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Research Article

Effect of Wind-solar Complementary Increasing Oxygen System in Aquaculture

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Abstract: In order to explore a sustainable aquaculture methodology, water was increased oxygen by a wind-solar power which was tested in a production period of the Penaeus vannamei in paper. The result shows that, compareing with the conventional aerating comparison, the system could improve water environment in ponds and dissolved oxygen, temperature, pH value and the content of nitrite stably and uniformly change; make full use of wind energy and solar energy clean energy, save 100% on power consumption, 15.9% on bait, 46.0% on drug; save aquaculture costs, increase income 282%. Using "Wind-solar" complementary increasing oxygen can improve water environment, save power, reduce aquaculture costs, increase aquaculture production and income, provide a new thought and method for green and ecological aquaculture, so it has high value of practical application.

Keywords: Aquiculture, energy saving, increasing oxygen, wind and solar complementary electricity generating

INTRODUCTION

Intensive and high density aquiculture is the main form in world, which has many advantages, for example, strong controllable ability, resistable risk ability and high yield per unit area (Cheng *et al*., 2011; Xingguo *et al*., 2009; Bing *et al*., 2011). In 2009, there were 2144700 hm^2 for pond aquaculture area, 14594500 t for aquaculture output in China, which occupied the 70.4% of freshwater aquaculture (Tao *et al*., 2010; Jian *et al*., 2011). Environment and body of water of the intensive and high density pond aquaculture are relative seal, with the high density of breeding biology and the large oxygen consumption. This extremely easy causes the eutrophication of water body and results in production drawdown (Tao *et al*., 2010; Jian *et al*., 2011). Therefore, how to furthest and quickly increase the dissolved oxygen content of aquaculture water will be vital to the purification of aquaculture water body. Maximize the quickly increase is vital to the dissolved oxygen content of purification.

In China, Mengchun *et al*. (2012, 2010) has developed a aerated water treatment system powered by photovoltaic/wind energy. The system may improve one grade for treated water quality. Lixin *et al*. (2011) has designed a water circulation oxygenation purifying device technology based on natural. The device completely adopts the solar energy and wind energy as power, is applied in landscape water body purification, is saving electric energy, achieves the exchange of the lower and upper water, can significantly improve the dissolved oxygen and transparency, decreases the chlorophyll. Xiangwen *et al*. (2010) has produced an experimental study on applying biofan to cultivate Penaeusvannamei. Chongwu *et al*. (2012) has studied oxygenation effect of wave aerator on shrimp culture. The result shows that two kinds of methods could improve water environment, reduce breed cost and increase piscatorial income. Guodong *et al*. (2012) has designedan increasing oxygen system based on solar energy and tested runing effect in a aquiculture cycle. In the study, oxygenation system based on wind and solar complementary electricity generating has been designed, experimented in aquaculture, used shrimp as culture object. The paper has studied the influence of dissolved oxygen, temperature, pH and nitrite and so on, water environment factors. Growth condition of the shrimp and economic benefit of saving energy and drug has been analysed and compared in order to discuss the practical application of wind and solar complementary electricity generating in oxygenation for aquaculture, explore a new way of the sustainable development and green zoology aquaculture.

INCREASING OXYGEN SYSTEM BASED ON WIND AND SOLAR COMPLEMENTARY

Increasing oxygen system based on wind and solar complementary has increasing oxygen system based on wind and solar complementary electricity generating and detecting system for water quality parameters.

Increasing oxygen system based on wind and solar complementary electricity generating uses solar and

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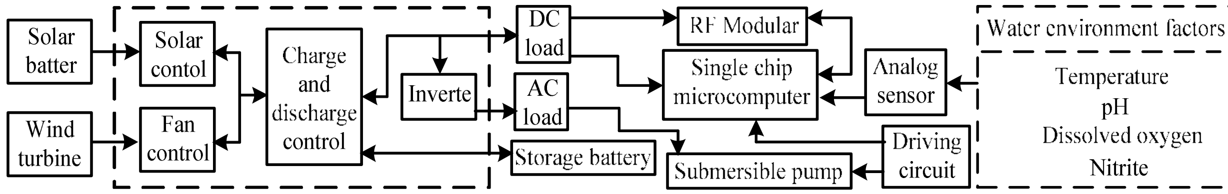

