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Researches on water aeration

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Abstract
The aim of the paper is to present the results of the theoretical and experimental researches on the operation of a porous diffuser (PD) with elastic membrane. For different airflows rates injected into the water, the air pressure loss through the porous diffuser is determined; the variation of the dissolved oxygen concentration in water, in time is theoretically and experimentally established.

Keywords: *Water Aeration, Porous Elastic Membrane Diffusers.*

1. Introduction

Water aeration is required when water is affected by anoxic conditions, usually caused by adjacent human activities such as wastewater discharges from agriculture, or overexploitation of fishing lakes.
As in the practice of water and waste water engineering, the gas phase is usually the air; the gas transfer is also called aeration.
Aeration can be accomplished by introducing air at the bottom of the lake, lagoon or basin by stirring at the surface from a well or by spraying with a device to allow the exchange of oxygen to the surface and to release the noxious gases such as carbon dioxide, methane or hydrogen sulfide.
Dissolved oxygen (DO) is a major contributor to water quality. Not only fish and other aquatic animals need it, but breathed oxygen by aerobic bacteria decomposes organic matter. When oxygen concentration decreases, anoxic conditions may develop and may reduce the ability of the water body to sustain life.
Oxygenation equipment's are based on the dispersion of one phase into the other, for example liquid into gas or gas into liquid, an energy consuming process [1] [2].
Oxygen diffusion in water, as well as the phase dispersion, is the most important factor to consider in designing and building stages of oxygenation equipment's.
This paper is based on the study of the interphase mass transfer with the help of equipment's that generates fine air bubbles called porous diffusers.
The amount of oxygen transferred into water depends on the operating conditions and the physical properties of the liquid, such as density, viscosity and superficial tension, studied in numerous papers in the field [3] [4].
The dependence of the void fraction (ε) and the volumetric mass transfer coefficient (ak_L) on the surface tension of the aqueous solutions are also reported in the literature [5] [6].
The purpose of this paper is to study the operation of a porous diffuser in an installation for experimental researches on water aeration. The porous diffuser has an elastic membrane of Etilen-Propilen-Dien-Monmer (E.P.D.M) with orifices with Ø <1 mm.

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2. Presentation of the constructive solution of the porous diffuser with elastic membrane E.P.D.M.

Fig. 1 Plastic ring for fixing the elastic membrane.

The elastic membrane made of E.P.D.M. [7] which has many orifices for the introduction of air in water is presented in figure 2.

Fig. 2 Elastic membrane of E.P.D.M..

Fig. 3 General view of the porous diffuser
1 - elastic membrane fastening ring; 2 - elastic membrane.

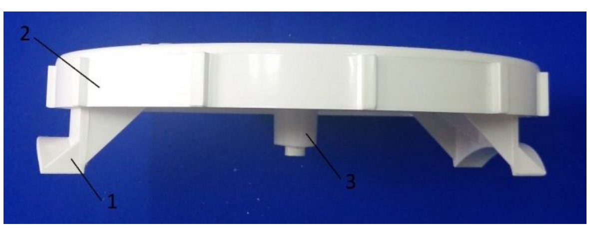


Fig. 4 Side view of the porous diffuser
1- support; 2 - elastic membrane fastening ring; 3 – air inlet.

The elastic membrane contains more than 1000 rectangular shaped orifices; a single orifice was measured using a modern OLYMPUS BX51M microscope [8].
The shape of the orifice is shown in figure 5.

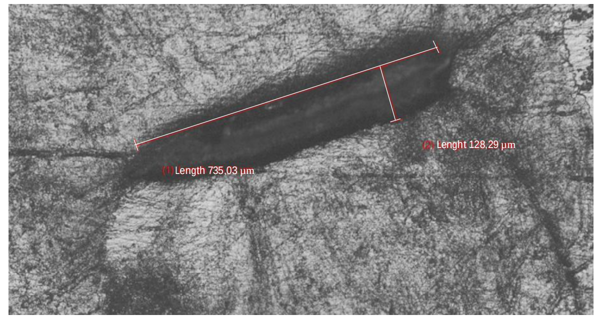


Fig. 5 View of the orifice in the porous diffuser.

The dimensions of the orifice, approximated as a rectangle, are:

$$L \times l = 735.03 \times 128.29 = 94296.998\ \mu m^2$$

The equivalent diameter of the orifice will be [9]:

$$d_e = \frac{4A}{P} = \frac{4 \cdot 94296.998}{2(735.03 + 128.29)} = 218.45\,\mu m = 0.21845\, mm \qquad (1)$$

The value of this diameter falls within the operating range of bubble generators, which emit fine bubbles [8].

