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Using Non-Conventional Technologies in Order to Build Fine Bubbles Generators

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ABSTRACT

The paper presents the manufacturing technology of a circular-shaped fine bubbles generator that can produce a column of fine bubbles. Manufacturing technology of the hole plate and of the generator body in which the plate is mounted are successively described. A non-conventional technology was used in order to manufacture the generator, namely the electro-erosion processing. Fine air bubbles are thus obtained, leading to the intensification of oxygen transfer to the water mass from a basin or tank.

GENERAL CONSIDERATIONS

Water aeration technologies have developed, through the time, from surface mechanical aerators to fine bubbles aerators; aeration technologies apply both to resting liquids and to flowing liquids with very small velocities ($w < 0.1$ m / s).

The aeration technologies follow both assurance of the oxygen necessary to the evolution of a biological process, if existent, and homogenization by mixing of the liquids containing different particles in suspension.

The mass transfer phenomenon from the oxygen in the air to the water in the purification station tanks or basins is used in the following cases:

- aeration of the residual waters from the purification stations;
- aeration of the waters from fountains, pools, piscines, basins for fish breeding;
- aeration of euthrophysed lakes.

The aeration plants work with air (21 % O_2, 79 % N_2) and in the most of cases the O_2 transfer to the water is looked; as consequence, in some papers [1] they are called oxygenation plants.

Aeration plants were built as consequence of elaboration of aeration technologies. These plants can be classified following the two criteria:

A. According to the destination:

→ aeration plants that have as principal purpose the oxygen transfer to liquids; in this case appear problems about the transfer velocity, the surface between the gas and the liquid, etc.;

→ aeration plants that follow the impulse transfer from the gas jet to the liquid mass; here there are problems regarding the induced movement, the maintenance in suspension of the particles from the liquid etc.

B. According to the functional principle, the aeration plants are classified in:
I. pneumatic plants;
II. mechanical plants.

C. According to the air bubble dimension that intrude in the water mass from a tank or basin, the bubble generators are divided in
a. fine bubbles generators with diameter $d_b < 1$ mm;
b. medium bubbles generators with diameter $d_b = 1 \div 3$ mm;
c. large bubbles generators with diameter $d_b = 3 \div 120$ mm.

The bubble dimensions depend on the air output hole diameter, on the air flow and the air pressure from the distribution net.

The following materials are used in order to achieve the air spreading into water:

- porous diffusers made from ceramic material;
- syntherised glass;
- rigid, porous, plastic materials;
- plates manufactured from metal or from other materials in which fine holes are drilled;
- elastomer membrane, made from natural rubber or ethylenpropylene.

For an efficient oxygenation of waters, is necessary to assure a uniform spreading of the air in the whole water mass from a tank or basin; the air bubbles uniformly spread must assure the necessary of oxygen needed by the respective biological process.

The following subjects will be presented in continuation:

- the manufacturing technology of the drilled plates;
- the manufacturing technology of the fine bubbles generator body;
- the fine bubbles generator (FBG) regarded as a whole.

1. Manufacturing technology of the drilled plates

Due to the fact that, for a good oxygenation of waters, the diameter of the air bubbles blown in the water had to be as small as possible [1], [2], [3] it was decided to use holes ∅ < 1 mm; a hole diameter of ∅ 0.5 mm was employed in the present case.

The distance between two holes (s – network step) has to be larger than the double of the hole diameter (d_0): $s > 2d_0$.

The drilled plate presented in Figure 1 was initially designed. The following parameters were chosen: $s = 20 \cdot d_0 = 20 \cdot 0.5 = 10$ mm. The hole network is square-shaped; there are a total number of nine holes having diameters of ∅ 0.5 mm.

Hole placement (the net border) is limited by a circle with a diameter of 35 mm specified in the constructive solution of the FBG.

At the beginning, the holes ∅ < 1 mm were drilled using a laser plant, but the hole outlines did not result perfectly circular. Consequently, it was not possible to calculate flow rates or pressure drops related to these holes.

Another non-conventional technology was subsequently used, namely the electro-erosion processing [4]. The holes were manufactured using the AG 55L electro-erosion processing plant produced by SODICK (Figure 2).

