Device for efficient gas transfer (bubble generation) suitable for aquaculture aeration

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Abstract
Using numeric simulations (CFD) and experimentation, the Group of Fluid Mechanics in the University of Seville has developed a new device based upon cross-flow which permits the generation of bubbles with a diameter less than 100 microns. Elastic membranes disposed along the flow avoid clogging problems. The aim of this equipment is to improve the efficiency of separation by flotation, industrial gasses dissolution and other chemical or biological processes for liquid-gas transfer.
The cross-flow technique allows the generation of bubbles with a size much smaller than that of the current membrane diffusers (tubular or disc). This reduction is possible because bubbles detach much earlier than when there are only gravitational and surface tension forces (Forrester et al.). By means of this technique it is possible to obtain bubbles less than 50 microns diameter, operating at pressures below 1 bar (Wace et al.). These devices are also easily scalable because there are no other limitations than the constructive ones. In this sense, we have already built a device which operates with injected gas flow up to 0,3 l/min.

Introduction
This technology, based upon a patent exploited by the company Drops & Bubbles Tecnología SL, can be used in two applications: a) oxygenation of open cultivation tanks for growing fish in aquaculture and b) oxygenation of cultivation tanks for fry also in aquaculture (nurseries and hatcheries). Both systems are at present time being tested at industrial level among the tasks due in the Life+ Project AQUASEF which is being carried out in Ayamonte, Huelva (Spain).

a) Oxygenation of open cultivation tanks for growing fish in aquaculture

Material and methods

Figure 1 shows a picture of the aerator device before immersion in the raceway and other at the beginning of the immersion operation. Among the main characteristics of this device, it should be mentioned: decrease in energy consumption, saving in operative costs (for not using pure oxygen), mixture of great volume of water, it does not demand high pressures of water and air, it has an efficient system to avoid clogging, materials used for its making are very durable and resistant, it is designed to be easily installed and uninstalled which facilitates maintenance tasks.


Figure 1. Aereator for aquaculture (growing phase)

Results and discussion

This oxygenation system achieves high efficiency in the aeration operations held in the growing tanks of aquaculture facilities: € per Kilogram of O_2 transferred to the water in the raceway. In Figure 2, costs associated to transfer tests in fresh and salted water are compared with those of systems nowadays in use. Figure 3 shows results of aerations tests according to a standard procedure described in the norm ASCE-1992

Cost comparison (€/Kg O_2)
D&Btech Devices vs Competitors

	Dissolved O2 mg/l	O_2BTech	Competitors (air)	Competitors (liquid O_2)
Fresh water at 20ºC	6,0	**0,06**	0,25	0,26
	7,0	**0,09**	0,37	0,26
	8,0	**0,18**	0,71	0,27
Salted water at 23ºC	4,0	**0,07**	0,34	0,26
	5,0	**0,10**	0,51	0,24
	6,0	**0,19**	0,97	0,24

Figure 2. Oxygen transfer data using air and pure oxygen

Name	Qair (l/min)	Qwater (l/min)	ΔPg (mbar)	W_air (W)	W_water (W)	W_total (W)	SAE_T (Kg/KWh)	SOTR (g/h O_2)	SOTE (%/m)
D&B 6.0	30	60	37	10,0	1,3	11,2	5,7	64	7,4
	30	90	38	10,0	2,7	12,7	5,8	73	8,4
	30	120	39	10,1	4,1	14,2	5,2	74	8,5
	20	40	22	6,1	0,4	6,6	7,2	47	8,1
	20	60	27	6,3	0,9	7,2	7,3	52	9,0
	20	80	28	6,3	1,3	7,6	7,2	55	9,5

Figure 3. Aeration tests in fresh water at 1,5 m depth. SAE_T: Standard Aeration Efficiency / SOTR: Estandar Oxygen Transference Rate / SOTE: Standard Oxygen Transference Efficiency

b) Oxygenation of cultivation tanks for fry in aquaculture

Material and methods

In Figure 4 the oxygen diffuser is shown in action. Main features about this device are: liquid may be fed from an outer intake or recirculating liquid present inside the tank, it has an effective system which avoids clogging by particles in suspension (valve with timer), it allows to obtain bubbles within a range of volume just acting on gas and liquid flows, it works at low pressure for both fluids

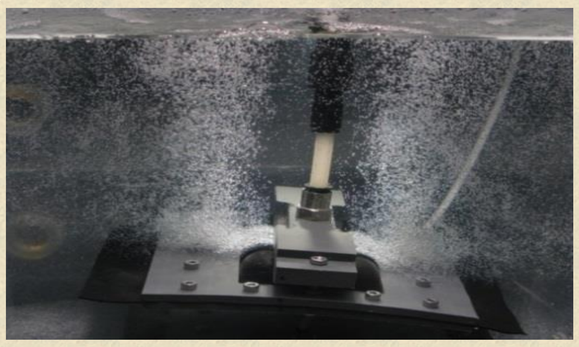


Figure 4. Difusser for aquaculture (fry growing)

Results and discussion

Figure 5 shows the numeric characterization of main parameters involved in the oxygen transfer operation: flow, pressure and bubbles size
Maximum gas flow: Q_g = 8 l/min
Water flow: mixture rate between 0,5 and 12 times that of the gas
Working pressure:
Gas: P_g < 1 bar
Liquid: P_l < 0,3 mH_2O

Q_g (l/min)	3,00	1,36	1,23	0,83
Q_l (l/min)	1,80	2,20	2,60	3,40
Mixture rate	0,60	1,62	2,12	4,08
Average diameter (mm)	0,33	0,35	0,60	0,25
Standard deviation	0,13	0,14	0,11	0,04
Maximum diameter	0,61	0,60	0,76	0,32
Minimum diameter	0,19	0,22	0,47	0,20

Figure 5. Bubbles size for different working regimes

References
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