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THEORETICAL AND EXPERIMENTAL RESEARCH REGARDING THE WATER OXYGENATION THROUGH PIPES

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Abstract: *The research paper in the area of water oxygenation through the introduction of a new type of fine bubble generator. By the realization of 0.1mm holes, water insufflation is ensured by air bubbles with the diameter <0.1mm, such that the transfer of the oxygen into the water is intensified. Presenting an experimental equipment which highlights the growth of the dissolved oxygen into the water.*

Keywords: *Water oxygenation, transfer of the oxygen into the water, fine bubble generator.*

1. Introduction

Through water oxygenation is understood the transfer of the oxygen from the atmospheric air into the water, which is in fact a phenomenon of transfer of a gas into a liquid. The most common method for removing organic impurities under the action of an aerobic bacterial biomass is the introduction of the oxygen gas into the wastewater. The oxygen comes most commonly from the atmospheric air, in this case the process bearing the name of water aeration. [1][2]
Aeration can be done through several methods, respectively: by using mechanical aerators (e.g. turbine type) or pneumatic aerators (e.g. injection of the air at the base of the water volume), the latter being the most commonly used. Also, the oxygen needed for the aeration process can also be introduced into the water by the mixed method (mechanical and pneumatic)
To increase the concentration of the dissolved oxygen from the wastewaters, several types of air diffusion devices have been developed. These devices can be found as simple holes (they generate large air bubbles – most usually used in pipes), or as fine bubble generators. Due to the generators which can be made of different materials, of different shapes and sizes, the air diffusion devices are classified according to the diameter of the produced bubbles. Thus, there exist fine, medium and large bubbles generators. [3][4][5]
At the moment the aeration is done using three methods: with mechanical aerator, with pneumatic aerators, and mixed aerators. Pneumatic aerators are most often used. After the introduction of the oxygenation processes with active mud, different types of air diffusion were created, tried and developed in order to increase the dissolved oxygen concentration from the wastewaters. These devices are either in the form of simple holes in pipes that generate large air bubbles or in the form of fine bubble generators. Due to the fact that the shape, material, and the material used to build the fine bubble generators differs, the air diffusion devices are classified and reported to the relative diameter of the produced bubbles. Thus there are fine bubble generators, medium bubble generator and large bubble generators. Fine bubble aeration is more efficient than large bubble aeration, because the specific area interfacial area between the two systems (air – water) is larger.
For the intensification of the phenomenon of mass transfer of the oxygen from the air, the realization of a maximum interphase surface is needed as a result of air bubbles with the minimum diameter. Theoretical and experimental research has been carried out for various constructive forms of fine bubble generators (G.B.F.) [6][7][8].

2. Presentation of a fine bubble generator

A F.B.G. is proposed where the dispersion holes of the air into the water are processed by micro-drilling. 152 holes of Ø 0.1 mm were realized in the plate. Figure 1 shows the plate with the holes.