A $50 \times 50\,\mathrm{mm}^2$ plate was cut from an aluminium sheet (Figure 3). The plate was fixed on a processing plant and the nine ∅ 0.5 mm holes were cut. A ∅ 35 mm circular disk was subsequently created by turning [4].

The essential element of a FBG is the hole disk, 4, which needs to satisfy the following conditions:

a. to be resistant at the action of the liquid with which enters in contact (residual waters, waters with special pH);
b. to allow the air uniform distribution with small pressure losses ;
c. to be easily cut (processed);
d. to have a high mechanical resistance, sufficient to resist at the weight of a water column of 4 ÷ 5 m.

The pressure loss when the air passes through the drilled disk can be evaluated as follows:
The drilled disk holes will be assimilated to *n* parallel capillary tubes. The pressure loss for a hole will be calculated in the following way [5]:

$$\Delta p = \sum \xi_i \cdot \rho_a \frac{w^2}{2} \qquad (1)$$

In this equation, the sum of the local pressure loss coefficients is made from sudden section variations [6]:
- when entering the hole ($s > 3d_0$): $\xi_i = 0.5$
- when getting out of the hole ($s > 3d_0$): $\xi_i = 1.0$

Thus $\sum \xi_i = 1.5$.

The air density ρ_a will be computed by considering an overpressure given by the height of the basin water (*h*).

The air flow speed through a hole having the diameter d_0 is equal to:

$$w = \frac{\dot{V}}{A} = \frac{\dot{V}}{\frac{\pi d_0^2}{4}} = \frac{4\dot{V}}{\pi d_0^2} \text{ [m/s]} \qquad (2)$$

where $\dot{V}$ is the air flow rate measured using a rotameter and divided by the number of holes (nine).

