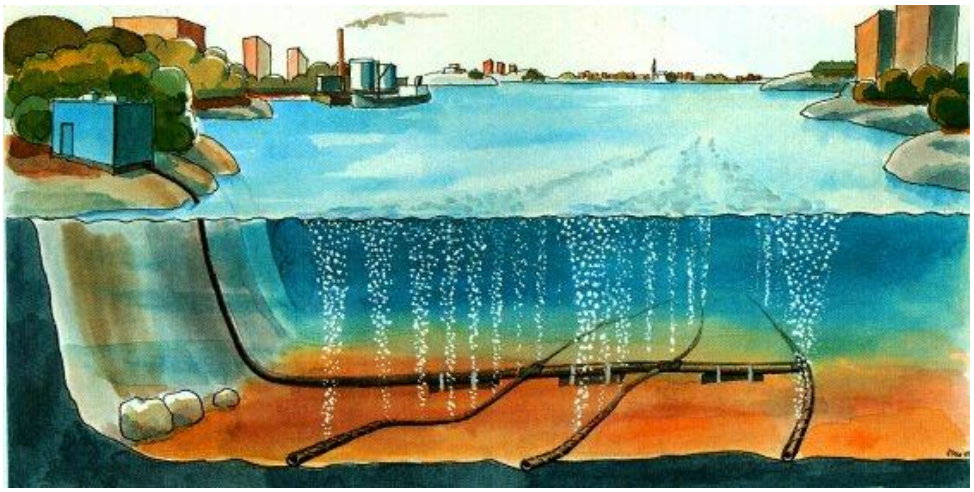
They are rectangular/square plates made of crystalline alumina or high silica sand. In this method the compressed air is blown into the water through a punched plate diffuser. The air is released through the holes in the plate and rises up in the form of bubbles. Thus the water absorbs oxygen from the air.

ii. Tube Diffuser

It consists of a punched tube suspended in the waste water at the bottom of lake and can also be removed for cleaning. The air comes out through the holes with great force and stirs the impurities in the water.



(DIFFUSED AIR AERATION)[5].



(Diffused Air Aeration)

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COMPONENTS NEEDED FOR THE MODEL MAKING

1. Base material (light weight material that can float easily on water)
2. Solar panels
3. Compressor
4. Diffuser
5. Piping
6. Wheels (paddles) for movement of the system
7. Remote and relay to move the system

APPLICATION OF AERATION AND RESULTS

Sr No.	Author	Process/ Equipment Used	Results
1.	Matthew Gray, Steve Kestel, Tilo Stahl(2011) [3],[6]	Diffused Air Aeration	Successful operation of the system depends on the successful operating of all the components of the system. The paper describes that a well-designed aeration system can save up to 25 to 40% of energy consumption.
2.	Avinash Kumar, SanjibMoulick, Bimal Chandra Mal [7]	circular stepped cascade (CSC), pooled circular stepped cascade (PCSC), 1-hp paddle wheel, 2-hp paddle wheel,	For a pond of size less than 1000 m^3 volume circular stepped cascade or pooled circular stepped cascade is more economical. For large size 5000 m^3 1 hp paddle wheel or 2 hp paddle wheel is economical.
3.	Claude E. Boyd (1998) [8], [9]	Paddlewheel aerators	Production cannot be increased by ignoring the economic consideration of the system as high ammonia concentration will impose a limit even though there is adequate amount of DO concentration.
4.	Meisheng Liang, Lianghu Su [10]	Dissolved Air Aeration	As the value of oxygen increases in the water the BOD removal efficiency improves to a certain amount. If we want to remove NH3-N and TN we must add nitrogen removal process.
5.	Doaa M. Atia1, Faten H. Fahmy1, Ninet M. Ahmed1, Hassen T. Dorrah2 [6]	Diffused Air Aeration	This paper describes a new design and sizing of dissolved air aeration system for better aquaculture by using FLC technique. With this technique high performance of control subsystem can be shown.