Fig. 1: Wind-solar power water purification system

wind complementary electricity generating as dynamic, drive interflow submersible pump and complete oxygenation for close water. Figure 1 is wind-solar power water purification system structure diagram. The system mainly includes a fan, a solar panel, a charge and discharge controller, batteries, AC and DC load. Solar panels and wind turbines relatively generate electricity respectively using photovoltaic and wind power and charge the battery; battery adopts maintenance-free lithium battery and completes the automatic control of the charge and discharge by the controller, at the same time the controller completes link and combination of every part of the power system. Electrical power generating system continuously chargings, discharges and float chargings to storage battery according to the sunshine intensity, wind force and change in load. The system changes and adjust to various working conditions, supplies electric energy for DC and AC load, at same time storage battery stores superfluous electric energy. When generating capacity cannot meet the need of DC and AC load, storage battery provides power to the load through a controller, to realize the battery alternating operation in various conditions and ensure the continuously, stablly operation of power system (Guodong *et al*., 2012; Rongjin *et al*., 2011; Fan *et al*., 2010; Yang *et al*., 2010; Wang and Zhang, 2012; Cheng *et al*., 2012; Xu *et al*., 2012a, b; Wang, 2012; Xing *et al*., 2012; Wang *et al*., 2012).

Increasing oxygen system (Zhongliang and Qiang, 2009; Zhongliang *et al*., 2011) sets floating body and trumpet-shaped tube structure, uses wind and solar complementary power as dynamic, adopts submersible pump to drive water, in order to make the fish pond bottom water radially to discharges to the surface of the water, destroy the anaerobic layer of water bottom (oxygen-depleted waters) and water temperature thermocline, increase the dissolved oxygen content in water body, promote the metabolism of microorganisms, accelerate the degradation rate of pollutant substance and destroy the living environment of planktonic algae through the water exchange, restrain and reduce the propagation of water bloom algae, so as to control water bloom, remit the eutrophication degree of water, consolidate the purifying capacity of water.

The detecting system of water quality parameter uses AVR ATMEGA128 as the main control chip, to detect and control the environmental parameter of breed aquatics. Dissolved oxygen content, pH value, temperature, nitrite content of various sensor are converted to various digital signals and stored up, then compared with the given values. The corresponding control signal is provided by the optimal control algorithm to control submersible pump. At same time the system can display water quality parameters by the RF remote control module.

MATERIALS AND METHODS

Increasing oxygen system based on wind and solar complementary electricity generating uses a set wind and solar complementary system of a 1000 W solar power and a 1000 W wind power generation combined. The system total cost is 25000 RMB. Solar energy and wind energy, respectively is convert ed electric energy by solar energy photovoltaic panels and wind driven generator. The system voltage is controlled in 48 V by the controller, offers the power for water quality parameters through conversion and chargings storage battery. At the same time, the inverter converts the AC 220V to supply power for 6 submersible pumps (parameters: the 750W rated power, the AC 220V working voltage).

Monitoring water quality indexs mainly include the content of dissolved oxygen, pH value, temperature, nitrite content. Dissolved oxygen meter adopt YSI-550A of Beijing Hongchangxin science and technology limited company to measure dissolved oxygen content, the measurement accuracy is 0.01 mg/L, error is ±0.02 mg/L; the apparatus also can detect the water temperature, the measurement accuracy is 0.1°C, error is ±0.3°C.

Shanghai Joint Industry and Trade Company Limited PHB-3 acidity meter is selected to measure pH value of water, the measurement accuracy is 0.1, the error is ±0.2. Beijing double Hui Jing Cheng Electronics Company Limited aquatic tester CM-07 is selected to detect nitrite content, the measurement accuracy is 0.01 mg/L, error is 0.05 mg/L. 3 four-wheel waterwheel aerator (rated power is 1500 W) are prepared, which are provided by the Jiangsu province Jinhu County Jeddah farming equipment factory.

The Litopenaeus vannamei shrimp for experiment are purchased in Tianjin City Sheng Miao aquaculture Limited company. Body length is 0.8 cm.

The feed for experiment is selected the pellet feed of Qingdao Yue sea aquatic feed Limited production.

Feed method adopts the combination of natural baits and artificial feed and 2 pond are, respectively provided with four feeding station, in order to facilitatly observe the feed and satiation condition of prawn. In cultivation early days,

In early days cultivation, natural bait, mainly Rotifera and Cladocera, in the pool is used as food, then gradually adding artificial compound feed. In the mid- to late cultivation, artificial compound feed is used as main bait, uniformly feed along pool side with adhering to the principle of frequently throw and few feed and feeding 4-6 times every day. In the first month after seedling, feeding frequency is arranged 4 times every day, at 6:00-7:00, 10:00-11:00, 15:00-16:00 and 20:00-21:00 in every day. Along with prawn growth, feeding quantity is increased, feeding frequency is also added. Feeding frequency is arranged 6 times every day, feeding 1 time about every three hours from 6:00 to 22:00, moreover feeding quantity after afternoon takes up approximately 60% feeding quantity in a day. Feeding quantity is 3-5% of prawn total weight, is increased or decreased at any time with observing weather, temperature, water quality, prawn's activity condition.