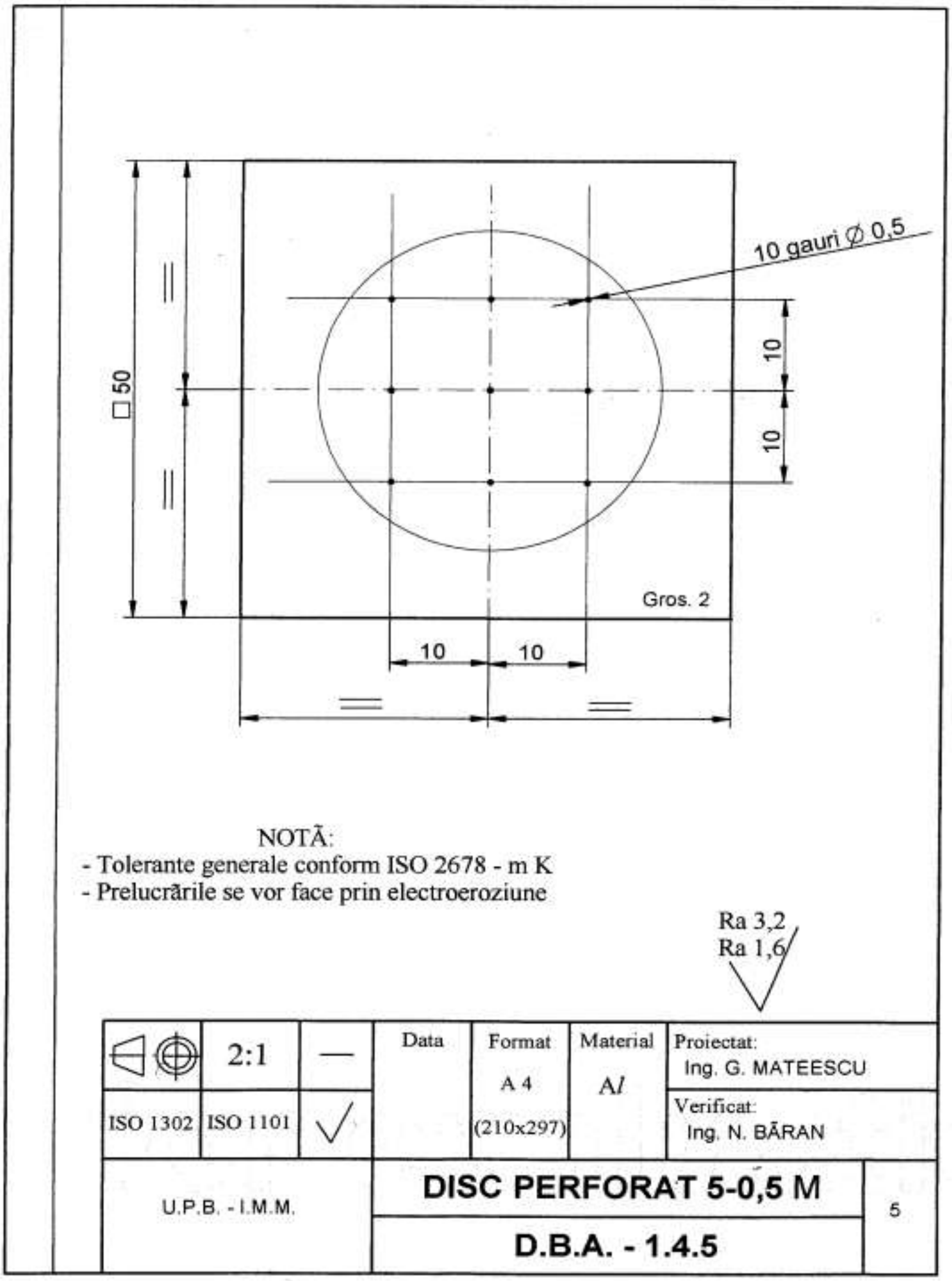


Fig. 1 The drawing of the drilled plate

Technical specifications

Data sheet	AG55L
X / Y / Z axis travel (mm)	550 x 400 x 350
Table dimension (mm)	750 x 550
Dielectric level (min - max, mm)	80 - 360
Max. workpiece weight (kg)	1.000
Max. electrode weight (kg)	50
Step resolution (mm)	0.0001
Max. positioning speed (mm/s)	5.0
Max. pulsation speed Z axis (m/min.)	36
Table - chuck distance (mm)	280 - 630
Controlled axes	4
Machine weight (kg)	6.440
C axis	
Resolution (°)	0.001
