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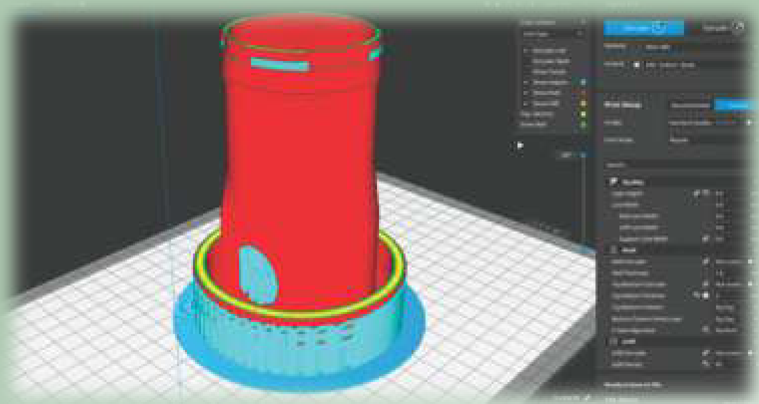

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EDITORIAL

Și inginerii proiectanți sunt ingineri

Dr. Ing. Petrin DRUMEA
DIRECTOR PUBLICAȚIE

Acest editorial nu este împotriva a ceva, ci este pentru ceva.

Cam de treizeci de ani a devenit o mare rușine, când te miști printre marii specialiști de tip nou, să spui ca ești inginer proiectant sau că te ocupi și de proiectare. Vechii noștri profesori încercau să ne convingă că un adevărat inginer face lucruri bine calculate și corect executate, că nu se poate inginer fără proiecte transferate în economie și fără să fie autorul câtorva brevete de invenție.

În ultimul timp sunt apreciați numai inginerii care se numesc cercetători și care au câteva articole cu un anumit tipic de calcul, fără să conteze subiectul și contextul realizării calculelor, dar musai să fie publicate într-un anumit tip de reviste.

Grav este că profesorii cu realizări, cu proiecte în spate, cu brevete extrem de interesante și utile nu pot să-i izoleze pe acești indivizi agresivi și de foarte multe ori influenți. Este limpede că orice produs trebuie calculat și optimizat prin cele mai moderne mijloace, dar trebuie evitată varianta când se fac niște calcule complicate, prin metode moderne chiar, dar fără nici o substanță tehnică de fond. Nu știu de ce în medicină profesorul de chirurgie este unul dintre cei mai buni chirurgi, de ce în arhitectură profesorul a condus realizarea unor proiecte extrem de interesante, vizibile pentru toată lumea, iar în inginerie profesorul, specialist de tip nou, nu are produse realizate după proiectele sale, nu are brevete, decât unul sau două împreună cu adevărații autori la care s-au atașat și ei, nu are cărți și teorii definitorii pentru domeniul în care se prezintă ca experți.

Că este nevoie de toate tipurile de ingineri este limpede pentru toată lumea. Neclar este de ce deciziile privind activitatea inginerească sunt atât de mult influențate de acest tip de specialiști fără operă inginerească și fără rezultate reale de tipul cărtilor esențiale, teoriilor-suport pentru activitățile de proiectare, brevetelor, produselor de mare impact, articolelor de direcționare.

După părerea mea, specialistii ar trebui apeciați și după numărul de brevete, și după numărul de produse introduse în fabricație, și după numărul de cărți, și după numărul de articole publicate în conferințele și revistele importante ale domeniului. Deși aceste orientări, cu anumite nuanțe, privind activitățile inginerești sunt internaționale, noi 'am reușit' să cădem în ridicol și cu această ocazie.

În final, revin spunând că editorialul este o susținere a ideii de inginer cercetător-proiectant, și nu un atac împotriva cercetătorilor și teoreticienilor.

Vă doresc multă sănătate!

EDITORIAL

Design engineers are engineers, as well

Ph.D.Eng. Petrin DRUMEA
MANAGING EDITOR

This editorial is not against something, but in favour of something.

For about thirty years it has become a great shame, when you move among the great new type specialists, to say that you are a design engineer or that you also deal with design. Our old-school professors tried to convince us that a true engineer does well-calculated and well-executed things, that one can't be an engineer without projects transferred to the economy and without being the author of several patents.

Lately, one appreciates only the engineers who call themselves researchers and have several articles with a certain calculation stereotype, regardless of the subject and context of the calculations, which it is a must to be published in a certain type of magazines.

The serious thing is that professors with achievements, with projects behind them, with extremely interesting and useful patents cannot isolate these aggressive and often influential fellows. It stands to reason that any product must be calculated and optimized by using the most modern means, but the practice of making complicated calculations - even by modern methods - without any technical substance, must be avoided. I cannot figure out why in medicine, the professor of surgery is one of the best surgeons, in architecture, the professor has led the implementation of extremely interesting projects, visible to everyone, while in engineering, the professors - the new type of specialists – have no products made according to their own designs, no patents, or only one or two in co-authoring with the real authors whom they also joined, no books and no defining theories for the field in which they present themselves as experts.

It is clear to everyone that all kinds of engineers are needed. It is unclear why decisions on engineering activity are so much influenced by such specialists with no engineering record and no real results such as essential books, support theories for design activities, patents, high impact products, field guiding articles.

In my opinion, specialists should be assessed by the number of patents, the number of products introduced in the manufacturing, the number of books, and the number of articles published in important conferences and magazines in the field, as well. Although these guidelines, with certain tones, on engineering activities are international, we 'have managed' to be just ridiculous on this occasion, too.

In the end, I reiterate that the current editorial is in support of the idea of a research design engineer; it is not an attack on researchers and scholars.

I wish you all good health.

Determining the Optimal Curves for Stator or Rotor Profiles of Multi-Action Hydraulic Pumps and Motors

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Abstract: *This paper presents a method of profiling the stator or rotor of the multi-action hydraulic motors and pumps in order to reduce the flow pulses rate (speed). On the basis of the presented theoretical elements, it is possible to determine correctly the profile curves, their number and also the number of pistons for the hydraulic machines of this type. The curves thus determined can be used for the creation of the programs necessary for the machining operations on numerical control machine-tools.*

Keywords: *Rotary hydraulic machines, diminution of pulses, profiling curves*

1. Introduction

The rotary hydraulic machines, pumps or motors are characterized by a specific size named capacity (stroke capacity). In the case of pumps, the flow that they supply (Q_P) is calculated using the relation [1]:

$$Q_P = q_P \cdot n \tag{1}$$

The rotation speed of a motor, neglecting the losses, can be done by means of the relation:

$$n_M = \frac{Q}{q_M} \tag{2}$$

The notations used in the relations above are the following: q_P, q_M – capacities of the pumps and motors, respectively; Q - flow; n – rotation speed (rpm).
Actually, these sizes noted by q_P, q_M are not constant, they have a pulsating and periodic character [1, 2, 3]. These pulses can introduce unwanted effects in the operation of the units. The size of their amplitude define the pulsation characteristic of the machine in the form [2]:

$$\delta = \frac{q_{MAX} - q_{min}}{q_{Med}} [\%] \tag{3}$$

It is desired that this size be as small as possible, even zero [2,4].
The frequency of pulses depends on the number of profiles, the number of pistons and, in the case of pumps, on the rotation speed of the driving electric motor.
These machines can have simple action or multiple action The machine is a simple action one if the pistons make a suction and a discharge during a full rotation. If the pistons make two or several suctions and discharges during a single rotation, the machine is a multi-action one [1, 5, 6].

2. Determining the profile curves

The case of the machines with multi-action radial pistons [1, 2, 6] is studied hereby.
It is considered that on the stator 1 operate the pistons 3 located in the rotor 2, as shown in Figure 1. This one rotates with the angular velocity ω, considered a constant.
Figure 1 has also the following notations: d – diameter of the pistons; α, β – profile defining angles; φ - current angle; $\rho(\varphi)$ - instantaneous radius expressed in polar coordinates; R_0 - minimum radius; h – difference between the maximum radius and the minimum radius (travel on profiles); ω – angular velocity (supposed to be constant); A, B, C – points defining the conditions for curves C_1

and C_2; $\rho \in [R_0; R_0 + h]$; $\alpha + \beta = \frac{\pi}{z_p}$, where z_p - number of profiles. During a complete rotation, the total stroke is executed as follows: $c_T = z_p \cdot h$.

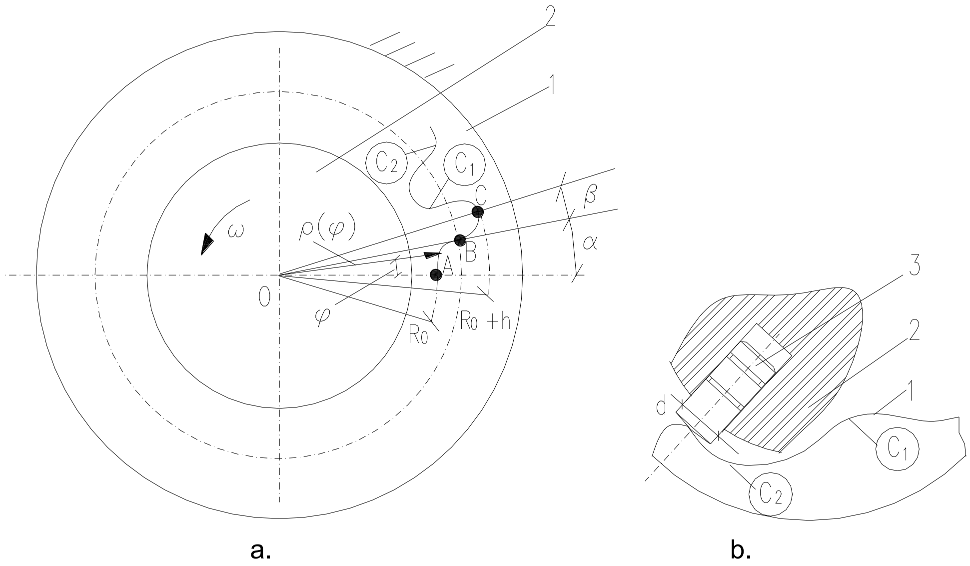

Fig. 1. Operation of the machines with piston and multiple action

The capacity of the machine is:

$$q = \frac{\pi d^2}{4} \cdot x_p \cdot z_p \cdot h \tag{4}$$

where x_p is the number of pistons.
The capacity of the machine (pump or motor) is theoretically constant, but in reality is pulsating [1, 2, 4].
The technical requirements are listed below:

- Capacity as big as possible in dimensions as small as possible;
- The curves C_1 and C_2 are determined so the capacity is constant for a certain number of pistons x_p and a certain number of profiles z_p;
- The pistons execute movements of relative translation with constant acceleration.

Figure 2 shows the exploded view on the angle (α + β).

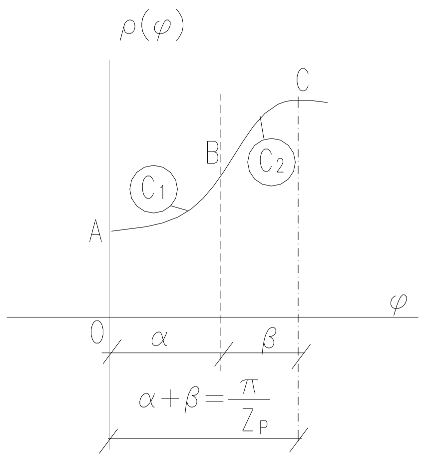

Fig. 2. Curves that define the profile

If the instantaneous radius for a piston is $\rho(\varphi)$, then the speed and acceleration have the expressions:

$$v = \frac{d\rho}{d\varphi}\frac{d\varphi}{dt} = \omega\frac{d\rho}{d\varphi} \tag{5}$$

$$a = \omega^2\frac{d^2\rho}{d\varphi^2} \tag{6}$$

If we consider that the driving speed ω is constant during the displacement on the angle $0 \rightarrow \alpha$ (curve C_1), one must write the necessary condition that the acceleration be constant too:

$$\frac{d^2\rho}{d\varphi^2} = c_1 \tag{7}$$

On the angle $\alpha \rightarrow \alpha + \beta$ (curve C_2) the constant acceleration means:

$$\frac{d^2\rho}{d\varphi^2} = c_2 \tag{8}$$

If the relations (7) and (8) are integrated twice, it follows:
- curve C_1:

$$\rho_1(\varphi) = a_1\varphi^2 + b_1\varphi + c_1 \tag{9}$$

- curve C_2:

$$\rho_2(\varphi) = a_2\varphi^2 + b_2\varphi + c_2 \tag{10}$$

According to the relations (9) and (10), the curves C_1 and C_2 are parabolas and the following conditions should be verified [7]:

$$\rho_1(0) = R_0 \tag{11}$$

$$\rho_2(\alpha+\beta) = R_0 + h \tag{12}$$

$$\left.\frac{d\rho_1}{d\varphi}\right|_{\varphi=0} = 0 \qquad \text{(minimum)} \tag{13}$$

$$\left.\frac{d\rho_2}{d\varphi}\right|_{\varphi=\alpha+\beta} = 0 \qquad \text{(maximum)} \tag{14}$$

$$\rho_1(\alpha) = \rho_2(\alpha) \qquad \text{(continuity)} \tag{15}$$

$$\left.\frac{d\rho_1}{d\varphi}\right|_{\varphi=\alpha} = \left.\frac{d\rho_2}{d\varphi}\right|_{\varphi=\alpha} \text{(continuous derivative - common tangent)} \tag{16}$$

The relations (11) to (16) represent a system of 6 equations with 6 unknowns: a_1, a_2, b_1, b_2, c_1, c_2. After solving the system, you get:
- curve C_1:

$a_1 = \frac{h}{\alpha(\alpha+\beta)}$; $b_1 = 0$; $c_1 = R_0$.

$$\rho_1(\varphi) = \frac{h}{\alpha(\alpha+\beta)}\varphi^2 + R_0 \tag{17}$$

$$\rho_1'(\varphi) = \frac{2h}{\alpha(\alpha+\beta)}\varphi \tag{18}$$

- curve C_2:

$a_2 = -\frac{h}{\beta(\alpha+\beta)}$; $b_2 = \frac{2h}{\beta}$; $c_1 = -\frac{\alpha}{\beta}h + R_0$.

$$\rho_2(\varphi) = -\frac{h}{\beta(\alpha+\beta)}\varphi^2 + \frac{2h}{\beta}\varphi - \frac{\alpha}{\beta}h + R_0 \tag{19}$$

$$\rho_2'(\varphi) = -\frac{2h}{\beta(\alpha+\beta)}\varphi + \frac{2h}{\beta} \tag{20}$$

The relations (17) ÷ (20) verify the conditions (11) ÷ (16).
In Figure 3 is shown the speed graph consistent with the relations (17) and (19).

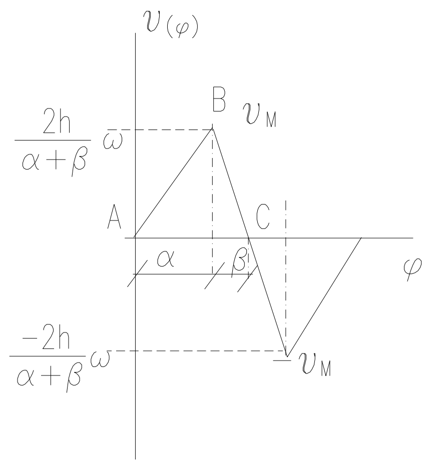

Fig. 3. Dependence of the pistons speed on their position

The derivative is maximum in point B:

$$\left(\frac{d\rho}{d\varphi}\right)_{Max} = \frac{2h}{\alpha+\beta} \tag{21}$$

Thus, the maximum speed of the pistons is:

$$v_M = \frac{2h}{\alpha+\beta}\omega \tag{22}$$

It is recommended that:

$$\frac{v_M \cdot \frac{\pi d^2}{4}}{\frac{\pi d_A^2}{4}} < v_{AD} \tag{23}$$

where d_A is the minimum diameter of the supply ports and v_{AD} – maximum speed of flow from laminar flow conditions (< 3 m/s).

3. Determining the optimum number of profiles and pistons

Further it is considered that the aspiration (filling of the piston chambers) is performed for $\frac{d\rho}{d\varphi} \geq 0$ and the discharge (emptying of the piston chambers) is performed for $\frac{d\rho}{d\varphi} < 0$. It is also considered that ω is constant.
In these conditions it is desired that, at any moment, the sum of the speeds be constant for the pistons located in the discharge area; as well as for those located in the suction area. For this reason, the number of pistons x_p will be even.

The technical conditions (spindle unloading) lead to the same work hypothesis.
If the number of pistons is 2, then surely the speed of a piston will not be constant. Therefore, the minimum number of pistons must be 4. So, two pistons are located in the discharge area and two in the suction area and it is desired that the sum of the piston speeds in the same state be constant.
We consider that there are 4 pistons and 3 profiles.
Figure 4 shows the initial position of the pistons.

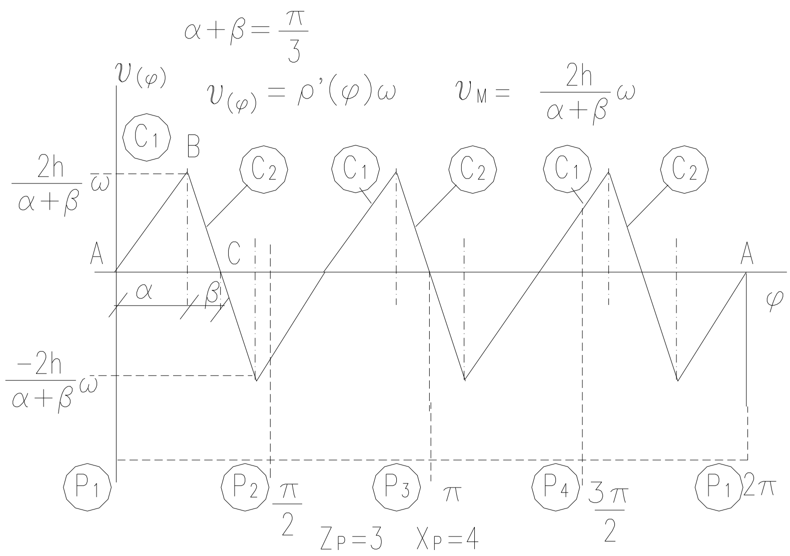

Fig. 4. Defining the initial position of the pistons for different α and β

At this moment, the speeds of the pistons P_1 and P_3 are summed in the discharge stage. We notice that the sum of these speeds cannot be constant because the speeds will increase during the movement to the right as both pistons are placed on the curve C_1. So, it is necessary for the pistons in the same state to be on different curves. Hence: α = β:

$$12\alpha = 2\pi \Rightarrow \alpha = \frac{\pi}{6} \tag{24}$$

In the new conditions, the initial position of the pistons is shown in Figure 5.