Experiment is carried through in aquiculture base, Yangjiapu Town, Hangu District, Tianjin City, China, on April 10, 2011. In a culture-cycle (18 weeks), water environment factors, effect of energy saving and drug saving, growth condition, quality and economic benefit for Penaeus vannamei cultivation in experiment pond and compare pond are compared and analysed.

Area of experiment pond and compare pond is, respectively 0.44 hm^2, depth of water is 1.6 m, the pond is east-west, the bottom is flat and sludge thickness is 14 cm. In order to avoid the interference phenomenon between 2 ponds and keep the surrounding environment be basically the same, 2 ponds are located in aquiculture base, Yangjiapu Town. There is not pollution source around aquaculture base. Seawater resources and fresh water resource are adequate, water body physicochemical factors are favorable, various heavy metal ions do not exceed the standard of water quality, water quality meets the aquaculture standard, flooding water and dewatering are convenient, illumination is adequate, power supply and transport are convenient.

An increasing oxygen system based on wind and solar complementary is applied in experiment pond, which supply power to 6 submersible pumps (power rating is 750 W, working voltage is AC 220V). 6 submersible pumps are respectively arranged in the experiment pond offshore 4~5 m, located on the same level, to form water circulation; Compare pond adopts 3 aerator with four wheel and waterwheel, are respectively arranged in the pond offshore 4~5 m too, at the same level line.

Before experiment, 2 ponds are dredginged, sealed brake and basked. It appears chap at the bottom of the pond after 21days. Remnant bait, sundries and sludge are moved to outside the bank and the bottom of the pond is turned over and basked in order to more reduce disease by means of low temperature and illumination in wintertime. Sludge is rushed out the pood by means of repeatedly perfusing and a way of mud pump after turning over. Poodridge is reinforced and renovated to ensure that the shrimp pond leak-proof, prevent escape facilities in good condition.

In order to ensure the normal growth of fry into the pool, in the test and control pond water after the shrimp pond before entering the pool around 15 d, the lime 650 kg, spade evenly spread around the pool and then washing pool; bleaching powder 200 kg dissolved in water after pouring the entire pool and the dry gel on the surface of the pool also splash; tea seed cake 75 kg drying and crushing, soaking in water for a day and into the water, the water disinfection. In 2 poods, the 9 m from the pool and pool in the middle of 5 measuring points arrangement, regular daily measurement under water and from the bottom of 20 cm dissolved oxygen, temperature and pH value on nitrite; and every other week value time. According to the density of 6667 caudal/hm^2, respectively to test and control pond shrimp pond on 660000 end and 680000 end and at the same time the breeding. In the test medium (7~10 weeks), the average body mass of about 5g/ tail, breeding density of about 10000 kg/hm^2; the late test (15~18 weeks), the average body mass of about 12 g/tail prawn fishing prawn, part, breeding density is about 20000 kg/hm^2.

In experiment, experiment pond applisan increasing oxygen system based on wind and solar complementary, which is opened from 10 days before cultivation and continuously works 24 h every day until aculture-cycle finishs; To ensure prawn's regular growth, 2 submersible pumps are added, with runing 2 h and 10 h at noon and evening in every day from cultivation 10 weeks. 3 submersible pumps are added, with runing 3 h and 12 h at noon and evening in every day from cultivation 13 weeks. The control pond applis a aerator with four wheel and waterwheel from 1 week to 4 week, with runing 3 h and 7 h at noon and evening in every day from cultivation. To ensure prawn's regular growth, 2 aerators are added, with runing 3 h and 12 h at noon and evening in every day. From 12 weeks, 3 aerators simultaneously run, with runing 6 h and 12 h at noon and evening in every day.

Time from putting seedling and cultivation to catch for 2 poods is 18 weeks (126 d).