Rotational speed (min. – max. rpm, continuous)	20 - 2000

Standard features of the AG55L

- "SGF" Nano-Wear Discharge Unit
- Improved Ease of Operation
- NC operation panel
- Rise and fall work tank

Options of the AG55L

- High Precision Rotary Head, C axis
- Linear electrode changer Shuttle ATC
- Automatic tool changer (ATC)

Fig. 2. Electro-erosion processing plant type AG 55L and its technical specifications

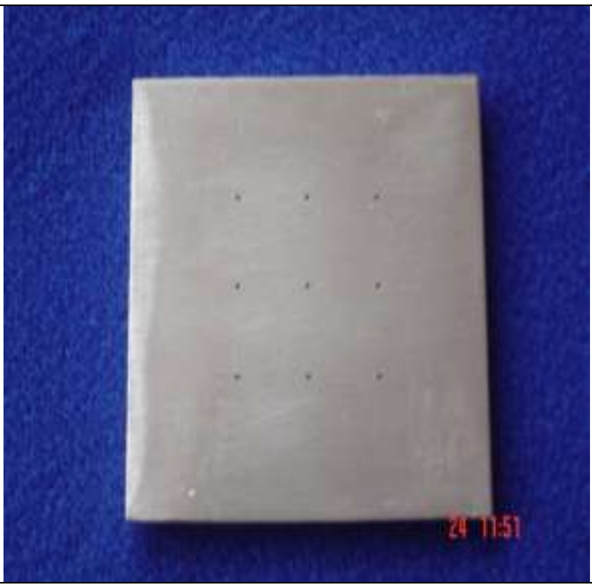
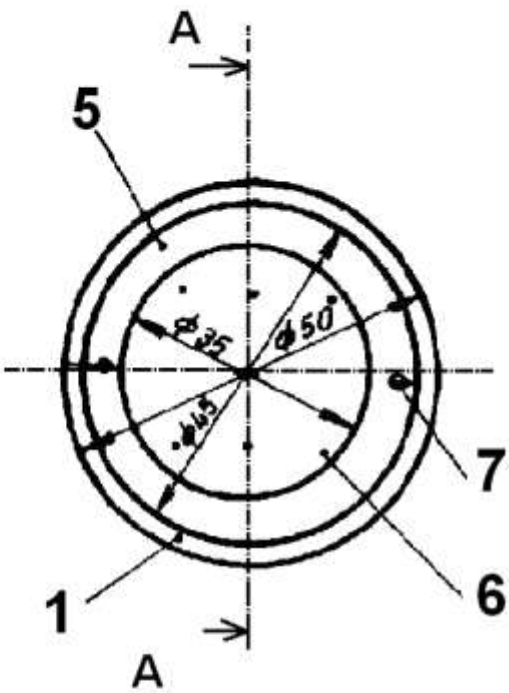
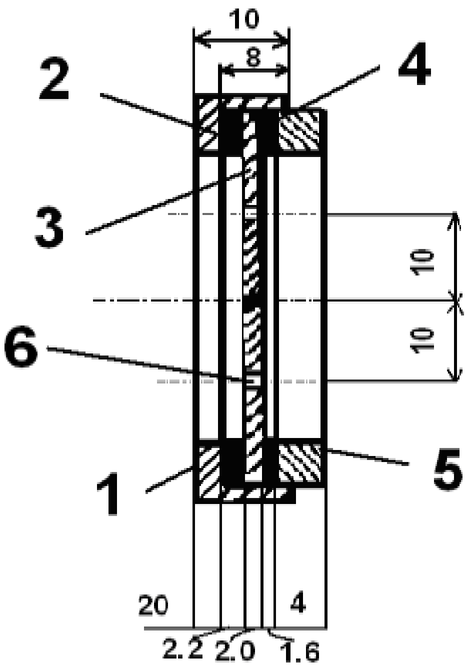