3. The equation of oxygen transfer speed to water

The oxygen transfer rate to water is given by the equation [2] [3]:

$$\frac{dC}{d\tau} = a \cdot k_L (C_s - C) \left[\frac{kg}{m^3} \cdot \frac{1}{s}\right] \qquad (2)$$

where:
ak_L – volumetric mass transfer coefficient [s^{-1}];
C_s – mass concentration of oxygen in water at saturation [kg/m^3];
C_0 – initial mass concentration of oxygen in water [kg/m^3].
Equation (1) indicates the modification of oxygen concentration in time, as a result of molecular diffusion of O_2 from the area with high concentration to the area with low O_2 concentration.
From equation (1) it is noted that to increase the transfer speed O_2 to water, the following are required:
I. the increase of k_L and C_s
II. the decrease of C_0
The conditions I and II are given in Table 1.

Table 1: Solutions for increasing dC/dτ

No.	The purpose	Theoretical solution	Practical solution
1	The increase of a	The decrease of the gas bubble diameter	The decrease of the FBG orifices diameter
2	The increase of k_L	The turbulence enhancement	Rotating the FBG Using mobile

3	The increase of C_S	The increase of the O_2 concentration into the water	Introducing air, oxygen and O_3 into water
4	The decrease of C_0	Minimum values for C_0 depending on the nature of the microorganisms present in the water	Decrease of the initial water temperature Introducing substances that reduce C_0

By the numerical integration of equation (2) and with the initial data $C_0 = 5.1$ mg / dm^3, $t_{H_2O} = 23^o C$, $C_s = 8.6$ mg/dm^3, $\tau = 45$ ' a computing program can be obtained resulting the theoretical function $C_{O_2} = f(\tau)$.

4. Experimental researches

The objectives of the experimental researches are:

4.1 Determining the pressure loss (for different airflows) that occurs when the compressed air passes through the "dry" elastic membrane (i.e. located outdoors)

Subsequently, the pressure losses for the "wet" membrane (the membrane inserted into the water tank).

Figure 6 shows the scheme of the experimental installation; after commissioning the compressor (5) the air flow rate and the pressure (7) were measured at the entrance at the porous diffuser. In this case, there was no water in the tank, so the pressure loss for the "dry membrane" is established.

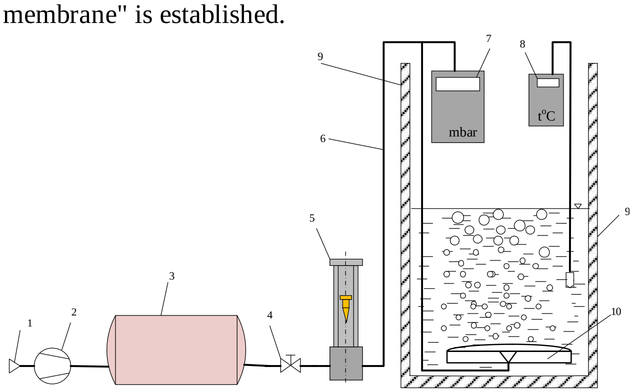
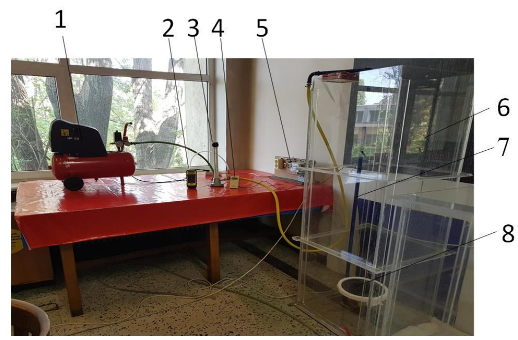


Fig. 6 Measuring scheme for the operation of the porous diffuser with elastic membrane
1 - air filter; 2 - electro compressor; 3 - air tank; 4 - pressure reducer; 5 - rotameter; 6 - compressed air pipe; 7 - digital indication manometer; 8 - digital thermometer; 9 - water tank; 10 - porous diffuser.

a)



b)

Fig. 7 Porous diffuser inserted into the water tank
a) Diffuser view
1 - porous diffuser; 2 - the compressed air supply pipe; 3 - water tank
b) Overview of the experimental installation
1 - electro compressor; 2 - digital manometer; 3 - rotameter; 4 - digital thermometer; 5 - 220 V current source; 6 - plastic water tank; 7 - compressed air pipe; 8 - porous diffuser with elastic membrane inserted into the tank.

For different flows rate resulted the pressure losses Δp, shown in Table 1. Thereafter, water was introduced into the tank (H = 500 mmH_2O) and the pressure drops for the "wet" membrane was measured; the air flow rate remained the same and the experimental results are shown in Table 2.