6.	Brain Kirke Ahmed El Gezawy (1996) [11]	Vertical Impeller and Horizontal Impeller	If the circulation is turned on before the thermocline is established there will be no density difference that will oppose the pumping of water. Mixing is not necessary the main key to prevent stratification is circulation of water.
7.	PongsakornKerdchang, [12]	Solar thermal Engine	Power and crank velocity of the system depend highly on the thermal performance of the solar collector. Regenerator volume should be carefully chosen to meet the assumption of constancy of mass in the system.
8.	Ahmed Mahmoud, Tuan Nguyen Quang [13]	Natural convection	The device relies on solar heat to induce convective water mixing using a numericalfluid dynamics model of a pond segment and it can circulate the water through natural convection.
9.	Tomas Beuzen, Alexander R. Horner-Devine [14]	Thermal infrared (IR) imagery	Remote sensing technology can be difficult and even expensive in measuring Situ. This technique are applied here and can be useful for large- scale study of subsurface dynamics.
10.	Daisuke Kitazawa, Jumbo Zhang [9]	Paddle Wheel Aeration	At the centre, upper right and lower left of the pond the frictional velocity was smaller. Even at the localized area the current velocity was smaller. Therefor the system should be placed where current is low as the circulation is needed.
11.	Zhen He, AnurakPetiraksakul [15]	Absorption and desorption	Absorption technique is used to transfer oxygen in water. SOTE level increases with the depth of water as the contact time of water with bubbles increases. For more precise measurement to SOTE with large depth of water.
12.	Mihaelaconstantin [16]	Diffused air aeration with 0.5 orifice fine bubble generator	The curves determined from the experimental measurements results has an increasing aspect and intersects after about 90 minutes of FBG functioning, highlighting the qualities of this type of fine bubble generator.
13.	BanchaSreewirote, AkeratanaNoppakant [17]	Thermal ventilation system	The system without the thermal ventilation system gives voltage of 34-35V and current of 7.2-7.6A, resulting in low output power (252-281W). On the other hand, the system integrated with the thermal ventilation system can provide more voltage; hence more output power which is 314-346W.
14.	Ruidong Xu, Dongsheng Yu [18]	Tilt angle of solar panel	The finest tilt angle of YL200P-23b PV panel changes from 25 to 2 after dust effect is taken into consideration.
15.	MoeinJazayeri [19]	Solar output relation with sun	Direct relation exists between the sun's height and the solar angle of incidence. As the sun grows higher the power input also increases. The panels should be placed accordingly.

16.	Mathias AarreMaehlum [20]		Efficiency of monocrystalline panel is high compared to polycrystalline and thin film. It occupies less area 6-8m^2 for 1kWp. It is widely used. According to cost polycrystalline is advisable.
17.	FigenBalo, LütfüŞağbanşuab [21]	Analytical Hierarchy Process	Compared to other solar panels like polycrystalline, thin film, the best used solar panel is monocrystalline. The results can vary according to the need of the customer.
18.	Connie D. DeMoyer, Erica L. Schierholz [22]	Submerged air aeration	The result of the model indicate that the surface transfer coefficient in a 9.25m tank is 59-85% of bubble transfer coefficient. Bubble concentration is also greater the air water concentration.
19.	Avinash Kumar, S. Moulick [23]	Propeller-aspirator-pump aerator	The optimum position angle obtained was 75°. Maximum SOTR and SAE obtained were 0.15 kg O2/h and 0.42 kg O2/kWh at 2840 rpm at the depth of 0.14m.
20.	Chun Liu, Jing-Liang Yang [24]	soybean oil, phenol and kaolin	The range of KLa values were larger than traditional bubble aeration. KLa values and α- values increase with the increasing concentration of soluble organic contaminants. Oxygen transfer enchantment is responsible of these contaminants.
21.	Martin R. Wagner, H. Johannes Popel [25]	Diffused air aeration	Higher diffuser density can help to obtain higher value of specific oxygen.Typical average values are 4.3 [Wh/m3·m at STP] for positive displacement blowers and 3.0 [Wh/m3·m at STP] for turbo-compressors at a pressure of 10m and an air flow rate of 5,000 m3/h at STP.

CONCLUSION: After studying the above research paper we can conclude that the aeration of water can be carried out by various process like Paddle wheel aeration, diffused air aeration etc. To obtain a better aeration effect every parameter like design of the system, rate of oxygen transfer in the water, proper selection of material in design of the system should be considered. Fine bubble generation is the best way to transfer oxygen within the water. Use of renewable source of energy can be a better solution for an eco-friendly environment. Solar panels have to be placed and fixed at a proper tilt angle to obtain better efficiency. With aeration not only water can be purified but it is also good for aquatic life. Farmer who look for aquatic life have obtained a better result using aeration technique. Waste water from chemical industries can also be purified with different modifications in the system. Overall the aeration system is good for both water purification as well as aquatic life as it improves the quality of water and life of aquatic life.

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