RESULTS AND DISCUSSION

On the influence of water quality indices:

Dissolved oxygen concentration: Figure 2 is the contrast variation curves of dissolved oxygen concentration. Figure 3a shows that, in the first 1~10

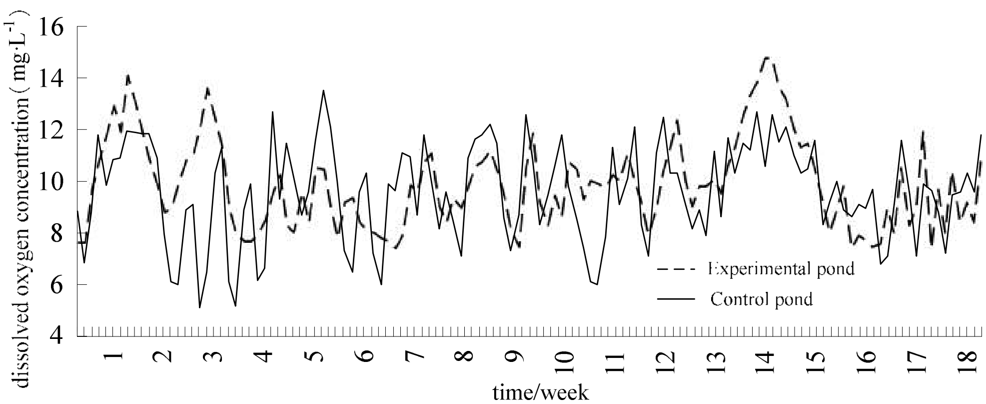

Fig. 2: Curves dissolved oxygen concentration

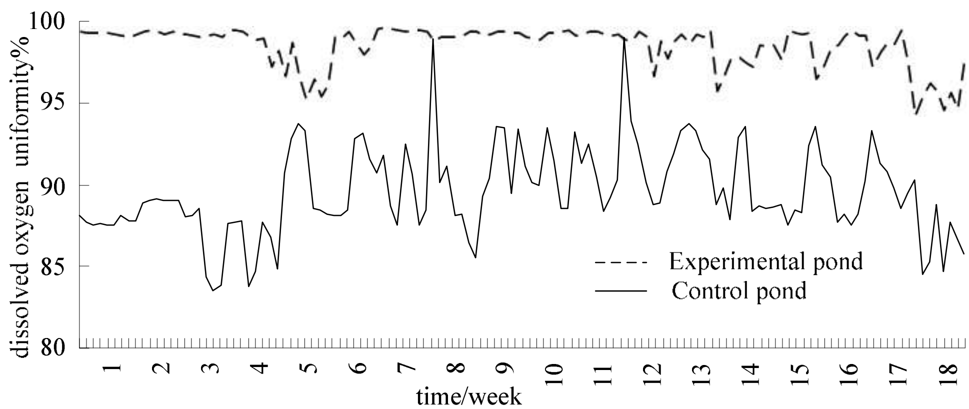

Fig. 3: Curves dissolved oxygen uniformity

weeks of the breeding cycle, being compared control pond, the average of dissolved oxygen in experiment pond is slightly higher, which illustrates that increasing oxygen system based on wind and solar complementary, with opening only 1 submersible pump, can meet the demand to increase dissolved oxygen concentration; In the 11~13 weeks, because prawn growth speed accelerates, a large amount of dissolved oxygen is consumed and the average of dissolved oxygen content in 2 poods is on a declining curve. In order to ensure the prawn growth is not affected, experimental pond is added by 2 submersible pumps, while control pond is added 1 aerator, with operating; At the beginning of the 13 weeks, because of the prawn growth rate being rapidder, 6 submersible pumps and 3 aerators run at the same time and respectively increase oxygen to test pond and control pond. At this time, the dissolved oxygen content for 2 poods are increased, while the value is higher the experimental pond one than the control pond one. In the breeding process, 2 kinds of oxygenation mode can improve the content of oxygen dissolved in water, but the dissolved oxygen concentration in the test pood reached a maximum of 14.82 mg/L and always maintains a high value by means of comparing with the control pond.

Figure 3 is uniformity comparison curves of dissolved oxygen in. As can be seen from Fig. 3, minimum and maximum values of dissolved oxygen uniformity in experiment pond are 93.20 and 99.61%. Maximum difference of dissolved oxygen concentration in the bottom is 1.71 mg/L; But, minimum and maximum values of dissolved oxygen uniformity in control pond are 83.89%and 94.41% and maximum difference of dissolved oxygen concentration in the bottom is 3.15 mg/L. Thus, the distribution of dissolved oxygen uniformity in experiment pond is uniformer and uniformity is apparently higher than control pond.

The control pond dissolved oxygen uniformity minimum and maximum values are 83.89 and 94.41% and the surface and bottom of dissolved oxygen concentration maximum difference 3.15 mg/L. Therefore, experimental pond dissolved oxygen in water distribution is uniform and the uniformity is obviously higher than the control pond.