Table 2: Air pressure drops through the elastic membrane porous diffuser

No.	„dry" membrane		„wet" membrane	
	$\dot{V}$[dm^3 / h]	Δp [mbar]	$\dot{V}$[dm^3 / h]	Δp [mbar]
1	400	1.47	400	575
2	600	2.11	600	61.1
3	800	2.70	800	62.40
4	1000	3.79	1000	64.50
5	1200	4.92	1200	66.30
6	1400	5.86	1400	68.20
7	1600	7.58	1600	71.80

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Based on the data in the table, the curves in figure 8 for the two cases were plotted.

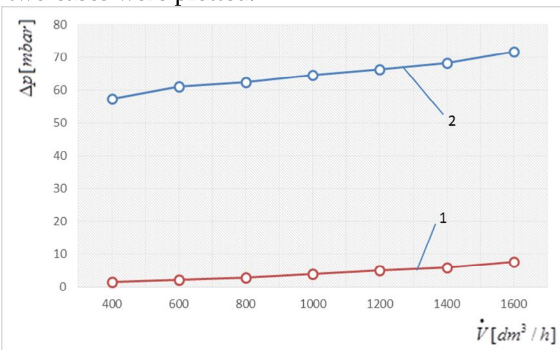


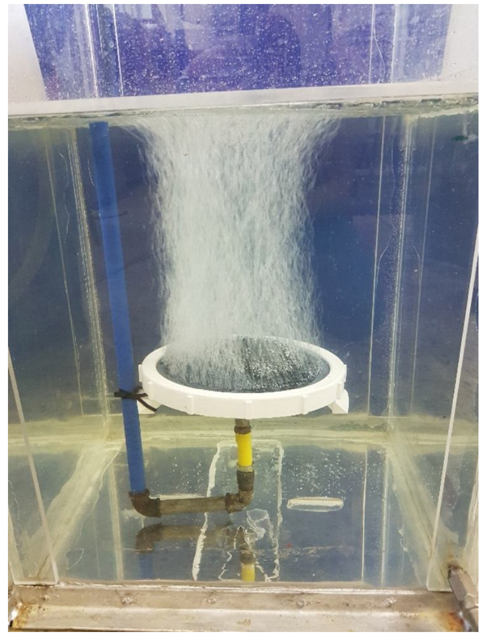
Fig. 8 Graphical representation of the function $\Delta p = f\left(\dot{V}\right)$

1- for „dry" membrane; 2- for „wet" membrane

The values of Δp in Table 1 are similar to those in the literature [10] [11].

Figure 9 shows the operation of the porous diffuser, the elastic membrane having Ø 229 mm.

a)



b)

Fig. 9 Air bubbles column generated by the porous diffuser

a) $\dot{V} = 1400\,dm^3/h$, b) $\dot{V} = 1600\,dm^3/h$

4.2 Experimental determination at operation of the porous diffuser of the increase in dissolved oxygen in water

For the determination of the increase in the dissolved oxygen concentration in water the following shall be measured:

• Water temperature t = 22.5 ^{o}C and from [12] results the saturation concentration C_s = 8.6 mg/dm^3.

• Initial concentration of dissolved oxygen in water C_0 = 5.10 mg/dm$^{3.}$

• The time is noted at which the experience begins and from 15 ' to 15' the concentration of dissolved oxygen in water is measured by the electrical method [13].

Figure 10 shows the oxygen probe introduced into the tank, which is displaced at a rotational speed of 0.3 m/s; the rotation is provided by an electromechanical mechanism placed on a platform mounted above the tank [12].

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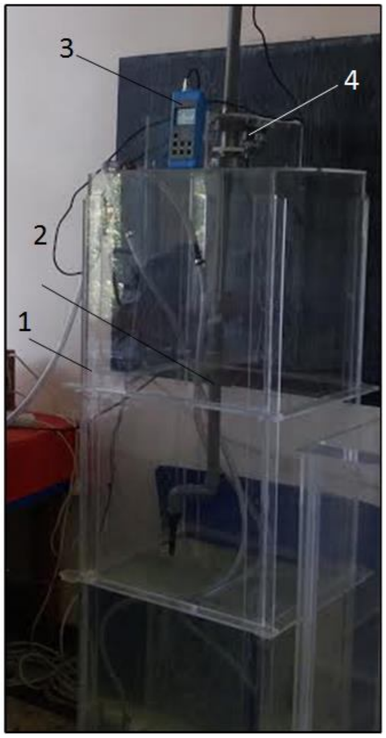

Fig. 10 Water tank with the oxygenometer sensor probe inserted into it
1 - water tank; 2 - oxygenometer probe; 3 - digital indicating oxygenometer; 4 - oxygenometer probe actuation mechanism

As a result of the measurements, data from Table 3 were obtained.