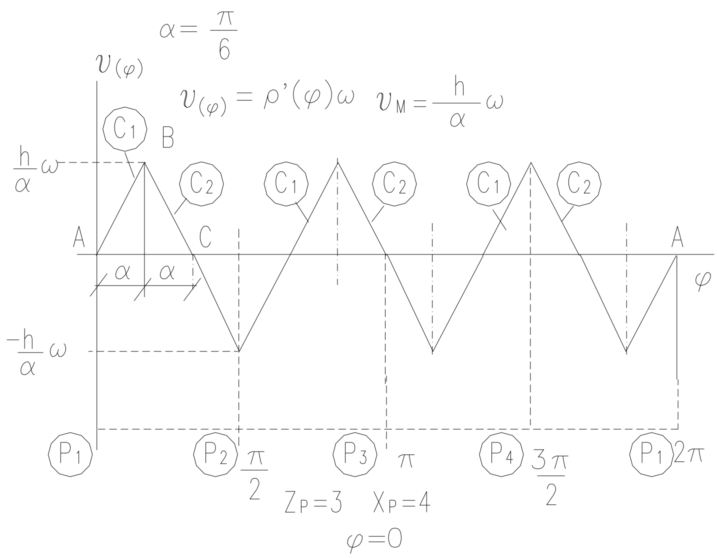

Fig. 5. Defining the initial position of the pistons for α = β

If we consider a rotation with the angle φ ($\varphi < \alpha$), the new position of the pistons is the one in Figure 6.

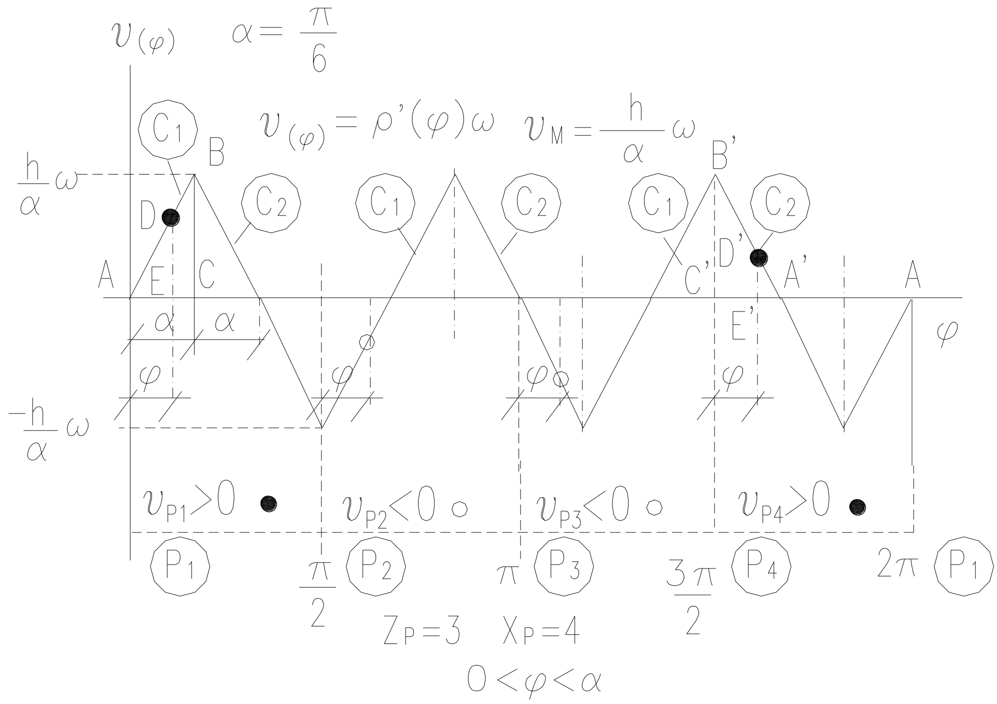

Fig. 6. Defining the current position of the pistons for $\alpha = \beta$

From the similarities of the triangles ABC and A'B'C' it follows:

$$\frac{v_{P1}}{\frac{h\omega}{\alpha}} = \frac{\varphi}{\alpha} \tag{25}$$

From the similarities of the triangles A'B'C' and A'D'E' it follows:

$$\frac{v_{P2}}{\frac{h\omega}{\alpha}} = \frac{\alpha-\varphi}{\alpha} \tag{26}$$

According to the relations (25) and (26) it follows:

$$v_{P1} + v_{p2} = \frac{h}{\alpha}\omega = ct. \tag{27}$$

If $\alpha < \varphi < 2\alpha$, the pistons P_1 and P_2 become active (discharge).
If $2\alpha < \varphi < 3\alpha$, the pistons P_2 and P_3 become active.
If $3\alpha < \varphi < 4\alpha$, the pistons P_3 and P_4 become active. Then the phenomenon is periodic.
Depending on the size (q) desired, other variants can be also achieved.
Numerical example:
h - imposed
d - imposed
$z_P = 3$ ($\alpha = 30^0 = \pi/6$; $\alpha = \frac{2\pi}{hz_p}$)
$x_p = 4$ (number of pistons)
The capacity is:

$q = \frac{\pi d^2}{4} \cdot x_p \cdot z_p \cdot h = \frac{\pi d^2}{4} \cdot h \cdot 3 \cdot 4$ (according to relation (4))

The flow is:

$$Q = q \cdot \frac{\omega}{2\pi} = \frac{\pi d^2}{4} 12h \cdot \frac{\omega}{2\pi}$$

We calculate the flow using also the relation (27):

$$Q = \frac{\pi d^2}{4} \cdot (v_{P1} + v_{P2}) = \frac{\pi d^2}{4} \frac{h}{\alpha} \omega = \frac{\pi d^2}{4} 12h \cdot \frac{\omega}{2\pi}$$

So, the theoretical flow is equal to the instantaneous flow and it is constant.

4. Experimental achievements

Based on the theoretical elements presented, a rotary hydraulic moment and a multi-acting pump were designed and manufactured. They are shown in Figure 7.

a. b.

Fig. 7. Hydraulic motor (a) and pump (b) with profiled elements with parabola arches

The basic characteristics of these hydraulic machines are shown in the Tables 1 and Tables 2.

Table 1: Characteristics of the rotary hydraulic motor

	q_M [cm^3]	x_P	z_P	h [mm]	p_{Max} [bar]	T_{Max} [Nm]
Motor	45	8	6	3	220	150

Table 2: Characteristics of the pump

	q_P [cm^3]	x_P	z_P	h [mm]	p_{Max} [bar]	Q at 1500 RPM [l/min]
Pump	4	4	3	3	220	6

5. Conclusions

For the multi-action machines with pistons, the profiles of the actuators can be made according to parabolas. In this case, the accelerations are constant and the relative speeds of the pistons relative to the bores depend linearly on the current angle.
By correlating the number of pistons with the number of profiles, constant capacities can be obtained. Due to size considerations, the number of these profiles, as of the pistons too, is limited.
Based on the presented curves, it is possible to create programs that allow the machining of the stators and rotors on numerical control machine tools.

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Analysis of Stresses and Displacements in the Deformed Bent 3D Hexagonal Toroid with Regular Hexagonal Cross-Section Used in Manufacturing of LPG Storage Tanks

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Abstract: *In this article an integrated simulation and optimization approach is adopted in the stresses and displacements analysis of a three-dimensional (3D) hexagonal toroid with regular hexagonal cross-section used in manufacturing of LPG storage tanks from the automotive industry. A 3D parametric model was built to represent the product structure connected with input and output relations. The specific simulation algorithms and the simulation results are used to evaluate the product behavior during the optimization process for each involved design dependency. The obtained results are compared, and it can be found that in the deformed bent structure the state of stresses (σ) and displacements (u) have increased values at the end of the exploitation period (n_a = 15 years). The highest percentage values relative to the initial state are: $\Delta\sigma/\sigma_0$ = 37.56 [%] and $\Delta u/u_0$ = 39.49 [%]. The results of analyzed numerical cases demonstrate the effectiveness of the used models and methods for designing of LPG storage tanks.*

Keywords: *3-D hexagonal toroidal LPG fuel tank, deformed bent structure, finite element analysis, industrial engineering design, optimization methods*

1. Introduction

The automotive storage tank market is expected to grow due to a number of factors (such as rapid urbanization, expansion of vehicle production, innovation in storage tank technology, increase safety, and others) over the upcoming years [1-4]. In addition, the growth in electric vehicles and hybrid electric vehicles can open new growth avenues [5-8].
Automotive fuel tanks are produced by various manufacturers in many variants (for passenger cars, light commercial vehicles and heavy commercial vehicles) [9-12] and complex shapes with high mechanical and chemical resistance [13-16] and different prices.
In the current automotive fuel tank market there is segmentation based on the capacity of fuel tank, into less than 45 L, 45 L - 75 L, and greater than 75 L [17-21]. A comparative analysis indicates a growing of fuel tanks production from materials (such as plastic, steel, and aluminum materials) based on advanced safety systems and high technology [22-25].
Finite element analysis (FEA) is a computational modern tool [26-28] in engineering to design [29-31] and failure analysis which provides a lot of advantages to complement laboratory experiments and the simulation results can allow a fast, comparison of numerous results for integrated product development. In engineering design process of automotive fuel tanks, the design engineers explore, innovate, and optimize by using specific CAD tools [32-35] and a variety of design recommendations in accordance with national and international standards [36-40], the product performance according to its intended use, size, structure type, materials, and service life [41-44]. In addition, for practical applications of automotive fuel tanks a quantitative estimation of possible geometric variations are applied for different work/impact scenarios [45-49].
The objective of this study is to determine the stresses and displacements as a result of the action of a bending moment that affect the geometry of structural model, a (3D) hexagonal toroid with regular hexagonal cross-section used in manufacturing of LPG storage tanks.

2. Design methodology

A parametric model of a 3D hexagonal toroid with regular hexagonal cross-section, generated by revolving of a closed generating curve C_G (a hexagon with rounded corners) along a closed guiding curve C_D (a hexagon with rounded corners) (fig. 1), is used in the following analyses according [22].

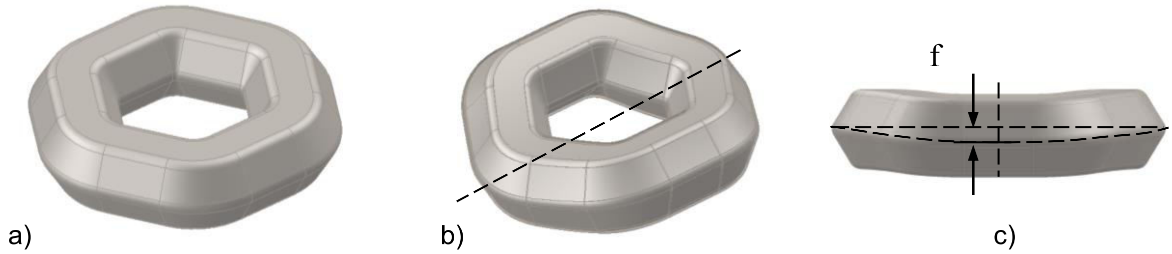

Fig. 1. a) The undeformed tank; b) and c) The deformed tank

The following geometric parameters are used in computational analyses (fig. 1): a) a closed generating curve C_G (a hexagon with a side value L = 175 mm, with rounded corners, radius R = 50 mm), and b) the guiding curve C_D (a hexagon with a side value L = 430 mm, with rounded corners, radius R = 180 mm).
The design data used were: the tank material is AISI 4340 steel; the maximum hydraulic test pressure: p_{max} = 30 bar; the working temperature between the limits: T = -30 ^{0}C up to T = 60 ^{0}C; supporting surfaces located on the inferior side; the duration of the tank exploitation: n_a = 16 years; the corrosion rate of the material: v_c = 0.07 mm/year; the thickness of the cover: s = 10 mm.
Let's consider as parameter the inclination angle α that occurs between horizontal plane and the deformed median plane that determines the vertical arrow *f*.
The geometrical model was created with AutoCAD Autodesk 2020 software [50] and the optimization analysis was performed with SolidWorks 2020 software [51] applying the: Static, Thermal and Design Study modules. The finite element method analysis was performed with the following parameters setting: mesh standard type, solid mesh with high quality, automatic transition, Jacobian in 16 points, element size 10 mm, tolerance 0.5 mm, number of nodes 436510, number of elements 219620, maximum aspect ratio 12.5.
Applying the proposed analysis procedure, the values of the state of stress and of linear deformations, as a function of temperature, flexion angle and corrosion, is shown in Table 1.

Table 1: The Von Mises stress of geometrical 3D model σ (T, α, n_a)

σ [MPa]	n_a= 0 years				n_a= 5 years			
	T [°C]				T [°C]			
α [°]	-30°	0°	30°	60°	-30°	0°	30°	60°
0	442.967	402.354	367.684	402.303	476.814	424.192	380.605	425.947
1	488.906	440.955	396.644	403.908	530.217	482.336	437.783	421.500
2	488.906	440.955	396.644	403.908	501.985	450.381	401.721	412.022
4	550.017	466.968	435.906	470.532	551.485	476.887	455.962	495.63
6	564.078	471.655	431.488	462.456	544.817	461.509	464.226	493.763
8	557.426	467.669	421.722	454.871	584.454	497.238	525.941	565.523
10	459.991	415.98	374.398	374.52	523.966	480.525	443.654	432.795

σ [MPa]	n_a= 10 years				n_a= 15 years			
	T [°C]				T [°C]			
α [°]	-30°	0°	30°	60°	-30°	0°	30°	60°
0	501.696	454.657	410.976	451.969	533.786	485.660	440.704	476.922
1	575.507	527.073	481.699	448.798	629.543	580.439	534.174	491.550
2	479.139	427.909	385.301	433.090	516.429	467.660	421.770	460.625
4	595.403	510.138	491.384	535.976	632.426	533.338	572.433	626.159
6	582.945	496.902	495.935	534.353	620.499	544.402	586.990	633.040
8	584.454	497.238	525.941	565.523	619.644	546.724	580.126	615.802
10	523.966	480.525	443.654	432.795	567.888	528.245	490.211	454.101

The graphs of the resultant Von Mises state of stress are shown in figs. 2-5.

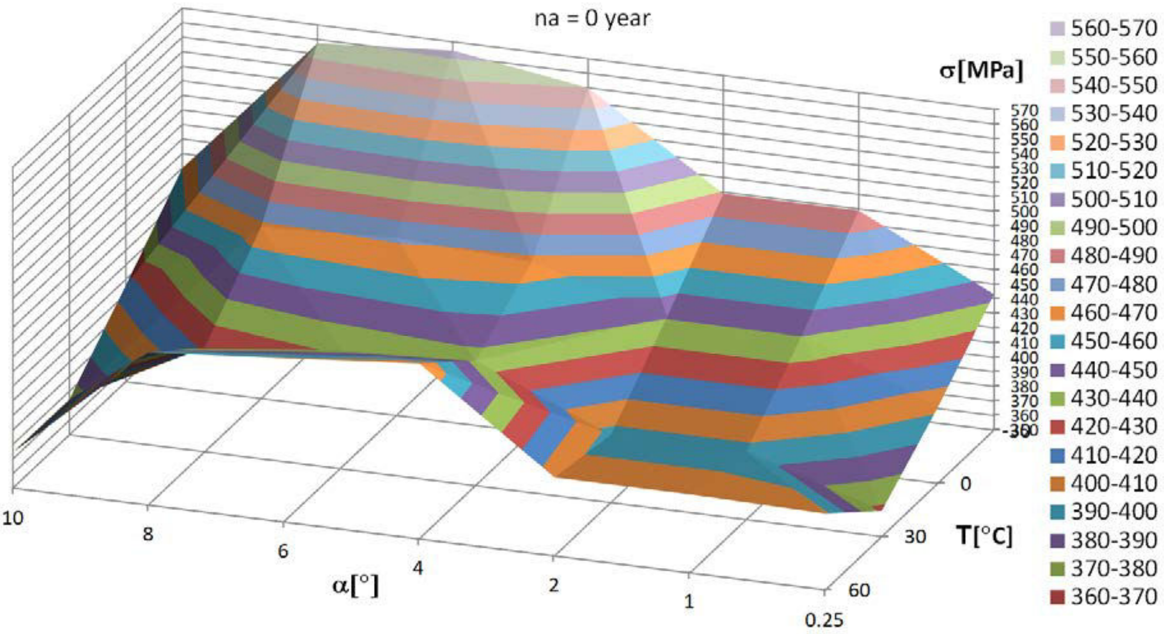

Fig. 2. σ (T, α, n_a= 0 years)

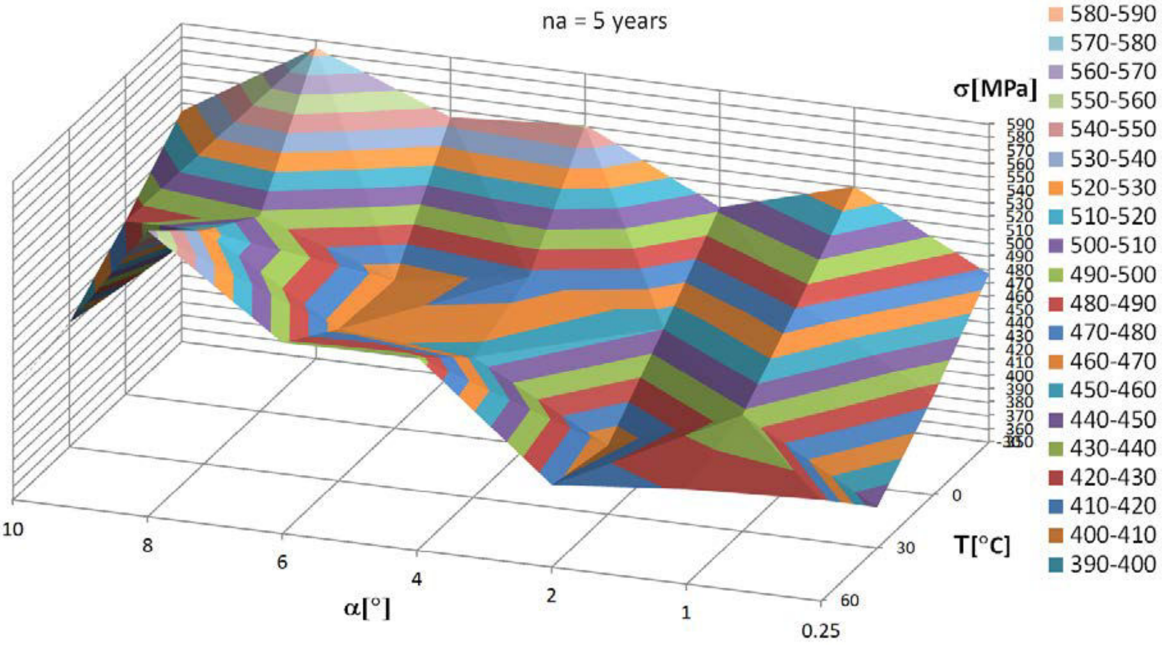

Fig. 3. σ (T, α, n_a= 5 years)