In conclusion, it can more make the surface to the bottom of high dissolved oxygen sufficiently low dissolved oxygen diffusion experiment pond appling

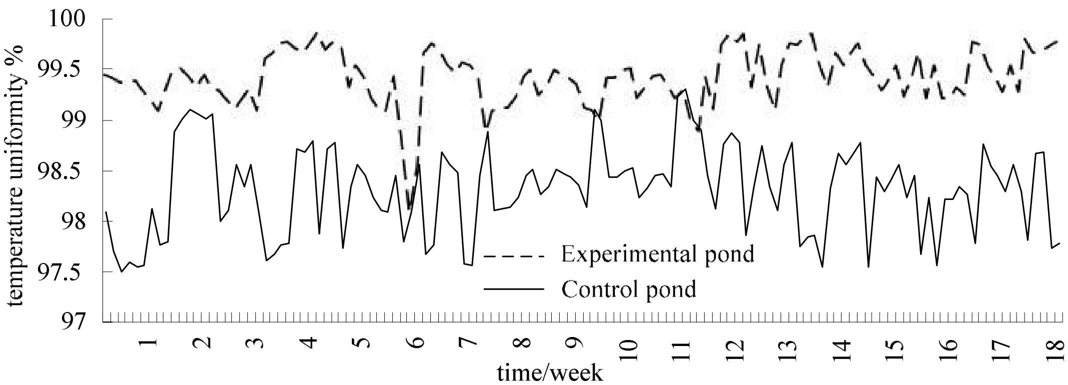

Fig. 4: Curves of temperature uniformity

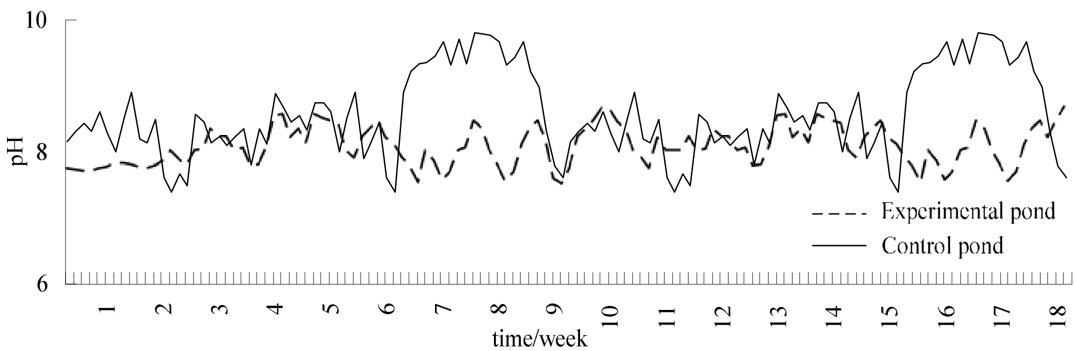

Fig. 5: Curves of temperature uniformity, pH

increasing of oxygen system based on wind and solar complementary than the control pond adopting mechanical oxygenation, increasing the dissolved oxygen content, dissolved oxygen uniformity in experiment pond is improved and the stability.

Temperature: In breeding cycle (126 d), temperature uniformity in the control pond is 97.5~99.1%, the maximum temperature difference between the surface and bottom is close to 1.2°C; Temperature uniformity in the test pool is 98.8~99.8%, the maximum temperature difference between the surface and bottom is close to 0.5°C, change is more stable and uniform by means of comparing with the control pond, experiment pond water temperature is basically consistent and its uniformity is significantly higher than that of control pood, because increasing oxygen based on the wind and solar complementary electricity generating stable operation makes test pond bottom water and surface water effectively exchanged, in order to enhance the water temperature stability. This illustrates that the use of increasing oxygen based on wind and solar complementary electricity generating can improve the water temperature uniformity, reduce difference in temperature between water surface and bottom. In a breeding cycle, to temperature test pond and control pond were respectively record, as shown in Fig. 4.

The value of pH: The breeding cycle, test and control pond pH value in 7.6~8.8 and 7.6~9.8, which shows the experiment pool pH value changes are stable, while the control pond is severe. Especially in the first 7~9 weeks, control pond pH value has remained at more than 9, reached a maximum of 9.8; while the test group pH has been change in a small range, namely 7.6~8.6, maximum value of no more than 8.6. Although in ninth weeks to control pond running benefits of water biological agent in order to regulate water quality, but played only a temporary regulation, only in the first 10~15 weeks pH variation is relatively stable, but the amplitude is also more experimental pond in. And from 16~18 weeks, pH value significantly again became concussion and experimental pond pH value change has been a slight concussion, reason is in the first 16~18 weeks, with continuous overcast and rainy day, Tong 2 although timely actuate the aeration system, but compared with the test value of pH changes in amplitude or larger pond. This illustrates the use of scenery complementary power supply oxygen system can effectively control and reduce pH value range, which is maintained at a low level. The change of pH value as shown in Fig. 5.