Table 3: Values of dissolved oxygen concentration in water

τ [min]	0	15	30	45
C_{O2} [mg/dm^3]	5.10	6.94	8.19	8.6

Based on the data in Table 3, the function $C_{O_2} = f(\tau)$ was graphically represented (Figure 11).

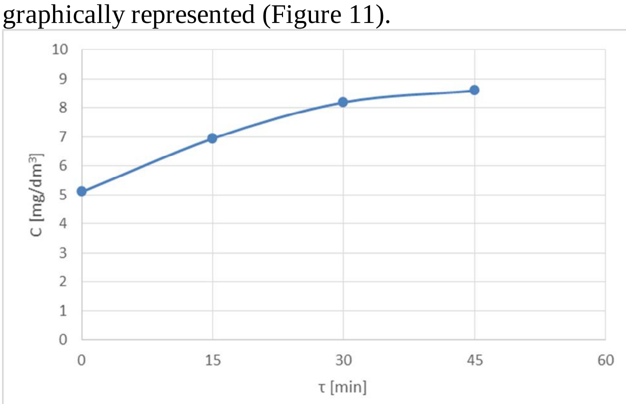

Fig. 11 Graphical representation of the function $C_{O_2} = f(\tau)$

The obtained results are similar to those in the literature [14] [15] [16].

5. Conclusions

1. Porous diffusers with EPDM membranes have a long service life, are shock-resistant, maintenance-free.
2. Elastic membrane porous diffusers have a simple construction, increased operational reliability.
3. The orifices of the perforated membrane have a diameter of about 0.21 mm, which ensures the dispersion of the fine bubble air (Ø ≈ 1 mm).
4. Loss of air pressure through the elastic membrane porous diffuser is greater by 2-10 mmH_2O compared to FBG with perforated plate through spark-erosion.
5. The disadvantages of porous diffusers are:
- emit bubbles of different sizes;
- does not ensure a uniform dispersion of air in a water volume.

References

[1] N. Băran, Gh. Băran, G. Mateescu, "Research Regarding a New Type of Fine Bubble Generator", Journal of Chemistry, vol. 61, nr. 2, 2010, pp. 196 – 199.
[2] G.M. Mateescu, "Hydro-gas-dynamics of fine bubbles generators" (in Romanian), PhD Thesis, Politehnica University of Bucharest, 2011.
[3] G. Oprina, "Contributions to porous diffusers hydro-gas-dynamics" (in Romanian), PhD Thesis, Politehnica University of Bucharest, 2007.
[4] Gh. Băran, G. Oprina, I. Pincovschi, "Hydro-gas-dynamics of aeration systems equipped with fine bubble generators" (in Romanian), Politehnica Press Publishing House, Bucharest, 2013.
[5] I. Pincovschi, "Hidrodinamica sistemelor disperse gaz-lichid", PhD Thesis, Politehnica University of Bucharest, 1999.
[6] S.G. Georgescu, "Evolution D'une bulle de gase", These, Institut National Polytechnique De Grenoble, Avril, 1999.
[7] www.sanitarie.ro
[8] www.olimpus.ro
[9] Al. Dobrovicescu, N. Băran s.a, "The basics of Technical Thermodynamics, Elements of Technical Thermodynamics" (in Romanian), POLITEHNICA PRESS Publishing House, Bucharest, 2003.
[10] M. Constantin, N. Băran, G. Roza, "Theoretical and Experimental Research about the Pressure Loss of the New Type of Fine Bubble Generator", International Journal of Emerging in Management & Technology ISSN 2278 – 935, Volume 6, pp 115 – 120.
[11] Al. S. Pătulea, The influence of the functional parameters and of the architecture of the fine bubble generators on the efficiency of aeration installations (in Romanian), PhD Thesis, Politehnica University of Bucharest, 2012.

[12] M. I. Călușaru, "The influence of liquid physical properties on the oxygenation processes efficiency" (in Romanian), Phd Thesis, Politehnica University of Bucharest, 2013.

[13] Al. Pătulea, I. M. Călușaru, N. Băran, "Researches regarding the measurements of the dissolved concentration in water", Advanced Materials Research, Trans Tech Publications, Switzerland, vols 550 – 553, 2012, pp 3388 – 3394.

[14] M. K. Stenstrom, D. Rosso, "Aeration", University of California – Los Angeles, 2010.

[15] Gh. Băran, N. Băran, "Hidrodinamica bulelor generate de difuzori poroși", Journal of Chemistry, vol.54, nr.5/2003, pp. 436÷440.

[16] W.W. Eckenfelder, "Absorption of Oxygen from Air Bubbles in Water," J. Environ. Eng. Div. ASCE, vol 85, No SA4, pp. 89-98, 1989.

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