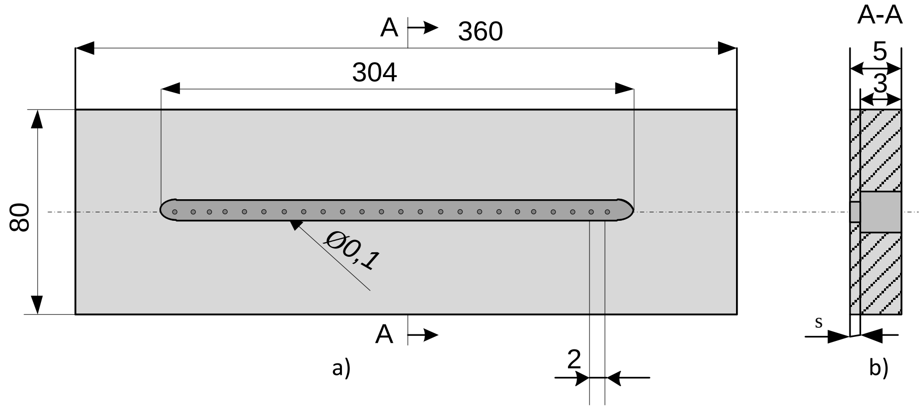

Fig. 1. Plate with holes as F.B.G.
a) Top view; b) cross section

To make the holes in the plate, a channel deep of 3mm, and a length of 304mm was created; a hole where the air comes out has a thickness of 2mm. Later with the help of a C.N.C (Computer Numerical Control), 152 holes with a diameter of Ø 0.1 mm were made in the channel.
The CNC equipment has a precision of ±0.5 µm, which assures the creation of an original F.B.G. solution
Figure 2 shows the constructive solution of F.B.G.

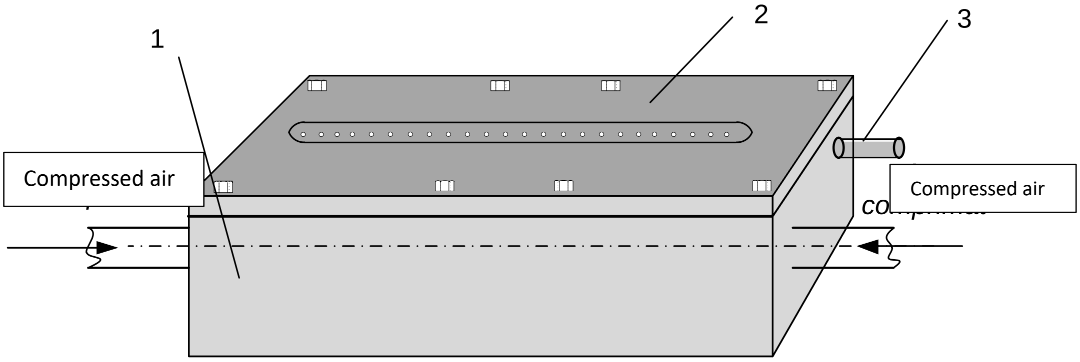

Fig. 2. Fine bubble air generator
1 – tank filled with compressed air; 2 – plate with holes;
3 – coupling for the measurement of the air pressure

When introducing an air stream into the water, the following aspects should be taken into account [9][10]:

- The kinetic energy of the gas stream is consumed to move the water particles.
- The outlet of the jet may have a circular or rectangular shape (square, rectangle);
- After leaving the initial section, the jet tents to retain its original section shape. [11][12] Thus:
- If the outlet is circular we will obtain a symmetrical axial jet;
- If the output section is a rectangle, the result will be a plane jet.

3. The experimental equipment

The same experimental equipment will be used for researches regarding the functionality of different types of fine bubble generators (F.B.G.)