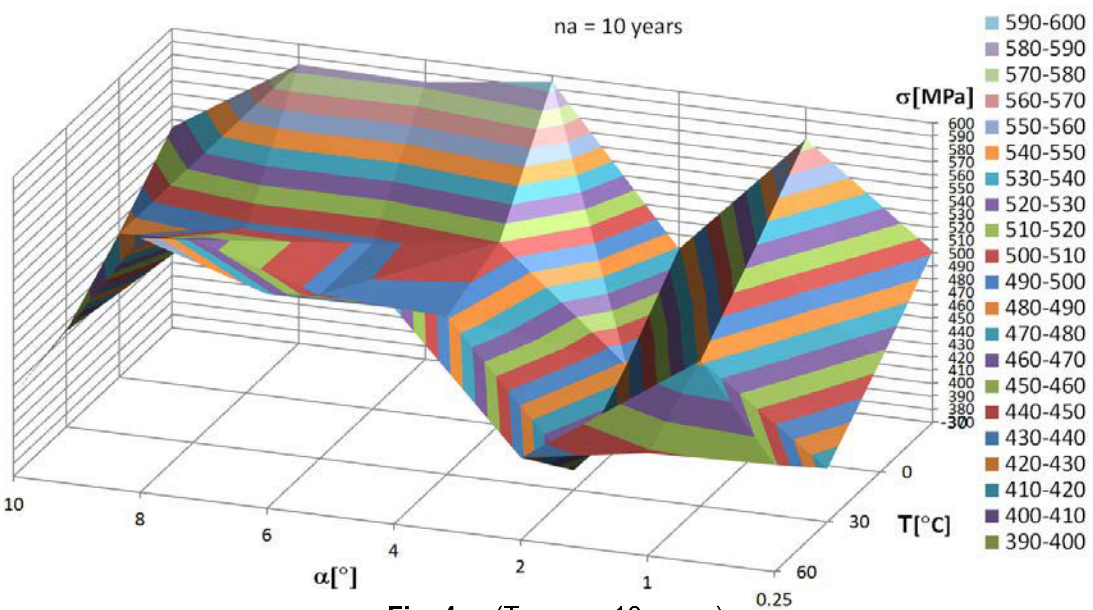

Fig. 4. σ (T, α, n_a= 10 years)

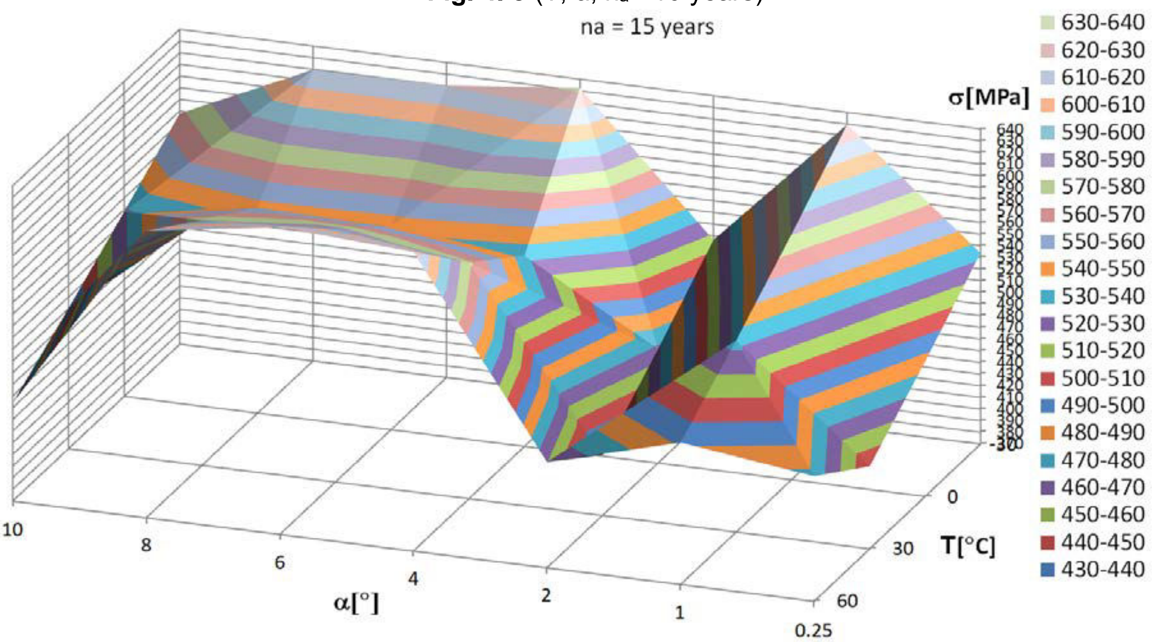

Fig. 5. σ (T, α, n_a= 15 years)

Table 2: The resultant Von Mises state of stress percentage relative to the initial state of geometrical 3D model, $\Delta\sigma/\sigma_0$ (T, α, n_a) [%]

$\Delta\sigma/\sigma_0$ [%]	n_a= 5 years				n_a= 10 years				n_a= 15 years			
	T [°C]				T [°C]				T [°C]			
α [°]	-30	0	30	60	-30	0	30	60	-30	0	30	60
0	7.64	5.42	3.51	5.87	13.25	12.99	11.77	12.34	20.50	20.70	19.85	18.54
1	8.44	9.38	10.37	4.35	17.71	19.52	21.44	11.11	28.76	31.63	34.67	21.69
2	2.67	2.13	1.27	2.00	-1.99	-2.95	-2.85	7.22	5.62	6.05	6.33	14.04
4	0.26	2.12	4.60	5.33	8.25	9.24	12.72	13.90	14.98	14.21	31.32	33.07
6	-3.41	-2.15	7.58	6.76	3.34	5.35	14.93	15.54	10.00	15.42	36.03	36.88
8	4.84	6.32	24.71	24.32	4.84	6.32	24.71	24.32	11.16	16.90	37.56	35.37
10	13.90	15.5	18.49	15.55	13.90	15.51	18.49	15.55	23.45	26.98	30.93	21.24

The graphs of the resultant Von Mises state of stress percentage relative to the initial state of geometrical 3D model, $\Delta\sigma/\sigma_0$ (T, α, n_a) [%] are shown in figs. 6-8.

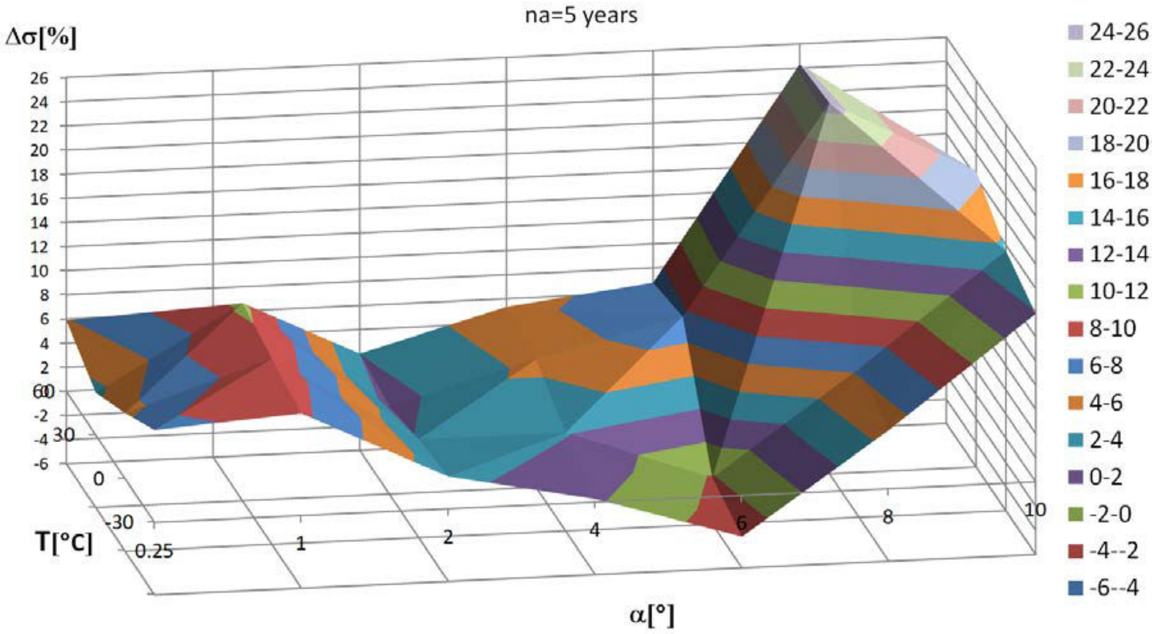

Fig. 6. $\Delta\sigma/\sigma_0$ (T, α, n_a = 5 years) [%]

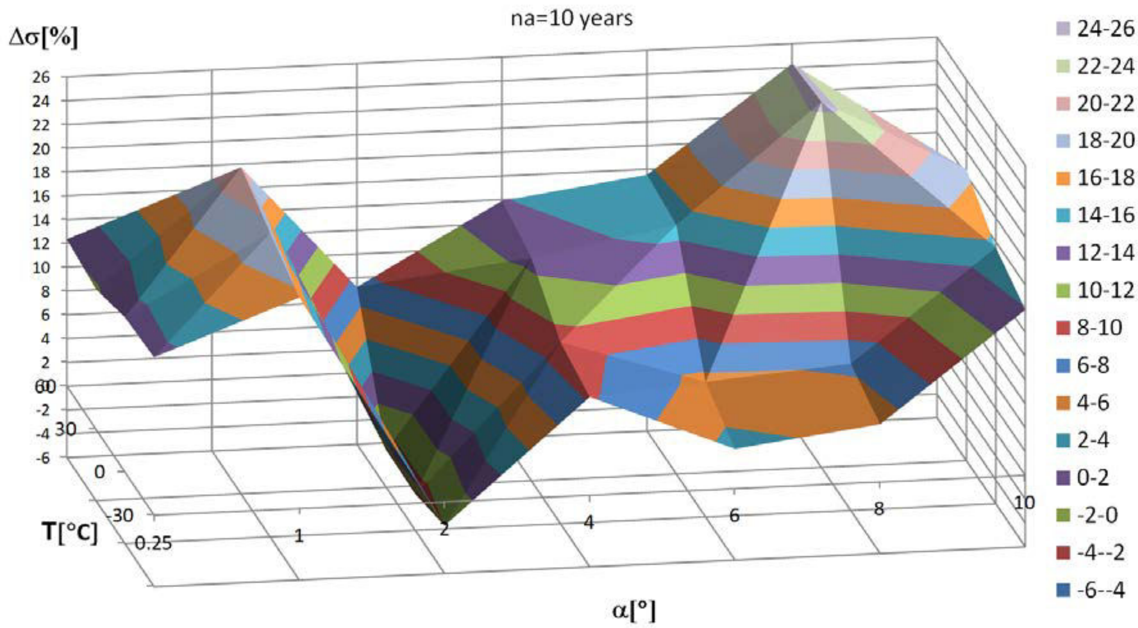

Fig. 7. $\Delta\sigma/\sigma_0$ (T, α, n_a = 10 years) [%]

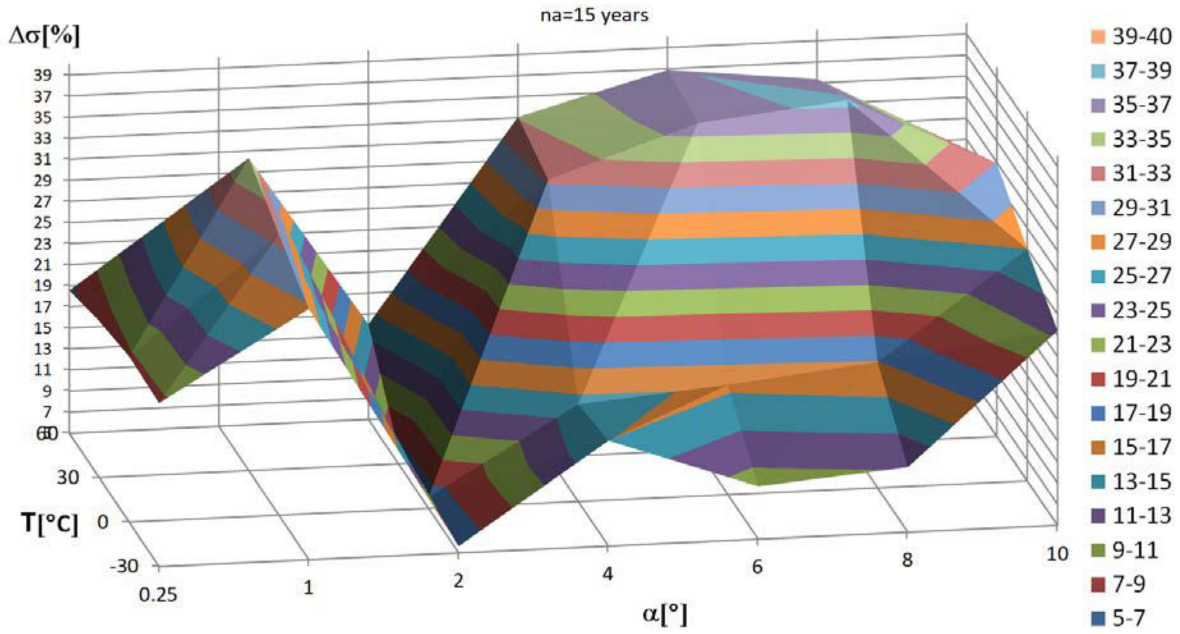

Fig. 8. $\Delta\sigma/\sigma_0$ (T, α, n_a = 15 years) [%]

Also the corresponding resultant linear deformations associated with these stresses, as a function of temperature, flexion angle and corrosion, are shown in Table 3.

Table 3: The resultant linear deformations of geometrical 3D model u (T, α, n_a)

u [mm]	n_a = 0 years				n_a = 5 years			
	T [°C]				T [°C]			
α [°]	-30°	0°	30°	60°	-30°	0°	30°	60°
0	0.66101	0.64168	0.62444	0.60879	0.71848	0.69716	0.69972	0.66404
1	0.66554	0.65167	0.6393	0.62851	0.72933	0.71502	0.70207	0.69057
2	0.78179	0.78864	0.79774	0.80987	0.72880	0.7098	0.6929	0.67731
4	0.78854	0.79728	0.80724	0.81838	0.87615	0.88465	0.89426	0.90494
6	0.79353	0.80305	0.81375	0.82561	0.88274	0.8897	0.89776	0.90686
8	0.80324	0.81117	0.82028	0.83051	0.89097	0.89823	0.90709	0.91697
10	0.69279	0.66939	0.65723	0.64675	0.75547	0.74217	0.73064	0.72025

u [mm]	n_a= 10 years				n_a= 15 years			
	T [°C]				T [°C]			
α [°]	-30°	0°	30°	60°	-30°	0°	30°	60°
0	0.77366	0.7552	0.73816	0.72248	0.85164	0.83065	0.81152	0.7941
1	0.79510	0.78095	0.76806	0.75651	0.85524	0.84237	0.83142	0.82191
2	0.79109	0.77242	0.75505	0.73889	0.85889	0.84037	0.82289	0.80652
4	0.96917	0.97821	0.98824	0.99924	1.08660	1.09410	1.10250	1.11780
6	0.98008	0.98897	0.99885	1.00967	1.09767	1.10397	1.11114	1.11919
8	0.98923	0.99746	1.00664	1.01676	1.1066	1.11324	1.12073	1.12906
10	0.83282	0.82092	0.81052	0.80138	0.93383	0.92238	0.91184	0.90221

The graphs of the resultant linear deformations are shown in figs. 9-12.