Nitrite: Throughout the 18 weeks of the breeding period, the 1~7 weeks, 2 ponds of nitrite content in

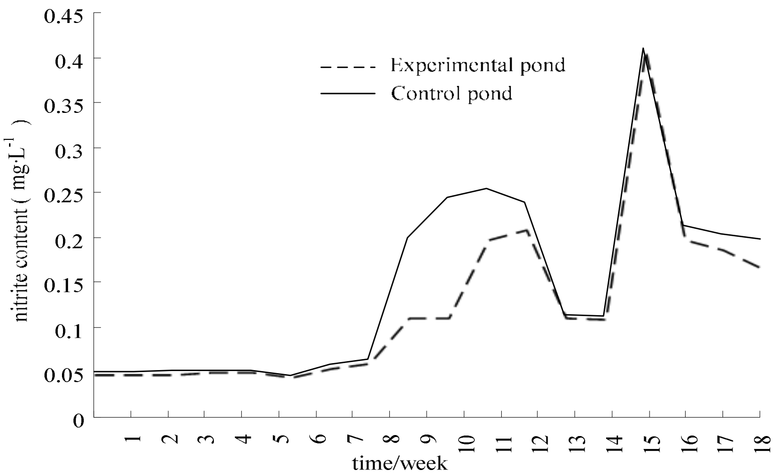

Fig. 6: Curves of temperature uniformity, pH and nitrite content

water is less than or equal to 0.06 mg/L, relatively low value. The reason is the breeding early fry growth slow, eat less and less, the bait, produced faecal less, nitrite decomposes to produce no more. After seventh weeks, 2 pond water nitrite content were increased and in eleventh weeks and 12 weeks up to a maximum of 0.25 and 0.21 mg/L and compared with control pond, pond water low content of nitrite test. 2 ponds water nitrite content were performed at eleventh weeks and 12 weeks later began to decline, in the fourteenth weeks were up to 0.12 mg/L, but at fifteenth weeks and increased and reach the breeding cycle in a maximum of 0.41 mg/L and then were began to decline, until the breeding cycle at the end of test pool of nitrite content in water is close to 0.17 mg/L; reason is in the fifteenth week of prawn caused when the algae die section and the nitrite content and planktonic algae have a relationship. However, the control pond in Fourteenth weeks after the start of continue to rise, although due to fishing shrimp nitrite content also decreased at fifteenth weeks, also reach the breeding cycle in a maximum of 0.41 mg/L, in Eighteenth weeks when the content of 0.21 mg/L, but are generally experimental pond to high. Indicates the use of scenery complementary oxygen system can effectively regulate the nitrite content in water and is maintained at a low level. Nitrite content of contrast variation curves in Fig. 6.

On growth, survival rate and yield, quality analysis: In 18 weeks the breeding cycle, test ponds of Litopenaeus vannamei happen without disease, growth of normal; at fourth weeks, the control ponds of Litopenaeus vannamei happened by Taura virus "red body disease" and took the drug treatment. Show experimental pond scenery complementary aerator system oxygen increasing effect compared to controls, mechanical aeration effect is good, water is also compared to the control pond, thus effectively reducing the occurrence of disease risk. In the breeding of thirteenth weeks, from experimental pond and pond are respectively controlled random fishing 20 shrimp and measurements of body length, the result is experimental pond shrimp obviously than control pond and the average body length than the control pond long 1.35 cm. Culture after the end of test and control pond, pond harvest shrimp specifications are, respectively 93/kg and 111/kg tail.

Test group and control ponds of Litopenaeus vannamei final harvest yield were 3735 and 3102.0 kg, test group than control pond production 633.0 kg.

Based on reference on Litopenaeus vannamei survival rate were measured, the test pool 52.6%, control pond is 50.6%, the test group compared to the control ponds of Litopenaeus vannamei survival rate 2% higher than the control pond.

Control pond shrimp body appendage portion of a red or brown, with rough and black, color dark, carapace black phenomenon; and experimental pond shrimp body appendage intact, smooth milky white color is light green, grey, normal color, color is translucent, smooth shell, shell is thick and hard, on a small amount of brown spots and has black spots, black; cooked taste after the discovery, control pond shrimp shell portion of meat is loose, shrimp meat less brittle, less sweet and slightly, the mud taste, while the experimental pond shrimp body plump, shrimp meat tissue close and firm, elastic, shrimp meat crisp, still a little sweetness and compared with the control pond, taste better.