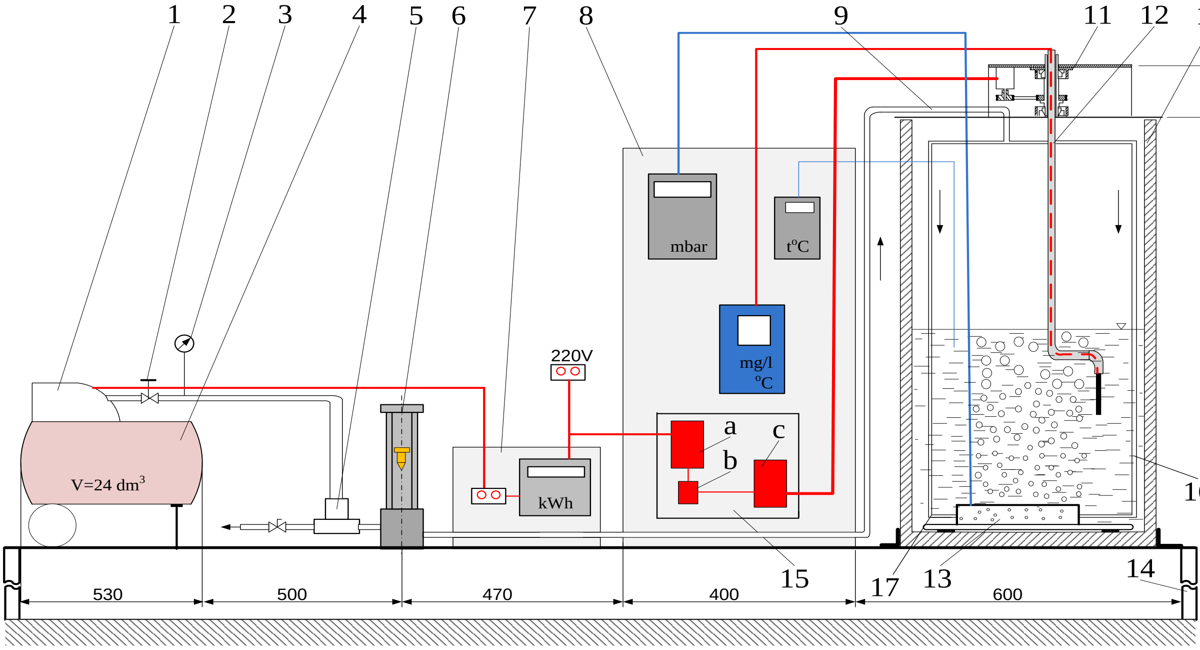

Fig. 3. Drawing of the experimental equipment for researches regarding the water oxygenation
1 – compressor with air tank; 2 – pressure reducer; 3 – pressure gauge; 4 – tank with compressed air V = 24 dm3; 5 – T coupling; 6 – flowmeter; 7 – electrical cabinet; 8 – panel with measuring devices; 9 – pipe for compressed air transportation; 10 – water tank; 11– probe drive mechanism; 12– Oxygen meter probe; 13 – F.B.G.; 14– equipment's stand; 15 – electronic command device: a – power supply, b – switch, c – command device; 16, 17 – compressed air pipes

4. The purpose and methodology of the research

Research objectives:
For a certain working regime, the concentration of dissolved oxygen into the water will be monitored as a function of time
The duration of the water aeration process will be established until the saturated concentration of dissolved oxygen in the water is reached.
Measurement involves the following steps [13][14][15]:
1. The 152 holes are checked if are working properly
2. The tank is filled with water la H = 500 mm H_2O;
3. CO, t_{H2O}, t_{aer} are measured;
4. The fine bubble generator (F.B.G.) is placed in the water, and the time (τ) is written down
5. Every 15 minutes, the F.B.G is pulled out of the water and the concentration of dissolved oxygen in the water is measured; [17][18]
6. When a horizontal line of the function (C = f (τ)) is reached, the measurements stops, with the condition that:
$C \approx Cs$;
7. From the previous researches [16][18], the concentration of the dissolved oxygen into the water tends towards concentration at saturation after a duration of two hours. The measurement of the oxygen's concentration will take place after 15 minutes; 30 minutes...120 minutes.
8. At the end of the measurements, the oxygen meter's probe is washed, and the water from the tank is flushed.

5. Experimental results

In the experimental equipment from figure 3, was mounted in position (13), F.B.G. mentioned above.
In figure 4 a fine bubble generator with 152 holes of Ø 0.1 mm each in diameter can be seen working.