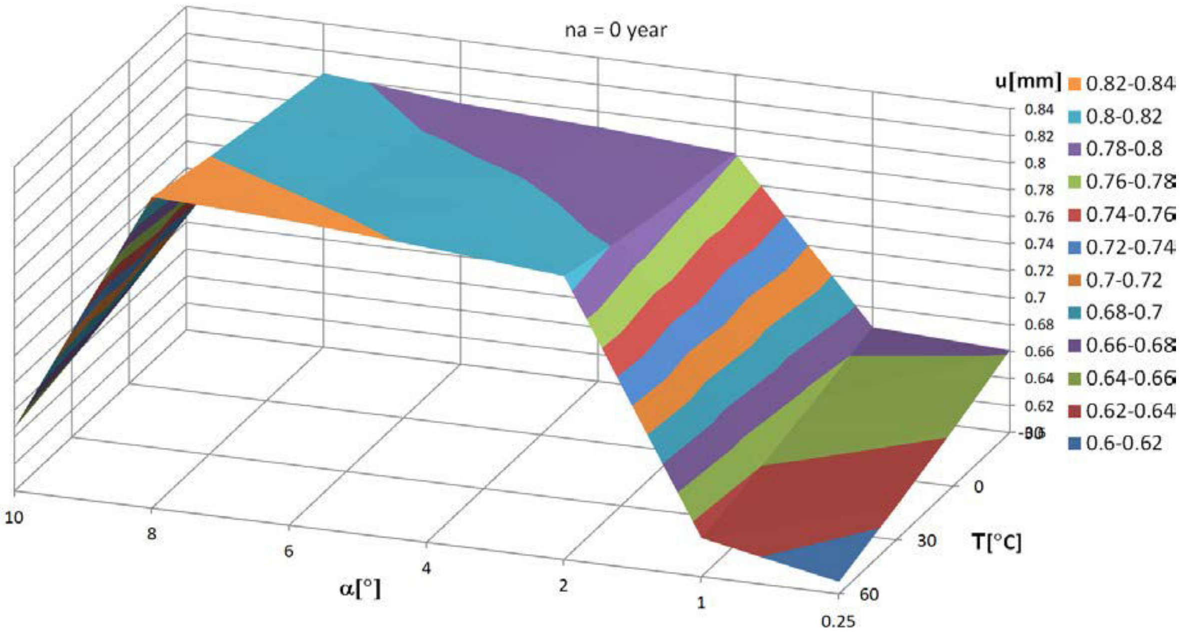

Fig. 9. u (T, α, n_a = 0 year) [mm]

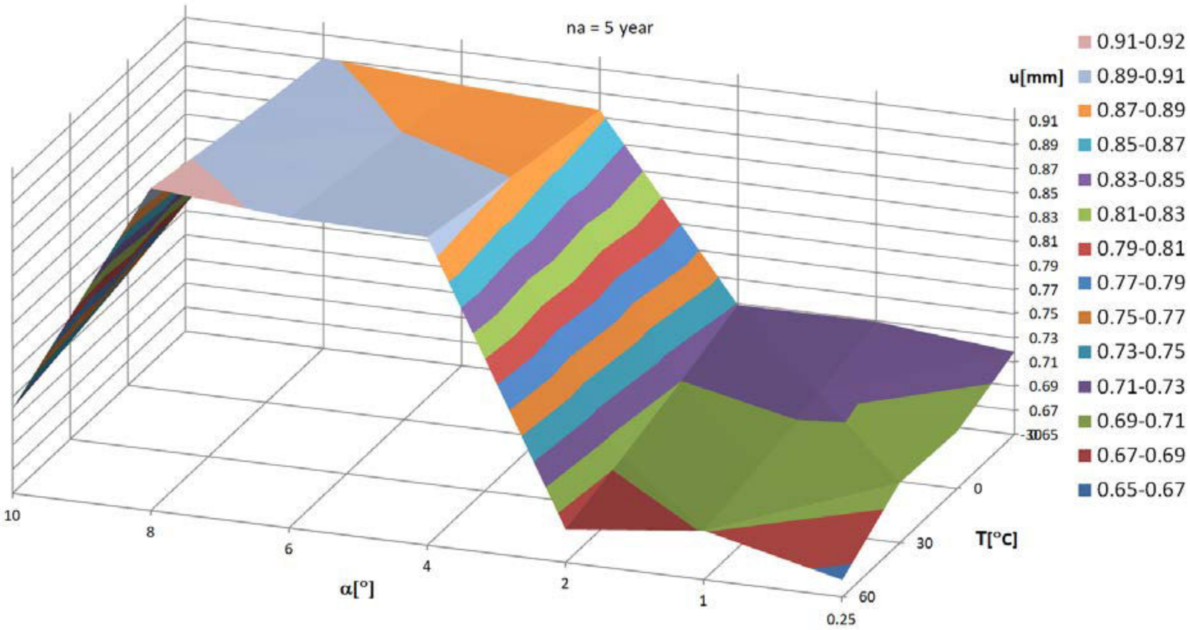

Fig. 10. u (T, α, n_a = 5 years) [mm]

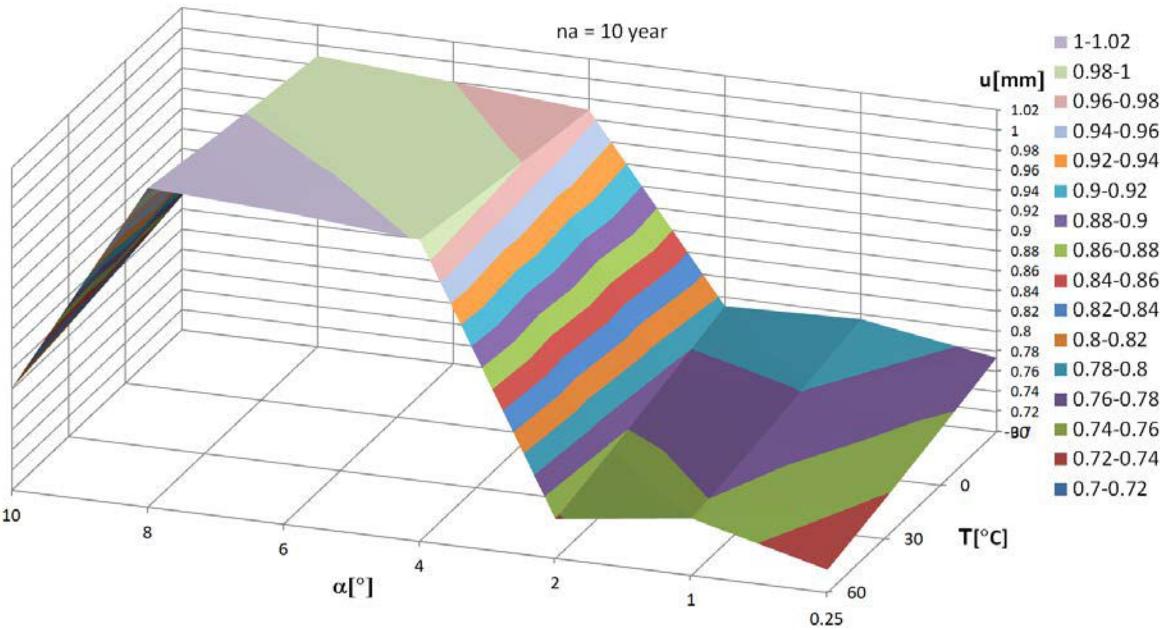

Fig. 11. u (T, α, n_a = 10 years) [mm]

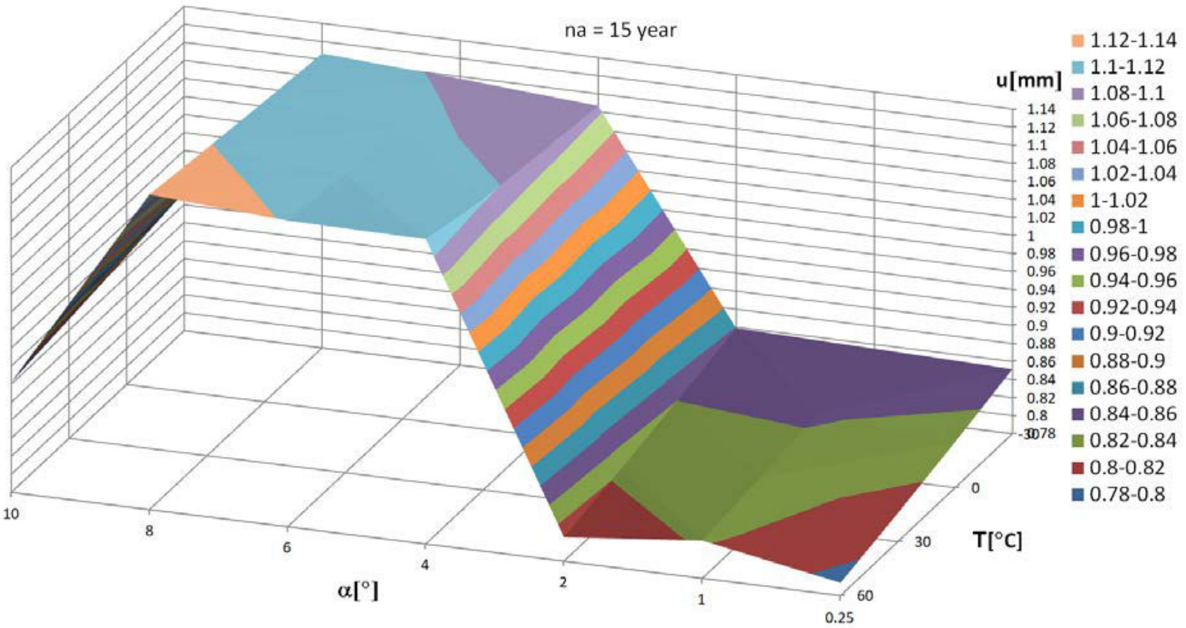

Fig. 12. u (T, α, n_a = 15 years) [mm]

Table 4: The resultant linear deformations percentage relative to the initial state of geometrical 3D model, $\Delta u/u_0$ (T, α, n_a) [%]

$\Delta u/u_0$ [%]	n_a= 5 years				n_a= 10 years				n_a= 15 years			
	T [°C]				T [°C]				T [°C]			
α [°]	-30	0	30	60	-30	0	30	60	-30	0	30	60
0	8.69	8.64	12.05	9.07	17.04	17.69	18.21	18.67	28.83	29.44	29.95	30.43
1	9.58	9.72	9.81	9.87	19.46	19.83	20.14	20.36	28.50	29.26	30.05	30.77
2	-6.77	-9.99	-13.1	-16.3	1.18	-2.05	-5.35	-8.76	9.86	6.55	3.15	-0.41
4	11.11	10.95	10.77	10.57	22.90	22.69	22.42	22.09	37.79	37.22	36.57	36.58
6	11.24	10.79	10.32	9.84	23.50	23.15	22.74	22.29	38.32	37.47	36.54	35.55
8	10.92	10.73	10.58	10.41	23.15	22.96	22.71	22.42	37.76	37.23	36.62	35.94
10	9.04	10.87	11.16	11.36	20.21	22.63	23.32	23.90	34.79	37.79	38.73	39.49

The graphs of the resultant linear deformations percentage relative to the initial state of geometrical 3D model, $\Delta u/u_0$ (T, α, n_a) [%] are shown in figs. 13-15.

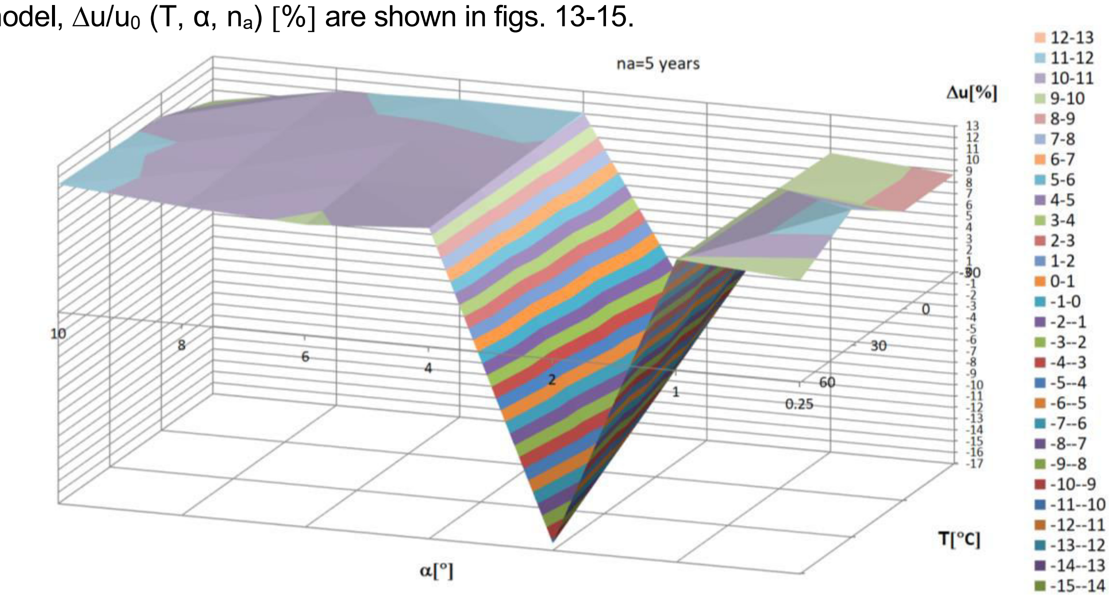

Fig. 13. $\Delta u/u_0$ (T, α, n_a = 5 years) [%]

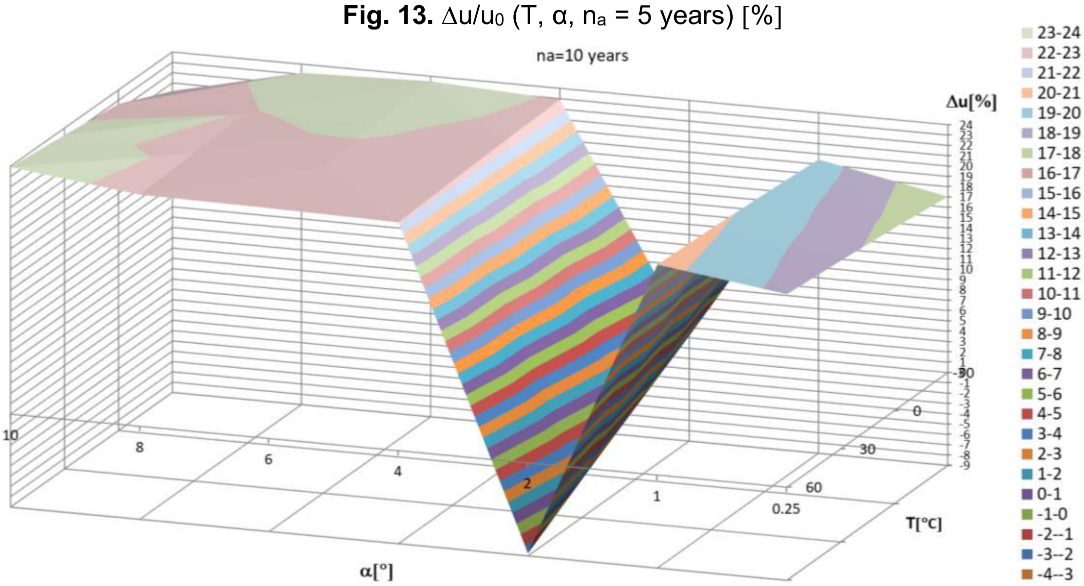

Fig. 14. $\Delta u/u_0$ (T, α, n_a = 10 years) [%]

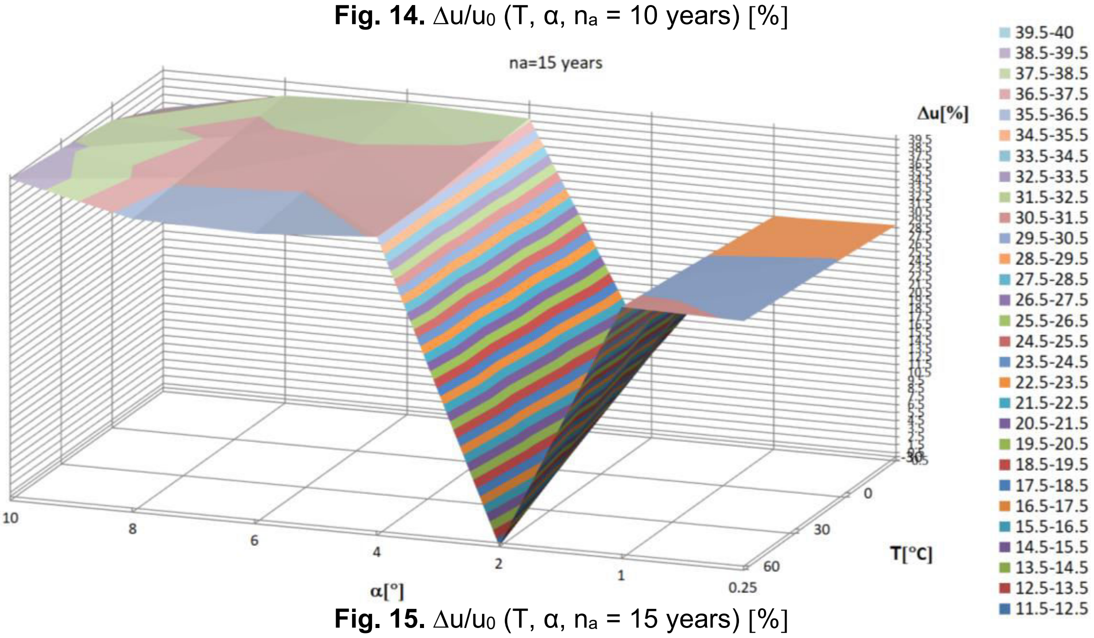

Fig. 15. $\Delta u/u_0$ (T, α, n_a = 15 years) [%]

4. Discussion

The problems of the optimization of LPG storage tanks, due to their diversity and complexity, cannot be described simply or analyzed by one method. Various factors such as safety, reliability, low weight, and economics require appropriately detailed computer analyses, according to the adopted optimization criteria. The adopted parametric model in this analysis is a numerically controlled representation of the design solutions.
Following the results of analyzed numerical cases and the resulting graphs for the deformed bent 3D structure through the method of finite elements it has been found that:
- the determination of the resultant Von Mises stress distributions and resultant linear deformation distributions is necessary for determining the level of performance of the product.
- in the initial state of the exploitation the resultant Von Mises stress distributions and resultant linear deformation distributions have the lower valuest.
- at the end of the exploitation period (n_a = 15 years), there are the highest values of the resultant Von Mises stresses (according to the Table 1); the highest percentage value relative to the initial state $\Delta\sigma/\sigma_0$ = 37.56 [%] is obtained for α = 8° and T = 30 °C (according to the Table 2).
- at the end of the exploitation period (n_a = 15 years), there are the highest values of the resultant linear deformations (according to the Table 3); the highest percentage value relative to the initial state $\Delta u/ u_0$ = 39.49 [%] is obtained for α = 10° and T = 60 °C (according to the Table 4).

5. Conclusions

Product designers and engineers can use these models for an intuitive understanding of the deformed bent 3D structure and as well as computational efficiencies to our solution approaches that affect the competitiveness of the final product.
This construction adopted from feasible constructive variants and determined by the finite element method is characterized by low weight and safety that permits to reduce the production costs. Numerical solutions found by using the finite element method for the parametric 3D model structure are much less time-consuming for many constructional variants and permit to choose the optimal variant. Furthermore, in the analyzed cases the numerical results give a measure of the structural significance of each data set and can assist in the process design, control and product quality evaluation.

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Flow Regime Characteristics and Hydrologic Statistical Analysis of the Extraordinary Low Waters of the Danube between Vámosszabadi and Esztergom in 2018

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Abstract: *In the August – October period of 2018, extremely low water levels were observed on the Hungarian section of the Danube. The observed water levels were below the lowest ever recorded water levels (abbreviated to LKV in Hungarian) in several water gauges in Hungary. In addition to low water levels, extremely low water discharges were also measured in most profiles. In my paper I deal with a simple statistical analysis of the measured hydrologic data of the Danube's Hungarian upper section, between Vámosszabadi and Esztergom. By evaluating the obtained results, I take into account the changes of the Danube riverbed in the past decades and their impact on the flow regime.*

Keywords: *Hydrological statistics, Danube, Low-flow, Trend-analysis, Distribution functions*

1. Meteorological history

With the analysis of monthly meteorological assessments published by the Austrian Central Meteorological and Geodynamic Institute (ZAMG), the weather in the catchment area of the Danube can be evaluated, which is important for the runoff, through the precipitation and temperature conditions in Austria. From March to October 2018, precipitation deficit was almost continuous and significant on the northern side of the Alps (and probably also in the upper Danube basin) compared to the average for the period 1981-2010, and average monthly temperatures in these areas were significantly above the average values. The anomaly from the multi-year average of the monthly accumulated precipitation and the monthly average air temperatures for the whole territory of Austria is shown on Fig. 1.