Energy saving effect and economic benefit analysis of drugs: From fry stocking to receive shrimp and clear pond, a breeding cycle of 123 d (18 weeks). In the breeding process, test and control pond of the total power consumption were 0 and 8695.0 kW ·h; the local price to be 0.68 RMB/kW·h, respectively 0 and 5912.6

Table 1: Comparison of drug costs (RMB)

Name	Experimental pond	Control pond
Quick lime	390.0	390.0
Bleaching powder	380.0	380.0
Tea bran	150.0	150.0
Glucose	190.0	190.0
Benefits of water biological agent	80.0	590.0
Amino acid fertilizer paste	700.0	900.0
Substrate modifying agent	—	680.0
Povidone iodine	—	320.0
Other	300.0	510.0
Total	2190.0	4110.0

Table 2: Comparison of input and output (RMB)

		Experimental pond	Control pond
Produce		67230.0	55836.0
Expend-iture	Charge for electricity	0.0	5912.6
	Fry	5280.0	5440.0
	The fees	2190.0	4110.0
	Bait	24052.0	28588.0
	Rent	300	300
	Labor cost	3000	3000
Total		32408.0	8486.0

yuan for electricity expenditure. To sum up, test group compared to the control pond with n little 8695.0kW·h, save 100% of electricity, reduce expenditure of charge of electricity 5912.6 RMB.

According to the practical farming, Table 1 for the 2 Tong drug usage. Table 1 shows that the control pond, drug costs a total expenditure of 4110 RMB, experimental pond drug costs a total expenditure of 2190 RMB, 1920 RMB less than the control pond and saving the cost of 46%.

According to the in the breeding process of the feed conversion rate of Test control pond, the bait is respectively 3436 kg and 4084.0 kg, stocking shrimp shrimp harvested into smaller relative, calculation is ignored, the feed utilization coefficient were 0.92 and 1.32, the Tong food conversion rate higher than the control. Bait by market price 7 RMB/kg calculation, experimental pond bait for a fee of 24052 RMB, the control pond bait for a fee of 28588 RMB, experimental pond to save food expenses 4536 RMB, saving rate is 15.9%. In summary, experimental pond than the control pond feed utilization coefficient is low and high conversion rate, less food residual.

Finished product of Litopenaeus vannamei by 100 end/kg market price of 18 RMB/kg calculation, fry by market price 80 RMB/thousand tail calculation. Two ponds were rent for 300 RMB, 3000 RMB reward for artificial. The actual test pond farming income is 32408 RMB, while the control pond is 8486 RMB, increase income 23922 RMB, income increase rate of 282%. Input and output is shown in Table 2.

CONCLUSION

In this study, the wind and solar complementary power supply is put into use in increasing oxygen system of aquiculture and carried through experiment and analysis for Litopenaeus vannamei in a breeding cycle. With the field operation, the following conclusions are obtained:

- Wind and solar complementary increasing of oxygen system could stablly and reliablly run, effectively improve the fishpond water environment and makes the dissolved oxygen, temperature, pH value and nitrite and so on, water environment factors, stablly and uniformly change
- In a breeding cycle, in test ponds, Litopenaeus vannamei did not appear disease, growth condition was normal. Litopenaeus vannamei of test pond and control pond were respectively caught 93 and 111 end/kg; Survival rates of Litopenaeus vannamei for test pond and control pond were respectively 52.6 and 50.6%. Moreover, survival rate for test pond was obviously higher than the control pond; production was more 633.0 kg test pond than the control pond; And quality of Litopenaeus vannamei in test is obviously better than the control pond
- After comparing with the traditional mechanical increasing oxygen mode, the increasing oxygen system makes full use of wind and solar energy, saves energy. Electricity consumption is less 8695.0kW·h test pond than control pond, electrical energy saving is 100% and energy-saving effect is very obvious; saving expenses for medicine is 46%, the system improves the utilization rate of pesticide; Utilization factor of fish bait is lower test pond than control pond and percent conversion is higher lower test pond than control pond; Increase of cultivation income is more 23922.0 RMB test pond than control pond

To sum up, increasing oxygen system based on wind and solar complementary is applied in aquaculture, which could effectively improve water quality, save electric energy, reduce breed cost, raise yield, increase income, so as to provide a green, ecological aquaculture new thought and method. The increasing oxygen method has higher practical application value.