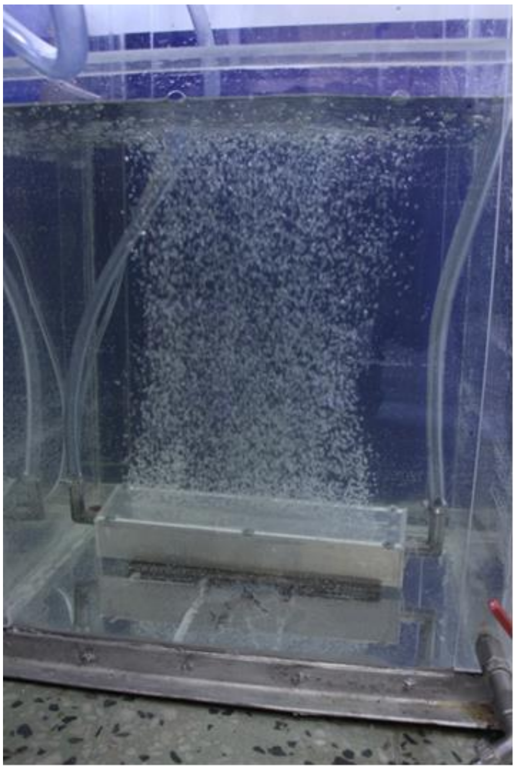

Fig. 4. F.B.G. with 152 holes

For experimental research, initial data is specified:

- The air flow introduced in F.B.G.: $\dot{V} = 600 dm^3/h$;
- Height of the water in the tank: H = 0.5 m;
- Air pressure in F.B.G.: p = 573 mm H_2O;
- Water temperature: t = 24 ^oC;
- Value of the concentration of dissolved oxygen into the water as initial value: C0 = 5,48 mg/ dm^3;
- Value of concentration at saturation: Cs=8,4 mg/ dm^3.

The data obtained after the experimental research can be found in table 1
OD – Dissolved oxygen in the water

Table 1: Experimental data obtained with F.B.G. of rectangular shape with 152 holes

Nr.crt	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
τ [min]	0	15	30	45	60	75	90	105	120
t_{H2O}[^{o}C]	23.7	23.7	23.7	23.7	23.7	23.7	23.7	23.7	23.7
t_{aer}[^{o}C]	24.1	24.1	24.1	24,1	24.1	24.1	24.1	24.1	24.1
OD[mg/dm^3]	5.48	7.39	7.85	8.01	8.26	8.30	8.35	8.37	8.39

Based on the data from table 1, the function was created: $C_{O_2} = f(\tau)$ from figure 5.

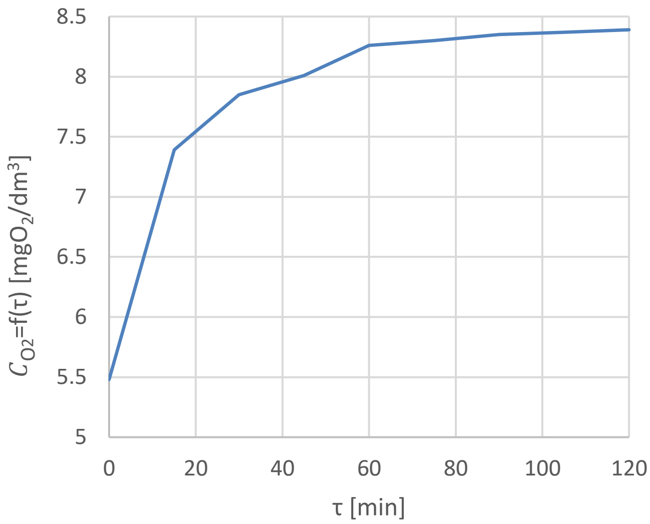

Fig. 5. Change of dissolved oxygen's concentration in the water, as a function of time

The experimental data obtained is similar with other results from the specialized literature [16][17][18].

6. Conclusions

This paper is of interest to a number of research engineers, PhD students, etc. who study in the field of water aeration.

The new findings consist of:

The F.B.G. which has very small holes (Ø 0.1 mm), is mounted, ensuring an efficient interfazic contact (air-water)

After functioning for two hours, the curb $C_{O_2} = f(\tau)$ is build, which shows that after the time interval, the saturation of concentrations of the dissolved oxygen into the water is reached Cs=8,4 mg/ dm^3 for a temperature of the water of 24^{0}C.

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