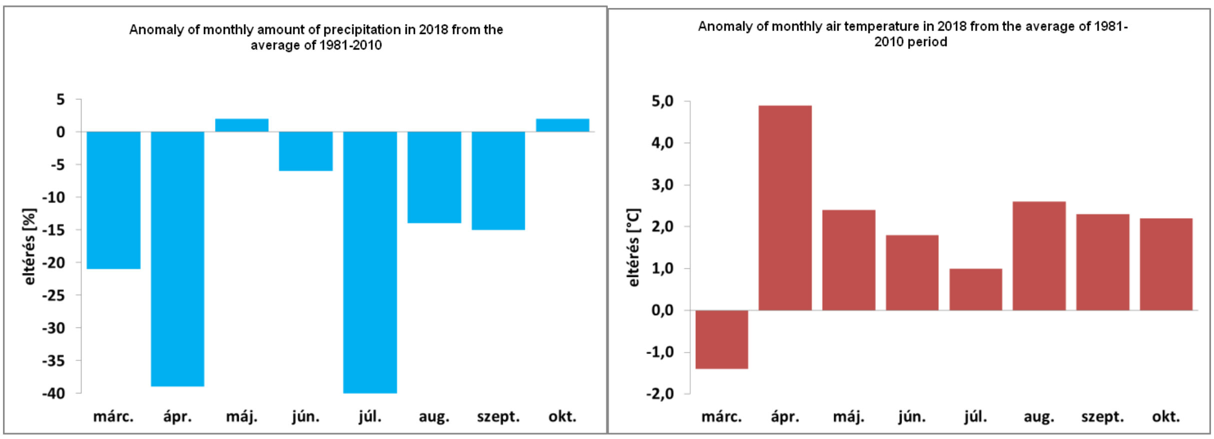

Fig. 1. Air temperature and precipitation anomaly (2018) in the whole territory of Austria [1]

In case of precipitation, it can be seen that only in May-June and October, was close to or reached the average, otherwise there was a significant lack of precipitation. Monthly average temperatures have been consistently and significantly above normal since April. The lack of precipitation and the high average temperatures indicated an increased evaporation loss on the river basin. As a result of this, the surface water runoff also decreased significantly in this time period on the whole Danube catchment area, which was also reflected in the flow regime.

2. Measured water levels and water discharges on the Danube between Vámosszabadi and Esztergom, August-October, 2018

The evaluated Danube section belongs to the North-Transdanubian District Water Directorate (EDUVIZIG) as its property manager. The layout plan of the Vámosszabadi – Esztergom section with the evaluated water gauges is shown on Fig. 2. Vámosszabadi is in the 1806 rkm, Esztergom is almost 100 km lower, in the 1715 rkm.

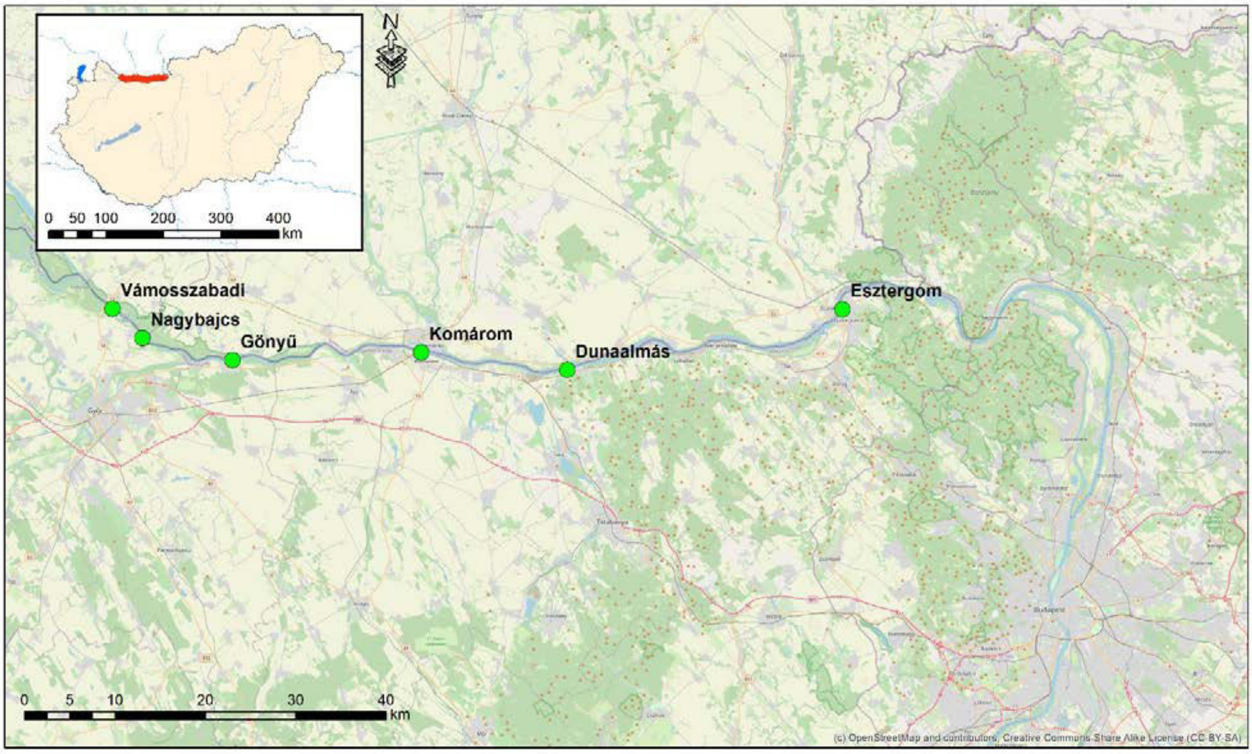

Fig. 2. The evaluated section of the Danube [2]

Since March 2018 the average monthly water discharges of the Danube has been below the long-term (1981-2010) average at all hydrographic stations on the territory of the Directorate. In January, due to two small flood waves, the water discharge was above the month’s long-term average. Then in February it was temporarily above average, and then stayed below the average values month by month. By the end of summer and then by the end of October, the low water status became so extraordinary that the water levels and water discharges in the whole Hungarian section were below the previous minimum values (abbreviated in Hungarian to LKV and LKQ) in several places.

The next table shows the new minimum water level and discharge values on the evaluated section.

Table 1: Previous and new extreme values on the evaluated Danube section [3]

Hydrographic station	Profile (rkm)	Ref. Point (masl)	Lowest water level (old)		Lowest water level (new)		Lowest discharge (old)		Lowest discharge in october 2018	
			Date	value (cm)	Date	value (cm)	Year	value (m3/s)	Date	value (m3/s)
Vámosszabadi	1805.6	108.40	30.11. 2011	-73	24.10.2018	-106	2006	669	24.10.2018	650
Nagybajcs	1801.0	107.40	26.10.1992	-31	24.10.2018	-32				
Gönyű	1790.6	106.04	26.10.1992	-93	-	-	-	-	-	-
Komárom	1768.3	103.88	01.01.2016	18	24.10.2018	-12	1938	595	24.10.2018	735
Dunaalmás	1751.8	103.12	04.01.1909	0	24.10.2018	1*	1985	802	24.10.2018	773
Esztergom	1718.5	100.92	30.08.2003	-2	25.10.2018	-21				

* - the measuring probe ran out of range, the minimum value was estimated by linearized regression

The measured water levels on this section developed as is shown on Fig. 3.

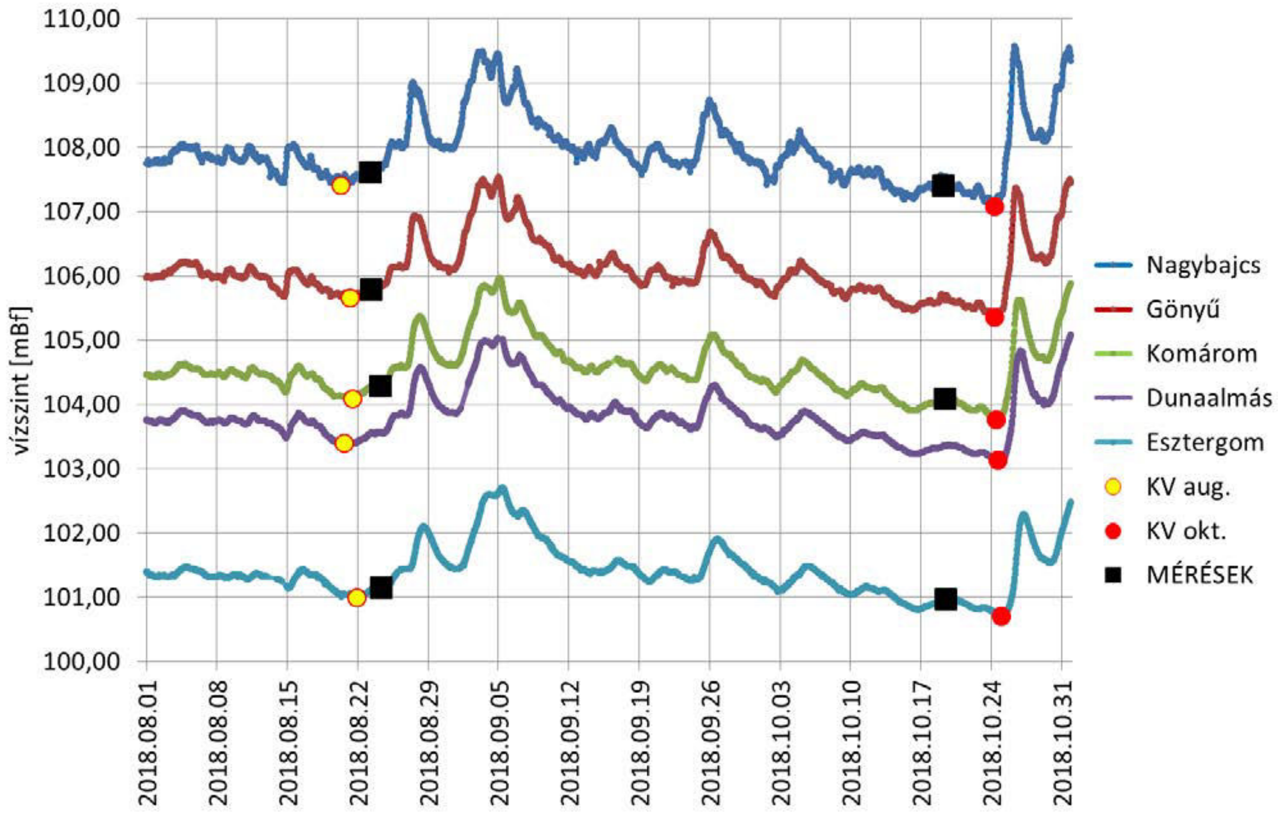

Fig. 3. Observed water levels on the Danube, August-October 2018 [3]

The figure also shows the location of the August and October extremes (yellow and red dots), as well as the results of water discharge measurements (black squares).
There were 3 measurement campaigns in August and in October, when the water discharges were measured by EDUVIZIG. The results of these measurements are shown in table 2.

Table 2: Measured water discharges on the evaluated Danube section [4]

Hydrographic station	Profile (rkm)	Ref. Point (masl)	august 23		august 24		october 19	
			H (cm)	Q (m3/s)	H (cm)	Q (m3/s)	H (cm)	Q (m3/s)
Vámosszabadi	1805.6	108.40	-53	847	-	-	-65	747
Gönyű	1790.6	106.04	-27	908	-	-	-	-
Komárom	1768.3	103.88	-	-	39	911	20	765
Esztergom	1718.5	100.92	-	-	21	994	3	896

The measurement conditions were established in a quasi-permanent status on the whole section, so the measured results were appropriate to evaluate the water discharges in the critical time period. Nevertheless, the measurements can be characterized by a larger standard deviation. This may cause by the operation of the Gabcikovo power plant, because the low water discharges are easily influenceable with the power plant. With the help of the long-term time series available at EDUVIZIG, the statistical properties of the low-water levels and low-water discharges can be determined at each hydrographic station.

3. Hydrologic examination of the water levels

In the first step I examined the trend changes of the annual minima of the water level time series on the affected Danube section's water gauges. These trend analyses are shown in the following figures.

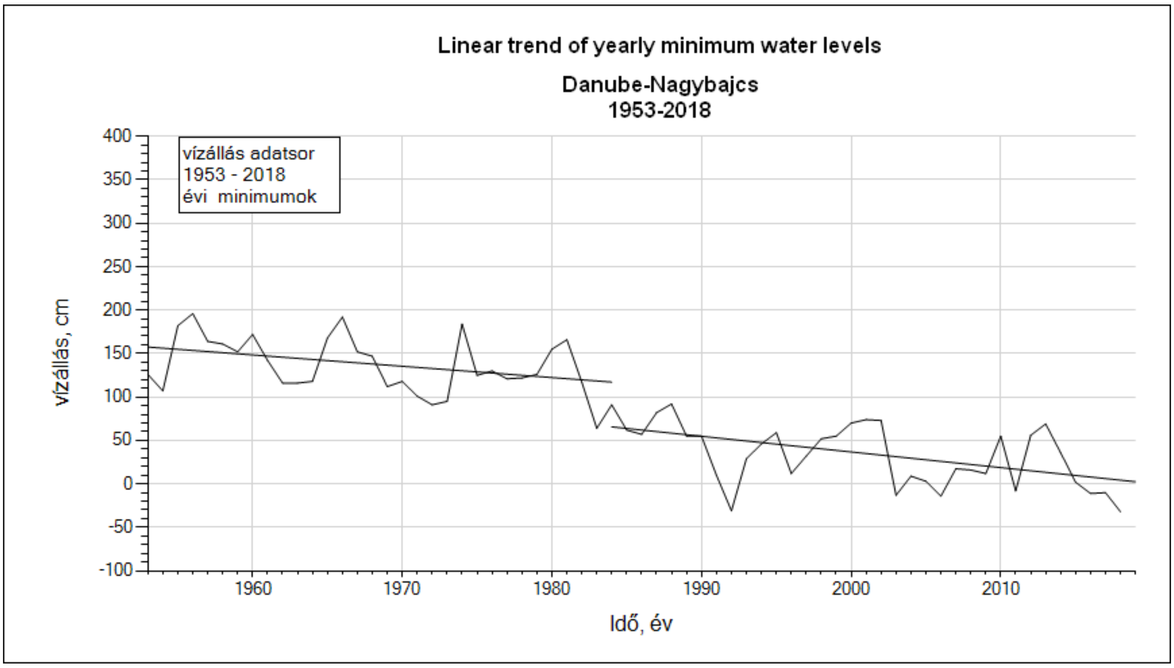

Fig. 4. Linear trend of yearly minimum water levels, Danube-Nagybajcs [5]

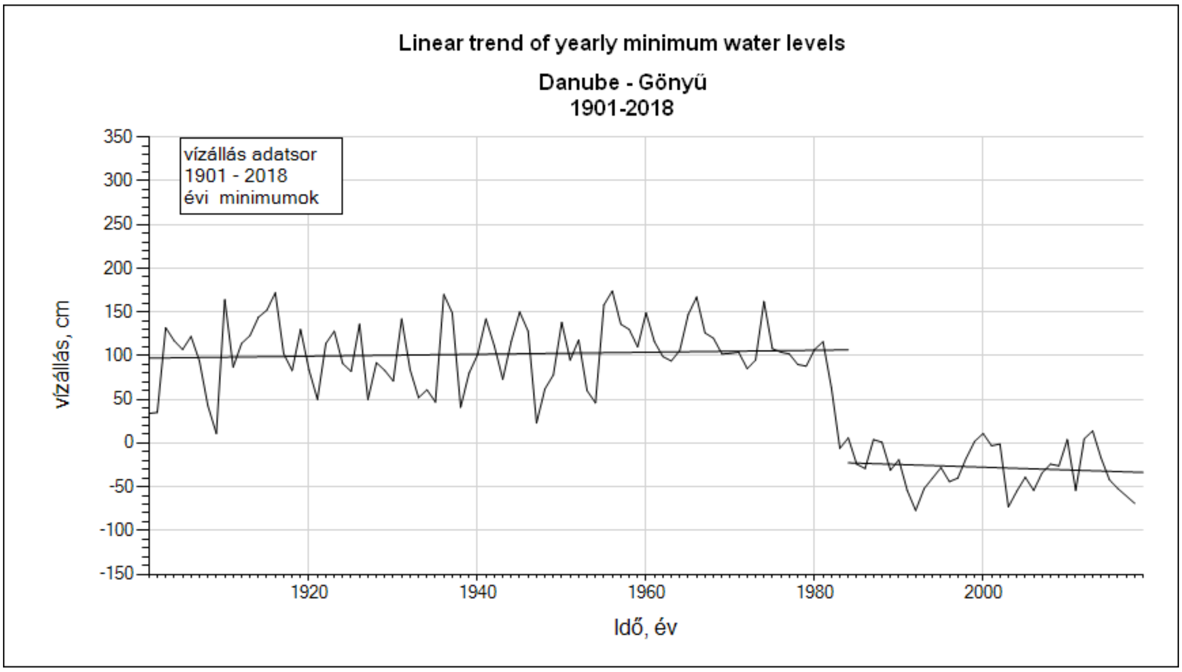

Fig. 5. Linear trend of yearly minimum water levels, Danube-Gönyű [5]

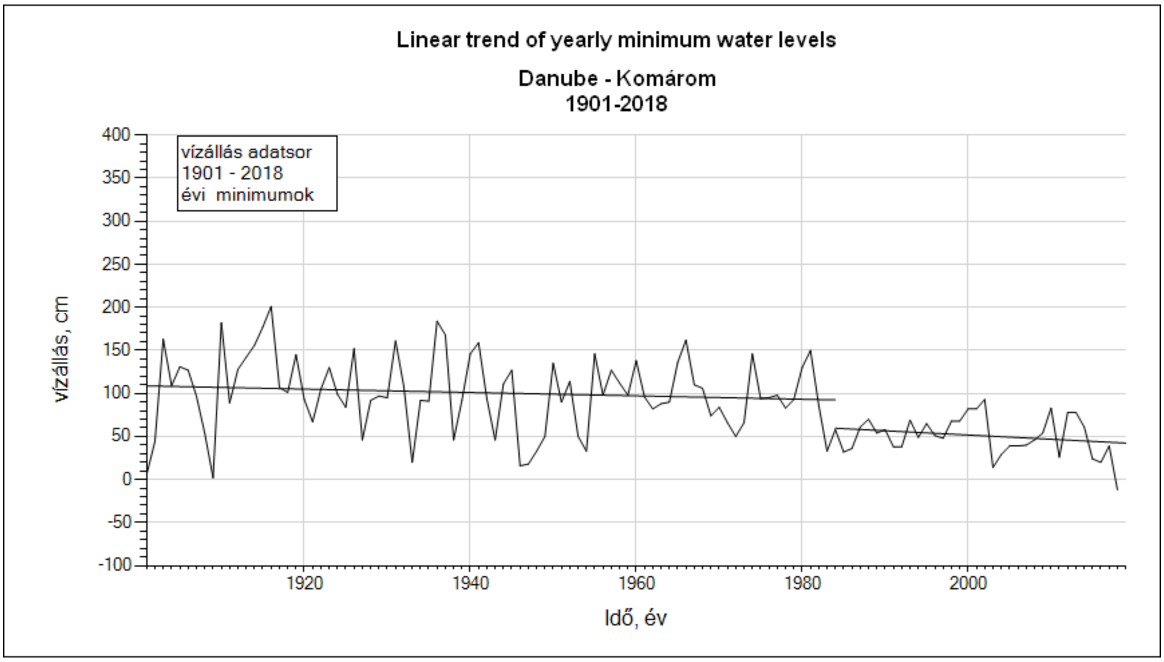

Fig. 6. Linear trend of yearly minimum water levels, Danube-Komárom [5]