Fig. 3 Processed plate

Fig. 4 Drilled disk



a)



b)

Fig. 5.Casing that contains the hole plate: a) view; b) transversal section view.
1 - casing body; 2 – seal; 3 – hole plate; 4 – safety ring; 5 – nut; 6 – holes; 7 – holes ∅ 0.5 mm.

The hole disk has to be fixed in a casing (Figure 5) mounted inside the FBG body.

Figure 5 shows the manner in which the tightening of the nut 5 leads to the pressing of the drilled plate into the seal 2; the nut is tightened using a ⋂ key that enters the holes (7).

After all the component elements are mounted, the casing is placed inside the FBG body.

2. The manufacturing technology of the FBG

The sections passed by the air flow entering the FBG were dimensioned pursuant to the air flow rate, leading to the drawing presented in Figure 6.

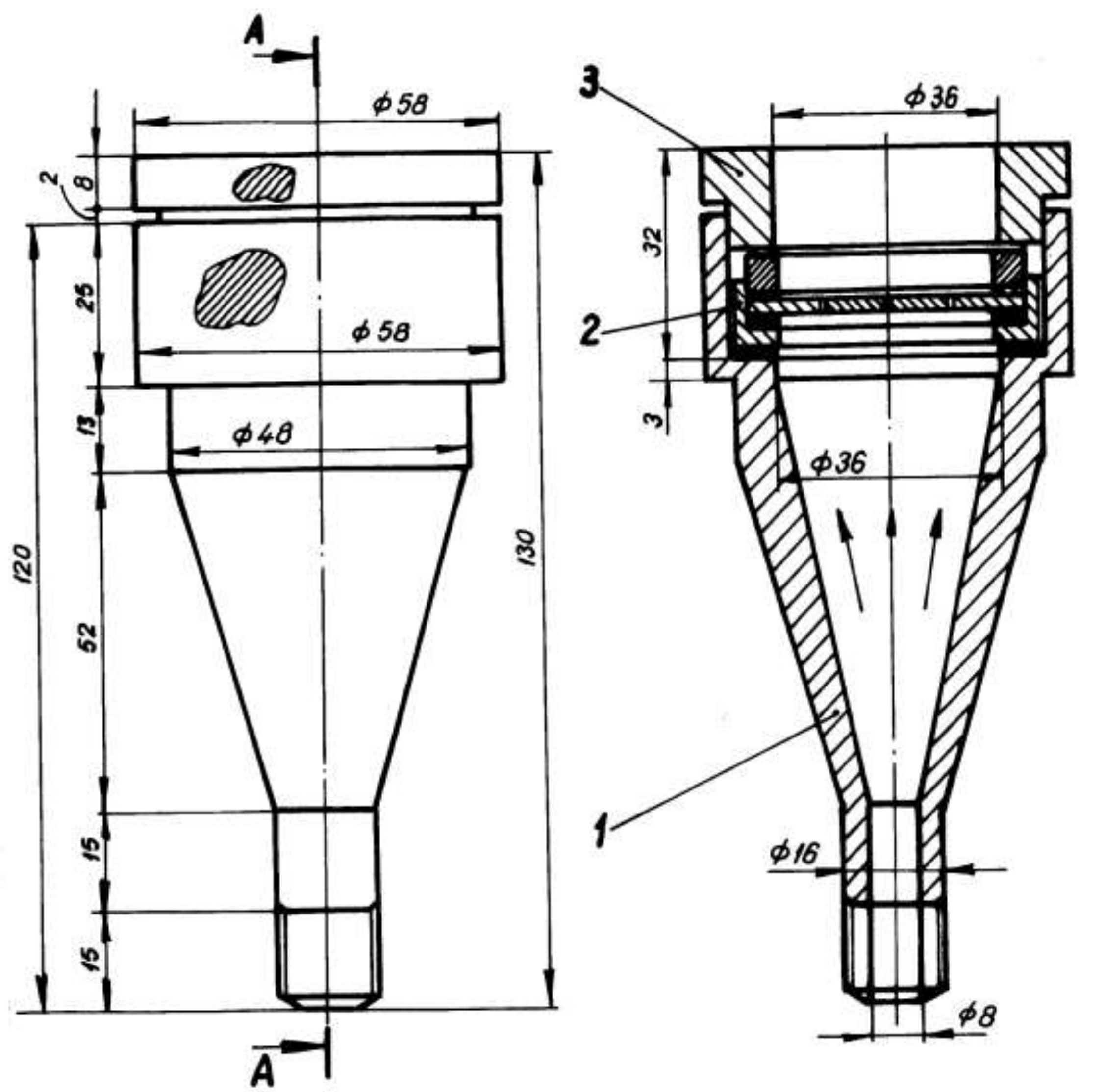


Fig. 6 The FBG body: a – view; b – transversal section view. 1- truncated cone body with inferior threaded part; 2 – seal; 3 – casing; 4 – tightening nut.

The component parts of the casing (2) were not detailed in Figure 6 due to the fact that they are presented in Figure 5.

The nut (3) is threaded on the truncated cone body (1). By its tightening, the casing (2) is fixed on the rubber seal (2), restraining the air from entering in the water layer by other holes than the ones drilled in the circular disk.

The truncated cone body (1) and the nut (4) are obtained from a bronze bar strip, by turning on a TOS type SM 16A turn. The processing of the truncated cone body starts with the inner boring with a drill, then continues with the inner conical turning, outer conical turning, inner threading, respectively outer threading, ending with the cutting [4].

The casing is manufactured by turning. The processing starts with the inner roughing turning, followed by the inner finishing turning, the outer turning and the cutting from the bronze bar strip in order to obtain the dimensions and the tolerances prescribed by the technical drawing.

3. The fine bubbles generator, regarded as a whole

After manufacturing, the drilled plate is introduced in the casing; the casing is mounted inside the FBG and the generator is fixed with the inferior part threaded in the compressed air supply pipe (Figure 7).

Fig. 7. Fine bubbles generator introduced in a water basin (h = 0.5 m)

The fine bubbles generator connected to the compressed air pipe can be noticed in Figure 7; it was introduced inside a water tank with a depth $h = 0.5$ m. Inside water one can see the air bubbles emitted by the FBG that ascend to the water surface.

Figure 7 shows that a static pressure inlet was drilled in the truncated cone body of the FBG. The inlet will indicate the precise value of the static air pressure before the hole plate.

CONCLUSIONS:

1. The manufacturing of fine bubbles generators using electro-erosion processing guarantees a uniform distribution of the air bubbles in the water mass.
2. The placement of the air blowing holes in the FBG can be done in the desired manner, because the electro-erosion processing machine works with the help of a computational program, in XOY coordinates; the obtaining of the distance between the holes is assured with a 0.0001 mm accuracy;
3. The experimental researches that will be subsequently performed will lead to the establishment of the optimal step of the net of holes, as well as their diameters, in function of the working conditions (water quality, height of water in the basin, blown air parameters a.s.o.).

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