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REFERENCES

Bing, S., D. Zhao and X. Liu, 2011. Intelligent monitoring system for industrialized aquaculture based on wireless sensor network. T. Chinese Soc. Agr. Eng., 27(9): 136-140.

Cheng, B., Y. Liu, H. Yang and G. Xiyan, 2011. Performance of shrimp recirculating aquaculture system with copper polluted water. T. Chinese Soc. Agr. Eng., 27(2): 248-254.

Cheng, P., J. Li and H. Lan, 2012. Modeling and simulation analysis on the ship power system with new energy. J. Converg. Inform. Technol., 7(15): 313-320.

Chongwu, G., H. Liu and H. Song, 2012. Oxygenation effect of wave aerator on shrimp culture. T. Chinese Soc. Agr. Eng., 28(9): 208-212.

Fan, Z., Z. Cai and M. Yang, 2010. Capacity allocation of rural hybrid generating system based on stochastic chance constrained programming. T. Chinese Soc. Agr. Eng., 26(3): 267-271.

Guodong, Y., S. Yang and J. Li, 2012. Increasing oxygen system based on solar energy and runing effect. T. Chinese Soc. Agr. Eng., 28(13): 191-198.

Jian, G., M. Tao and L. Xingguo, 2011. Energy-saving technology for pond mechanical aeration based on oxygen mass transfer. T. Chinese Soc. Agr. Eng., 27(11): 120-125.

Lixin, Z., R. Liao and X. Hu, 2011. Application of water circulation oxygenation purifying device technology based on natural. Beijing Water, 10(5): 12-14.

Mengchun, H., Y.C. Zhang and W.L. Wang, 2012. Structure and functioning of a aerated water treatment system powered by photovoltaic/wind energy in Slender West Lake. Chinese J. Environ. Eng., 6(1): 21-25.

Mengchun, H., Y.C. Zhang, W.L. Wang and X.Y. Tang, 2010. Wind and solar energy powered water purification system of aerobic biological contact oxidation. J. Ecol. Rural Environ., 26 (Supp. 1): 30-33.

Rongjin, Z., W. Sun and J. Zhang, 2011. Field test building design for controlled aquaculture based on renewable energy heating system. T. Chinese Soc. Agr. Eng., 27(10): 218-221.

Tao, L., D. Shangfeng and D. Nan, 2010. Development of intensive aquaculture distributed control system. T. Chinese Soc. Agr. Eng., 26(Supp. 2): 298-301.

Wang, J., 2012. The study on transfer technology of the lowcarbon and environment-friendly based on game theory. J. Converg. Inform. Technol.,7(2): 225-231.

Wang, J., Z.L. Liu and C. Yan, 2012. Comparative analysis of economic efficiency of grain storage by solar absorption refrigeration. Adv. Inform. Sci. Serv. Sci., 4(14): 341-348.

Wang, T. and X. Zhang, 2012. Driving control study of solar energy vehicle. J. Converg. Inform. Technol., 7(10): 224-230.

Xiangwen, D., S. Zhang, X. Sun and Z. Wanli, 2010. Experimental study on applying biofan to cultivate Penaeus vannamei. T. Chinese Soc. Agr. Eng., 26(8): 130-135.

Xing, L., B. Shan, M. Xu, 2012. China's CO2 emission scenarios to meet the low carbon goals by 2020. Adv. Inform. Sci. Serv. Sci., 4(14): 320-326.

Xingguo, L., L. Zhaopu, W. Pengxiang and L. Miao, 2009. Aquaculture security guarantee system based on water quality monitoring and its application. T. Chinese Soc. Agr. Eng., 25(6): 186-191.

Xu, R.L., X. Xu and X. Hou, 2012b. A prediction model for wind farm power generation based on genetic-neural network. J. Converg. Inform. Technol.,7(14): 11-19.

Xu, S., X. Ling and H. Peng, 2012a. Simulation on the plate-fin thermal storage in a new desalination system. J. Converg. Inform. Technol., 7(13): 387-395.

Yang, W., H. Geng and K. Shi, 2010. The mining of dynamic information based on P-sets and its application. Int. J. Adv. Syst. Sci. Appl., 10(2): 234-240.

Zhongliang, N. and Z. Qiang, 2009. Design of maximum power point tracking controller of solar purification device of water. Microcomput. Appl., 30(9): 65-69.

Zhongliang, N., H. Liu and C. Wang, 2011. Research of solar water purifying system based on AVR. Electron. Meas. Technol., 34(9): 5-8.