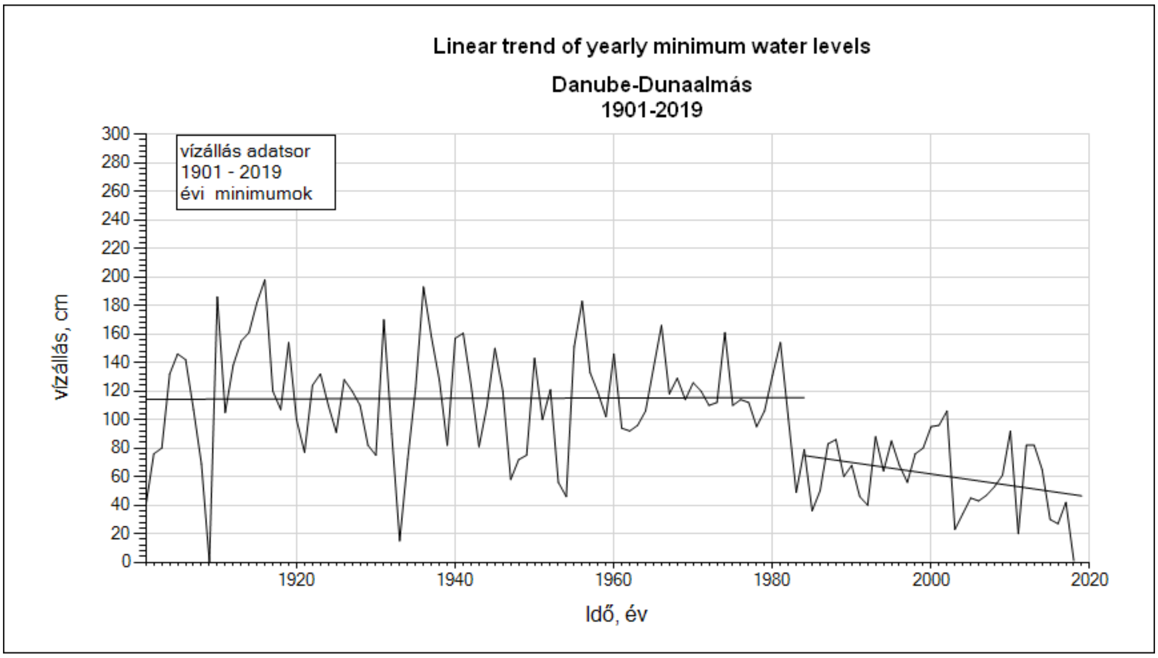

Fig. 7. Linear trend of yearly minimum water levels, Danube-Dunaalmás [5]

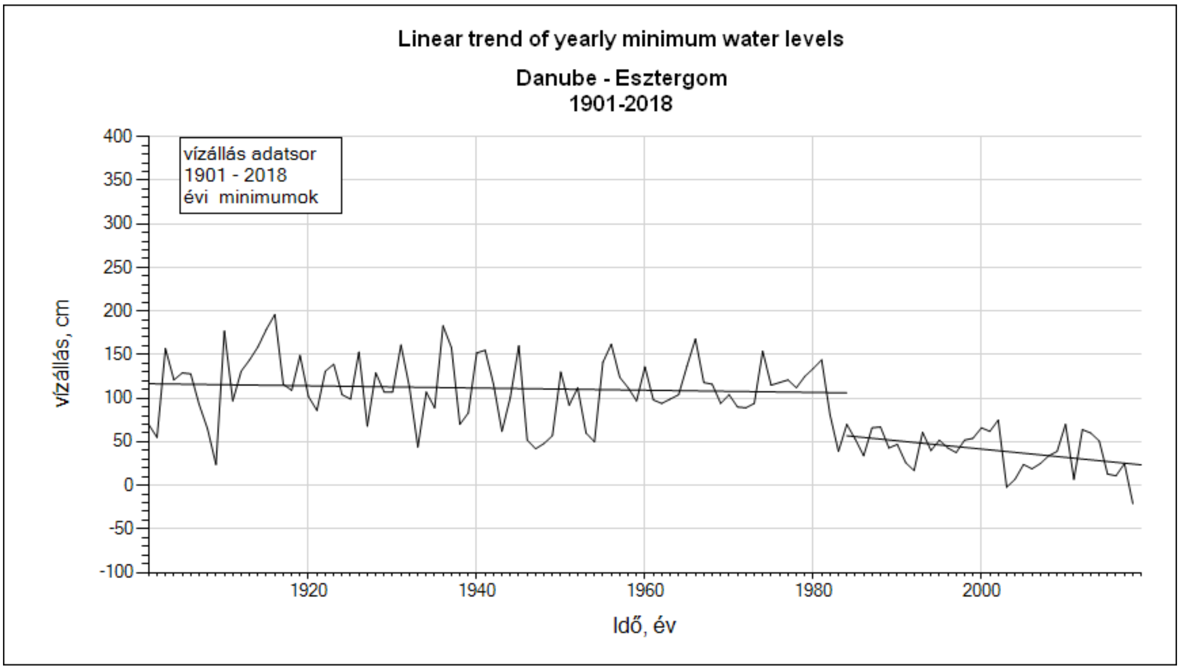

Fig. 8. Linear trend of yearly minimum water levels, Danube-Esztergom [5]

The formerly known significant changes of the Danube riverbed sinking, which began in the first half of the 1980s, are well illustrated by the staggered trend line plotted on the long-term data series. This phenomenon has significant impact on water regime, the low water levels are continuously decreasing. For this reason, the complete time series cannot be considered statistically homogeneous in any way. Despite the better fit, distribution function examinations for the whole period (1901-2018) of the time series would not provide reliable estimations on the behavior of the 2018 low-water levels, so I evaluated the primary stochastic variable, the water discharges.

The table below summarizes the average values of the linear trends fitted to the water level minima for each station.

Table 3: Linear trend analysis of the water levels

Hydrographic station	whole period	average trend (cm/year)	period1	average trend (cm/year)	period2	average trend (cm/year)
Nagybajcs	1953-2018	-2.8	1953-1983	-1.3	1984-2018	-1.8
Gönyű	1901-2018	-1.3	1901-1983	0.1	1984-2018	-0.3
Komárom	1901-2018	-0.6	1901-1983	-0.2	1984-2018	-0.5
Dunaalmás	1901-2018	-0.6	1901-1983	0.0	1984-2018	-0.8
Esztergom	1901-2018	-0.8	1901-1983	-0.1	1984-2018	-1.0

The annual minima of the Danube water levels show a decreasing trend for the whole period from Nagybajcs to Esztergom, but the extent of this sinking is significant only in the upper part of the examined Danube section. Prior to the 1980s, there was no significant change in the values of the annual minima (the time series in Nagybajcs is significantly shorter than the others). In the last 34 years there has been a definite decrease in the water levels in the area of Nagybajcs and Esztergom.

4. Hydrologic examination of the water discharges

The trend analysis results of the annual water discharge minima for stations with water discharge statistics are presented in the following figures.

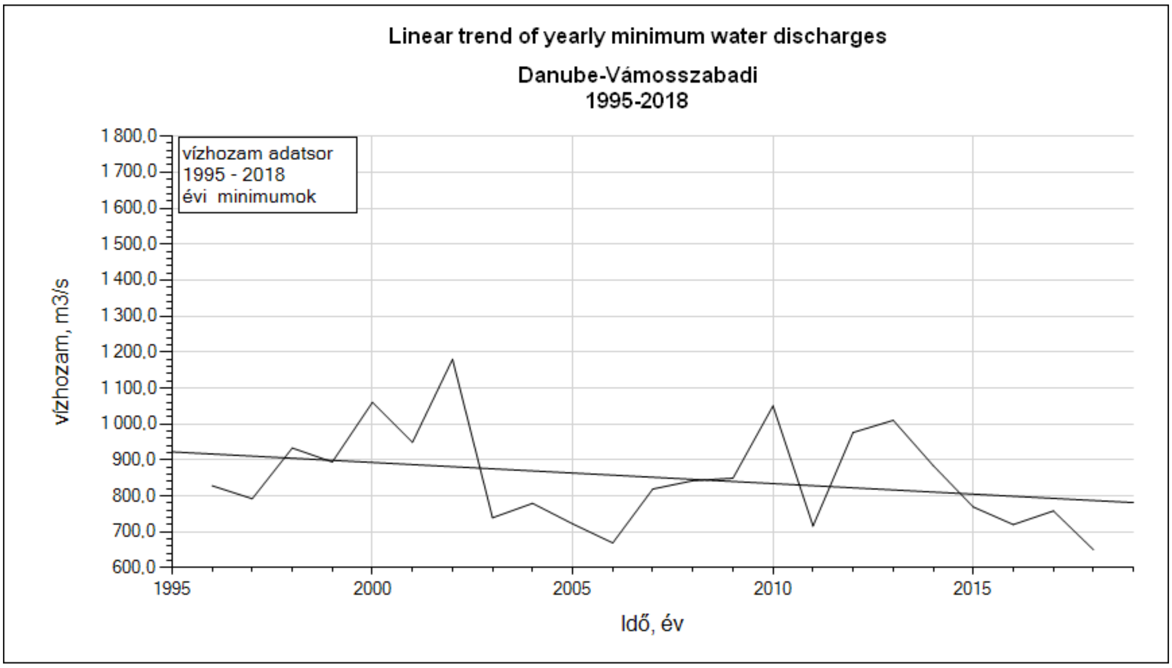

Fig. 9. Linear trend of yearly minimum water discharges, Danube-Vámosszabadi [5]

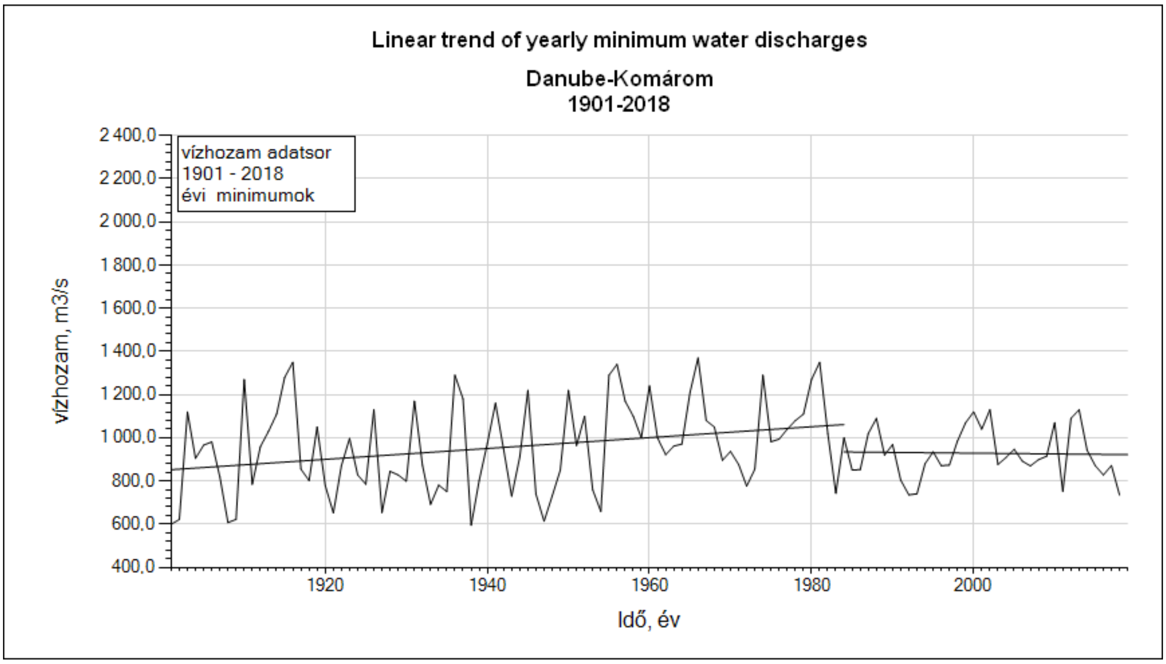

Fig. 10. Linear trend of yearly minimum water discharges, Danube-Komárom [5]

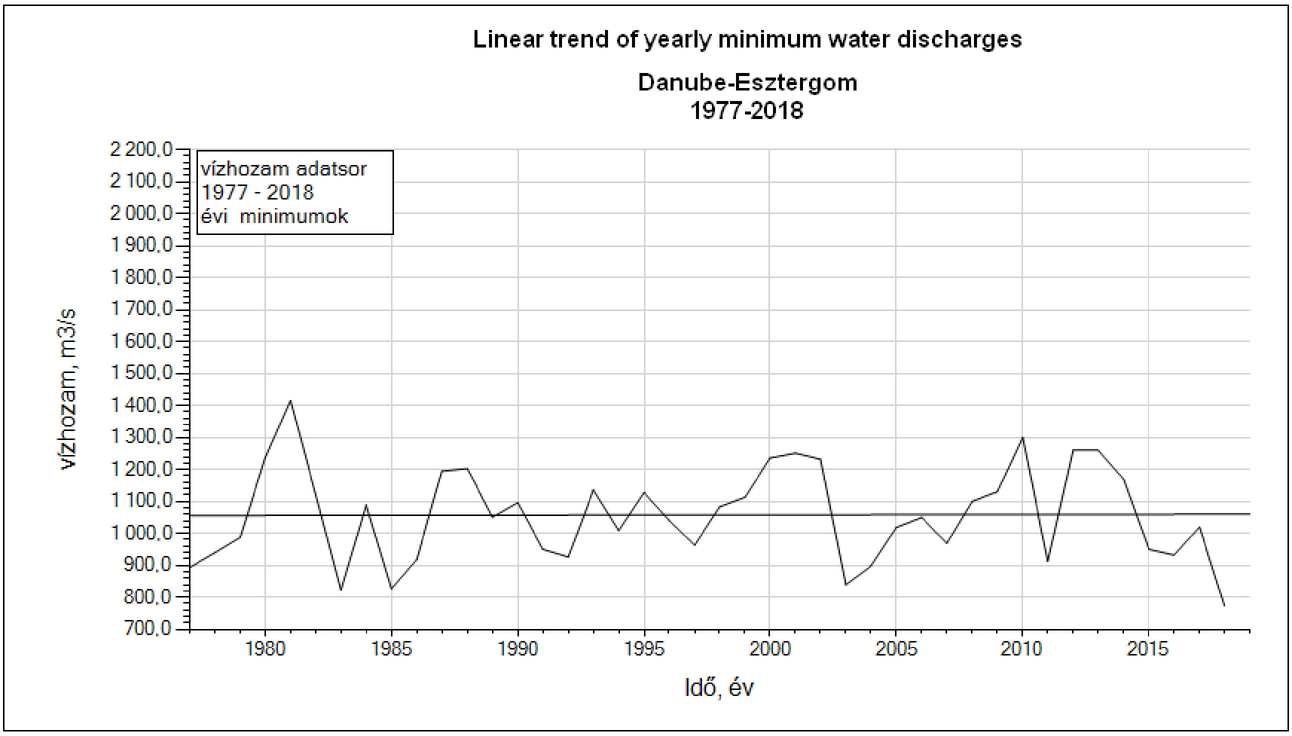

Fig. 11. Linear trend of yearly minimum water discharges, Danube-Esztergom [5]

In case of the annual minima of water discharges, the historical time series only at Komárom water gauge are long enough to show the effect of the changes of the 1980s in the trend analysis, where a slightly upward trend ceases and the standard deviation of the values is almost halved ($D_{1901\text{-}2018}$ = 187 m^3/s, $D_{1901\text{-}1983}$ = 211 m^3/s, $D_{1984\text{-}2018}$ = 114 m^3/s).
In the area of Nagybajcs (Vámosszabadi) the short data series shows a definite decrease, but this cannot be considered significant due to the shortness of the data series. The Esztergom time series does not show relevant a change in the values of low-water discharges since the beginning of the measurements.
The following table shows the average values of trend parameters.

Table 4: Linear trend analysis of the water discharges

Hydrographic station	whole period	average trend (cm/year)	period1	average trend (cm/year)	period2	average trend (cm/year)
Vámosszabadi	1995-2018	-6	-	-	-	-
Komárom	1901-2018	1	1901-1983	3	1984-2018	0
Esztergom	1977-2018	0	-	-	-	-

Overall, the trend analyzes show that the annual minima of water levels follow a detectable, decreasing trend, while in the case of water discharges this can only be observed in the short data set of Nagybajcs (Vámosszabadi). The two types of trend analyses together prove the known process of sinking and embedding of the Danube riverbed. The extent of this phenomenon is the most significant in the Gönyű area. The figure below shows the long-term changes in the annual minimum water levels and discharge data observed in the Danube-Komárom water gauge. The water level data set apparently undergoes a marked change since the 1960s and is forced into a "trend channel" (red graph). The increasing frequency of extreme small waters (even LKV) can also be attributed to this declining trend.
Looking at the data series of water discharges, we can talk about a different process from the change in water levels. From the 1980s onwards, low-water discharges - probably due to the

reservoirs established in the upper section of the Danube - are scattered in a narrower range than before, the trend channel is horizontal and unchanged (green graph).

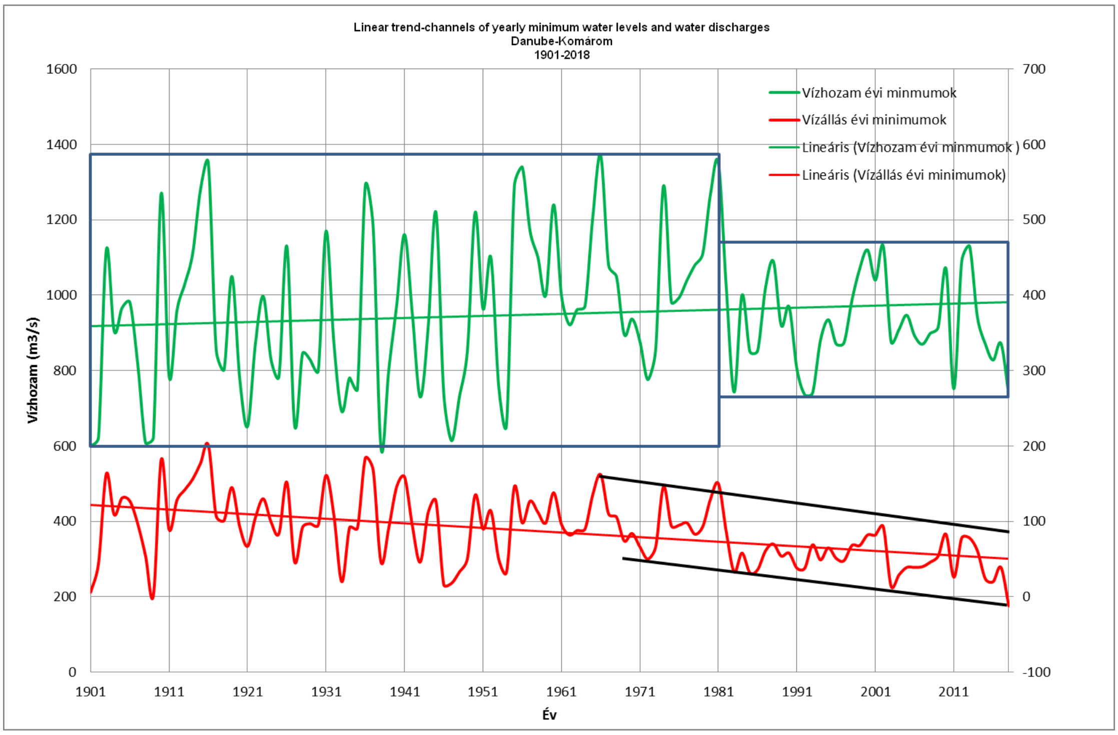

Fig. 12. Linear trend-channels of yearly minimum water levels and water discharges, Danube-Komárom

In the case of the Komárom water discharge minima, the period function of the long-term data series also well reflects the changes, in line with the trends.

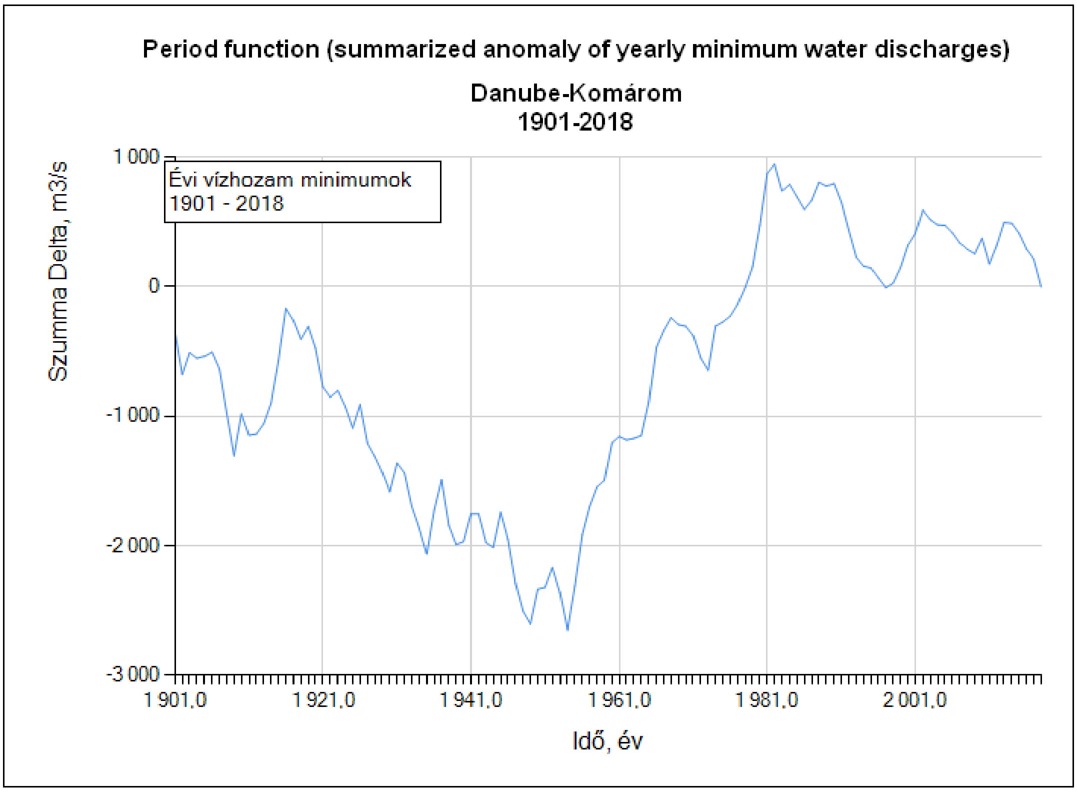

Fig. 13. Period function, Danube-Komárom [5]

The distribution function of the annual water discharge minima was also examined, but for water level data this was omitted, due to the significant inhomogeneity observed in the time series. By separating the water discharge data sets in 1984, we obtained samples that can already be considered homogeneous, although the size (number of items) of the samples is rather small. Based on the results the probability of the occurrence of low-water discharge values occurring at each hydrographic station in October 2018 can be estimated, so we can calculate their average return time. The finally chosen Pearson3-type theoretical distribution functions are as follows:

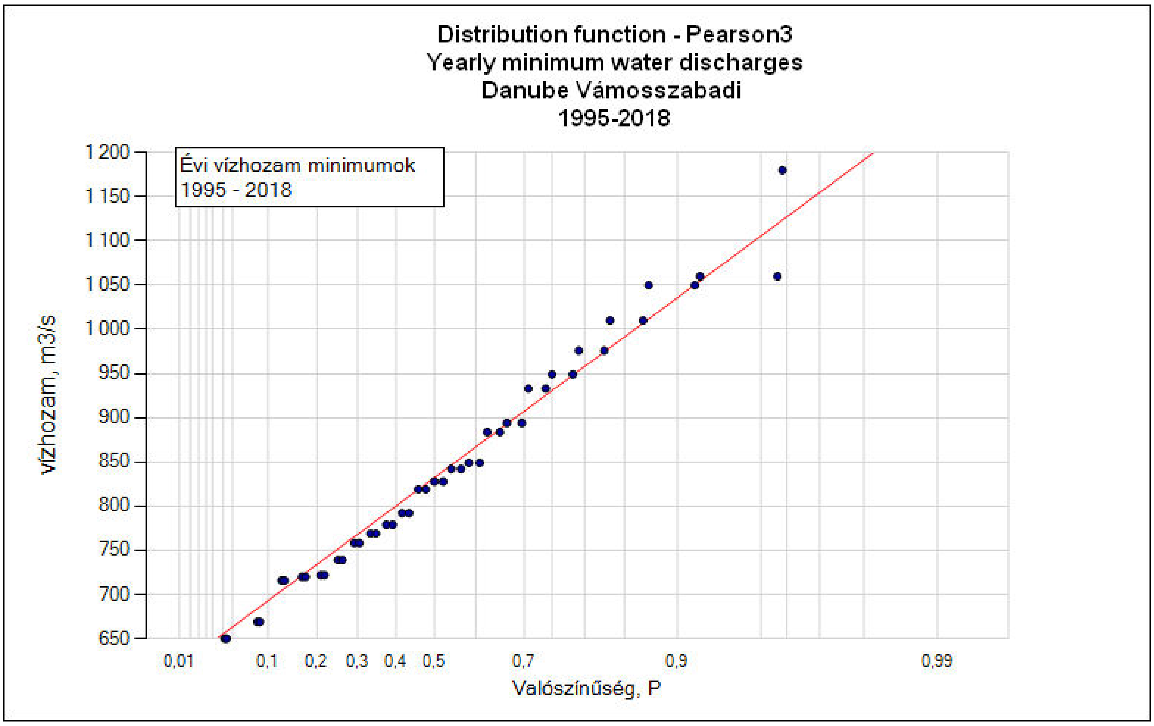

Fig. 13. Pearson3-type distribution function for yearly minimum water discharges, Danube-Vámosszabadi [5]

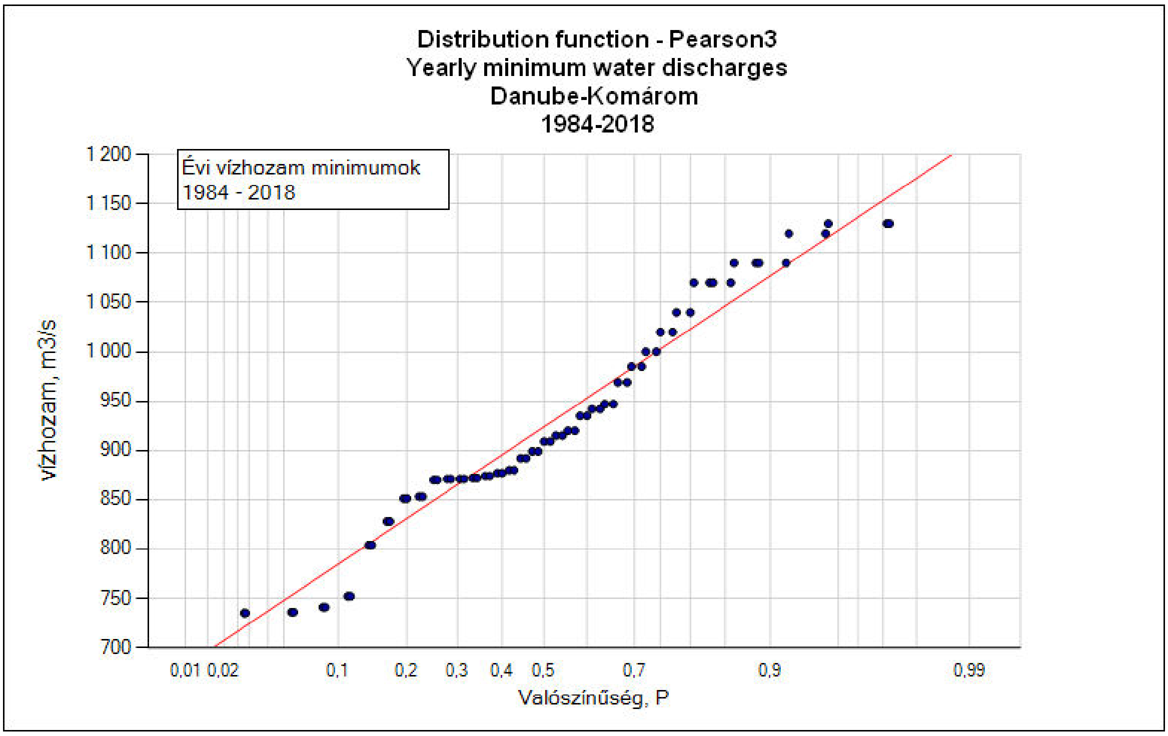

Fig. 14. Pearson3-type distribution function for yearly minimum water discharges, Danube-Komárom[5]

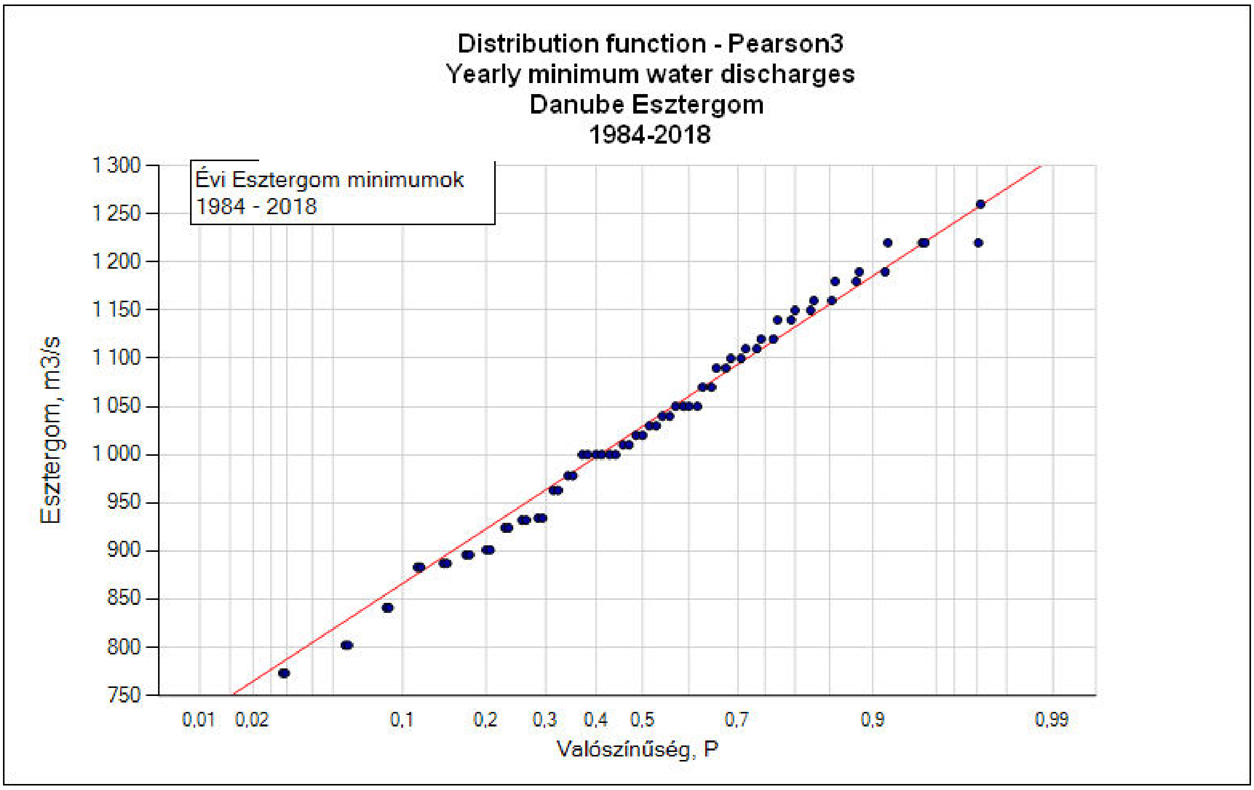

Fig. 15. Pearson3-type distribution function for yearly minimum water discharges, Danube-Esztergom [5]

Based on the empirical distributions of the annual minima of water discharge and the three best fit theoretical distribution functions overall, the estimated low-water discharge return times in October 2018 are given in the table below.

Table 5: Calculated return times of the 2018 low water discharges

Distribution function type	**Nagybajcs**	**Komárom**	**Esztergom**
	1995-2018	1984-2018	1984-2018
Log-Pearson 3	30 years	28 years	49 years
Pearson 3	**30 years**	**26 years**	**43 years**
GEV	25 years	30 years	42 years
empirical	**46 years**	**70 years**	**68 years**

Conclusions

Examining the Komárom data after 1984, or the shorter time series on other stations, we get that the low-water discharges return times in October 2018 can be characterized in the range of 25-50 years. Considering the empirical distribution this range is between 45-70 years. The higher return times are characteristic on the lower stations of the evaluated section.

Based on the basic statistical evaluations, the following conclusions can be drawn:

Due to the natural changes and artificial interventions affecting the Danube riverbed, the available ≈100-year-long water level and water discharge time series cannot be considered statistically homogeneous.

The methodological theses of previous low-water studies, which considered the statistical evaluation of water levels as primary variable, seem to be overturned. It is possible that the water discharge data sets for the period from 1980 to the present seem more realistic as a primary variable for the study of low waters. Using the data of the last nearly 40 years, we get a mostly homogeneous time series, however, when examining annual extreme values, the statistical sample will be quite small, which can significantly impair the results and reliability of the simple trend and distribution function tests. The studies established different average return times for the low-water level and low-water discharge values in October 2018 at the given hydrographic stations, respectively. In addition to the trend studies, this is explained by the changes in the riverbed that can still be observed in the Danube, which are the most significant in the Gönyű regional section.

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Researches on the Constructive Solutions of Fine, Fixed Bubble Generators

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Abstract: *The paper presents the constructive solutions and the operation of fine, fixed bubble generators, used for aeration / oxygenation of stationary waters. By the scheme, the components and the operation of four installations for water treatment are revealed; the advantages of using fine bubble generators in water aeration processes are indicated.*

Keywords: *Fine bubble generator, water aeration installations.*

1. Introduction

Stationary water aeration is important and has many technological applications.
One of the ways to improve the mass transfer from air to water is by moving the fine bubble generators; this operation can be done through a variety of systems depending on the geometry and size of the tank, the lake where aeration is desired.
This aeration by moving the fine bubble generator is thought of as a local aeration, or as a series of local aerations.
Under normal conditions for a more efficient oxygenation of stationary water, with free surface, it is necessary that the air bubble that is emitted by a generator of fine bubbles describes a trajectory as long as possible in the water.
This trajectory practically influences the amount of oxygen that dissolves in the water, and is optimal for aerations where the height of the water layer above the fine bubble generator is not high, this height being practically determined by the amount of oxygen in the air bubble; above this height, the air bubble no longer provides a transfer of O_2 to the water even if it is still in contact with water.
The dynamics of gas bubbles in a liquid are treated extensively in fluid mechanics, especially the problem of rising bubbles having important applications in biochemistry, medicine, etc.
It also raises interesting mathematical problems; in this sense many studies have been conducted to study the rise of gas bubbles emitted from submerged orifices.
Aeration of water is achieved by introducing atmospheric air into the water as follows [1]:
1. By mechanical aeration;
2. By pneumatic aeration.
- In the case of mechanical aeration, the air is introduced into the water under the action of rotors, pallets, etc. performing surface aeration.
- In the case of pneumatic aeration, the air is sent to diffusers made of plastics, ceramics, etc.; these diffusers are located below the water level, thus aerating the water with air bubbles. Recently, fine bubble generators (FBG) have also been used [2].
From the literature [4][5] it is known that the rate of oxygen transfer to water increases as the diameter of the air bubble decreases; the diameter of the air bubble is a function of the diameter of the orifices in the perforated plate of the FBG.

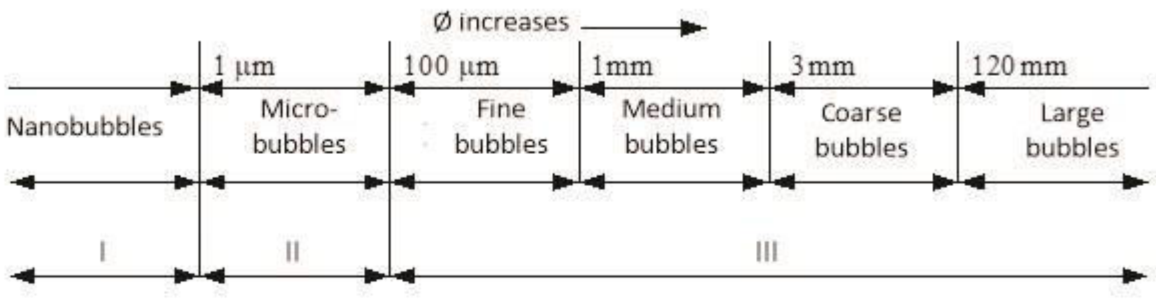

Fig. 1. Classification of gas bubbles according to their diameter
I - the area where the gas bubbles can be observed under the microscope;
II - the area where gas bubbles can be observed with difficulty;
III - the area where gas bubbles can be observed with the naked eye.

Gas bubbles (atmospheric air or a mixture of gases) can be classified according to the data in figure 1.

2. Constructive solutions and operation of fine, fixed bubble generators, which are used for water aeration

2.1 Classification of air bubble generators

The classification of fine bubble generators (FBG) is based on the following criteria [6]:
I. By placing the orifices in the perforated plate:
- Circular FBG;
- Rectangular FBG.

II. According to the nature of the gas introduced into the water, there are:
- FBG at which atmospheric air is introduced into the water;
- FBG in which a gaseous mixture consisting of:

- atmospheric air + oxygen from a cylinder;
- atmospheric air with low nitrogen content;
- atmospheric air + ozone.

III. According to the operation principle, fine bubble generators (FBG) are divided into two classes:
1. Fixed FBG;
2. Mobile FBGs, which may be in one of the following situations:

- performs a rotational movement in the water tank;
- performs a translational movement in the water tank.

It is useful to make a division of expressions, as follows:
I. Water aeration refers only to the introduction of atmospheric air into water (21% O_2 + 79% N_2).
II. Oxygenation of water refers to the introduction of gaseous mixtures in which the oxygen exceeds 21%.
Obviously, I + II have the same purpose, namely to increase the concentration of dissolved oxygen in water. Increasing the percentage of O_2 introduced into the water by more than 21% reduces the time in which water oxygenation takes place.

2.2 Fine, fixed, circular bubble generators

Fine, circular bubble generators are the best known and most used due to their constructive advantages; they are either with elastomer membranes, or made of ceramic materials or perforated plates.
Membrane fine bubble generators, unlike ceramic ones, are suitable for intermittent operations, as the air release perforations will open and close depending on the air inlet, while preventing waste water from entering the aeration system.
Membrane fine bubble generators are therefore a standard component in both nitrogen removal (simultaneous denitrification, circular) and biological phosphate removal (aerobic / anaerobic alternatives, also circular).

Membrane fine bubble generators have a supporting structure (FRP, PVC or PPE) in their construction, on which the perforated rubber membrane and the air supply are fixed. Having adequate perforations and constructed of a quality material, the characteristics of the bubbles will depend on the distribution of the discharge along the effective surface of the fine bubble generator.
The orifices open after a certain deformation of the diaphragm, deformation that depends on the air flow rate and pressure in the fine bubble generator, the fastening element of the diaphragm and the constructive shape of the body of the fine bubble generator.
With the increase of the air flow rate in the fine bubble generator, all the above factors no longer influence the formation of air bubbles, because all the openings will open at a certain flow rate.
Because the design is circular (cylindrical), and after deformation takes the form of a dome, a large part of the air flow rate will pass through the central part of the membrane into larger bubbles, while the marginal areas are not representative.
These areas lead to a significant decrease in the active area of air bubble formation in the case of circular fine bubble generators.
For the experimental study, a circular bubble generator was designed and built, with a perforated plate as an element of air dispersion in the water mass, because in this constructive version no problems are encountered with membrane equipment or porous materials.
A constructive version of a plate with 37 orifices was designed, having a diameter of 0.5 mm which were arranged so that they create, as a whole, a column of "circular" bubbles; the distribution of the orifices in the circular plate can be seen in figure 2, they being arranged linearly and comprised in a circle with a diameter of 35 mm, at a distance equal to each other 5 mm.

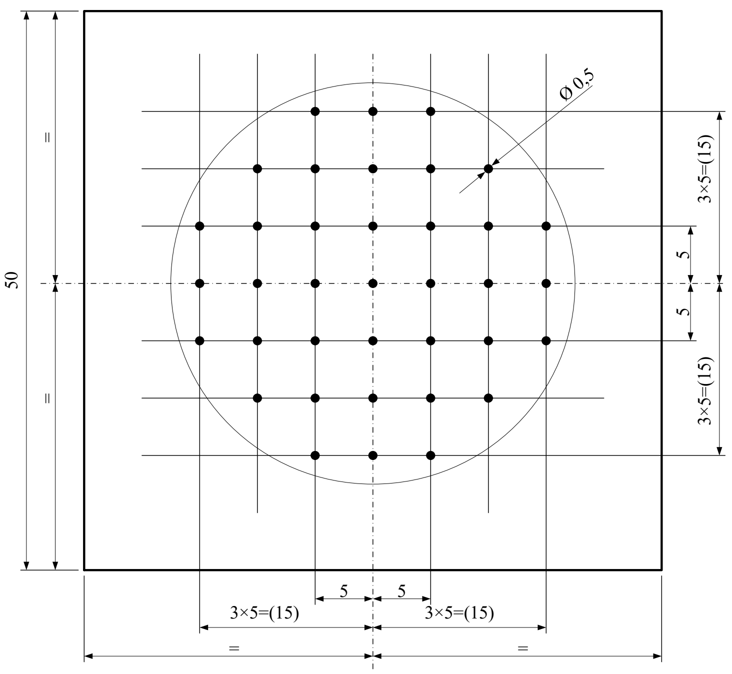

Fig. 2. Sketch of the perforated plate of the fine bubble generator

This plate has been designed and built to be an integral part of a fine bubble generator, with which experimental researches are performed in the laboratory, which will establish the operation and performance of such equipment.
The plate of figure 2 constitutes the main element of the generator of fine bubbles, of circular shape, presented in view (fig. 3) and in section (fig. 4); its orifices form fine air bubbles through which the water is oxygenated.

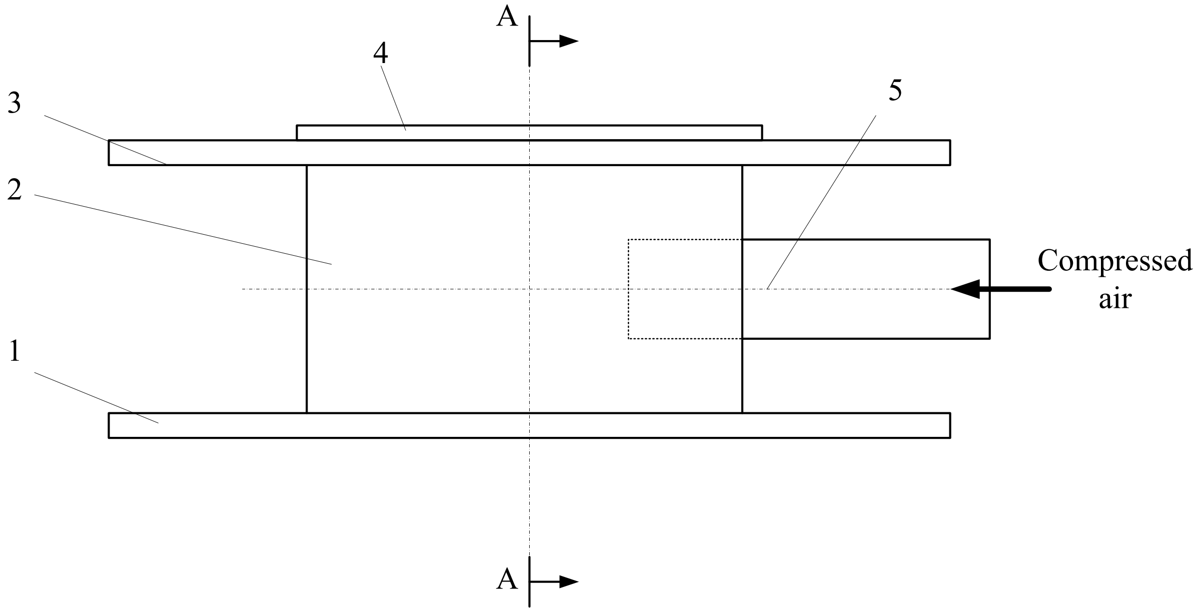

Fig. 3. Circular fine bubble generator (view):
1 - base plate; 2 - cylinder ø35; 3 - upper plate;
4 - plate with orifices; 5 - air supply pipe

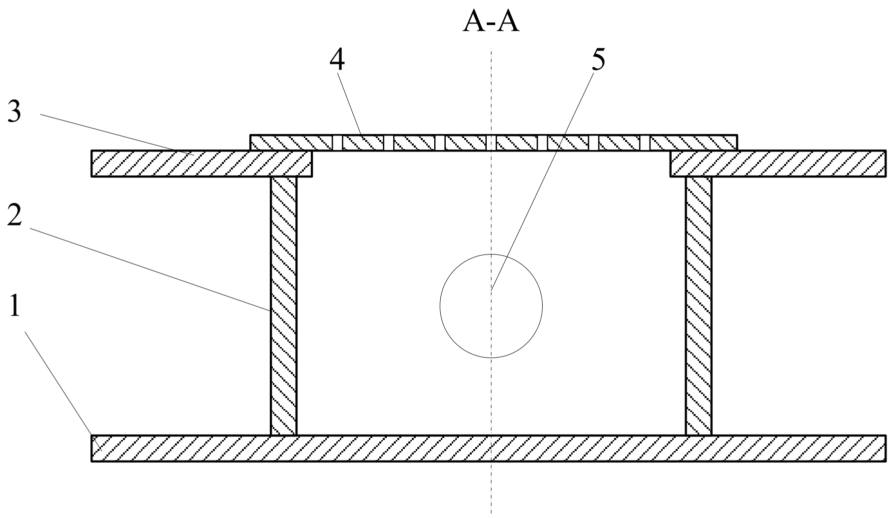

Fig. 4. Circular fine bubble generator (section):
1- base plate; 2 - cylinder Φ 35; 3 - upper plate;
4 - plate with orifices; 5 - compressed air supply pipe

Fixing the plate to the body of the fine bubble generator as well as its construction (gripping the component parts) was done by gluing, using a compound based on Acrylic.

2.3 Rectangular fine bubble generator

In the second constructive version, i.e. rectangular FBG, the plate also has 37 orifices with a diameter of 0.5 mm which were arranged in a single row, at a distance of 5 mm, so that the bubble columns as a whole, at the exit of the fine bubble generator, to create a bubble curtain similar to that of a flat jet that has a rectangular cross section [3]. The distribution of the Ø0.5mm orifices is observed in figure 5, where one can see the construction of the generator and the connection to the compressed air duct:

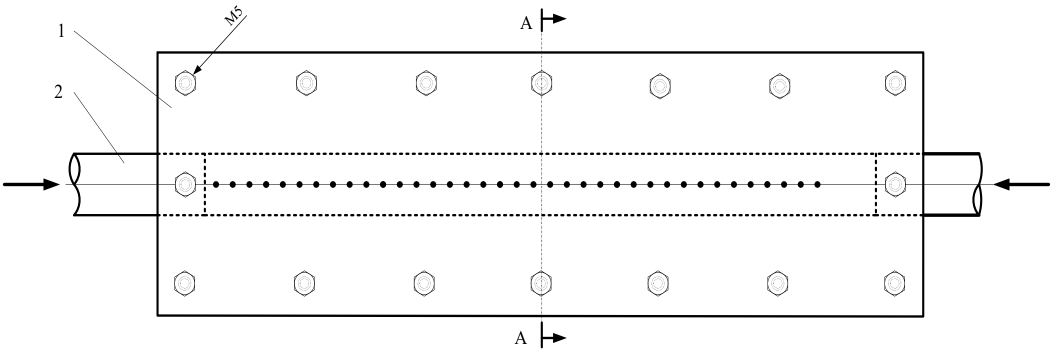

Fig. 5. FBG sketch in version II where the perforated plate can be observed:
1-plate with holes; 2- compressed air supply pipe

As one can see from the construction of this type of fine bubble generator, the air supply can be made through both ends of the generator. This facilitates the connections between the generators, when one use a series of such generators.

If a section is performed through the fine bubble generator (A-A), one can obtain the figure below, where its components are also presented (figure 6).

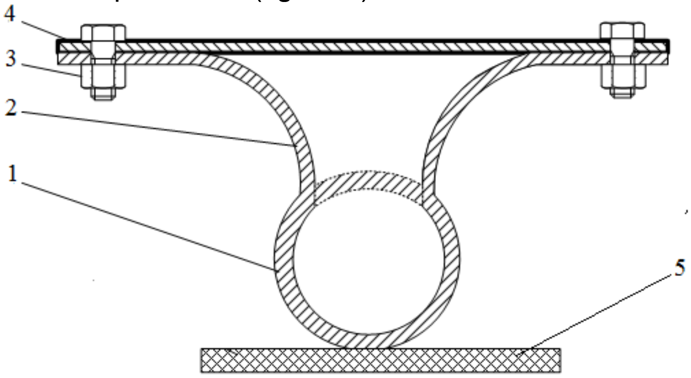

Fig. 6. Rectangular FBG section:
1- compressed air supply pipe; 2 - FBG body; 3 - body plate fixing screws; 4- plate with orifices; 5 - support

Following the calculations and the imposed conditions, this fine bubble generator was calculated, resulting in a rectangular fine bubble generator, (figure 7):

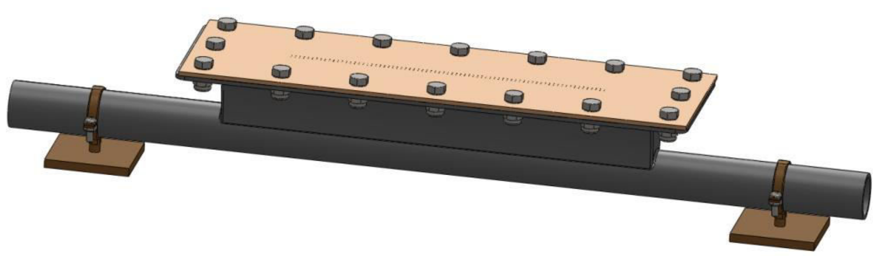

Fig. 7. Fine bubble generator - the second constructive version, rectangular shape

By its design, the physical realization of the designed model was carried out, namely the plate with orifices was also eroded, and the component parts of the body of the fine bubble generator were made of metal and joined by welding.
Figure 8 shows the built-in and assembled fine bubble generator.

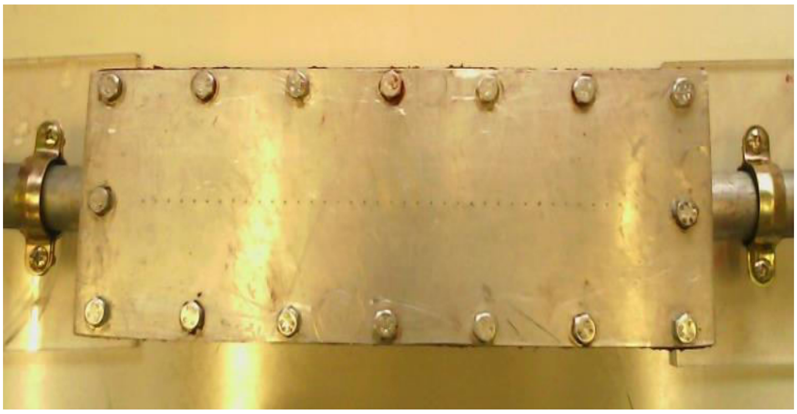

Fig. 8. FBG assembly of the fine bubble generator body and the plate fastened with screws

A sealing system is provided between the orifice plate and the flange of the fine bubble generator body to withstand the action of water consisting of a silicone gasket.

3. Installations for the insufflation of gas mixtures in water

Depending on the nature of the gas introduced (criterion II, par. 2.1) into water, there are [7][8]:

3.1 Fine bubble generator which introduces atmospheric air into the water (figure 9)

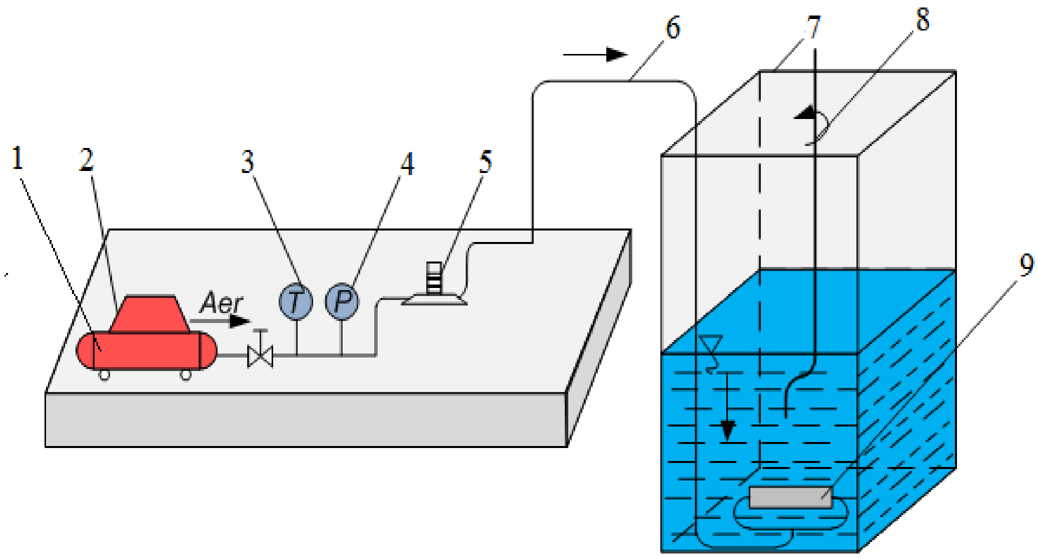

Fig. 9. Sketch of the experimental installation for introducing atmospheric air into water
1 - air compressor; 2 - compressed air tank; 3 - temperature measuring device; 4 - gas pressure measuring device; 5 - rotameter; 6 - compressed air supply pipe of the fine bubble generator; 7 - parallelepiped tank with water; 8 - oxygenometer probe; 9 - bubble generator with 152 orifices Ø 0.1 mm

From the compressor (1) the air is introduced into a compressed air tank (2) and then the rotameter (5) is used to measure the flow rate; finally the air enters the FBG (9).

3.2 Fine bubble generator which introduces a gas mixture: air + oxygen from the cylinder

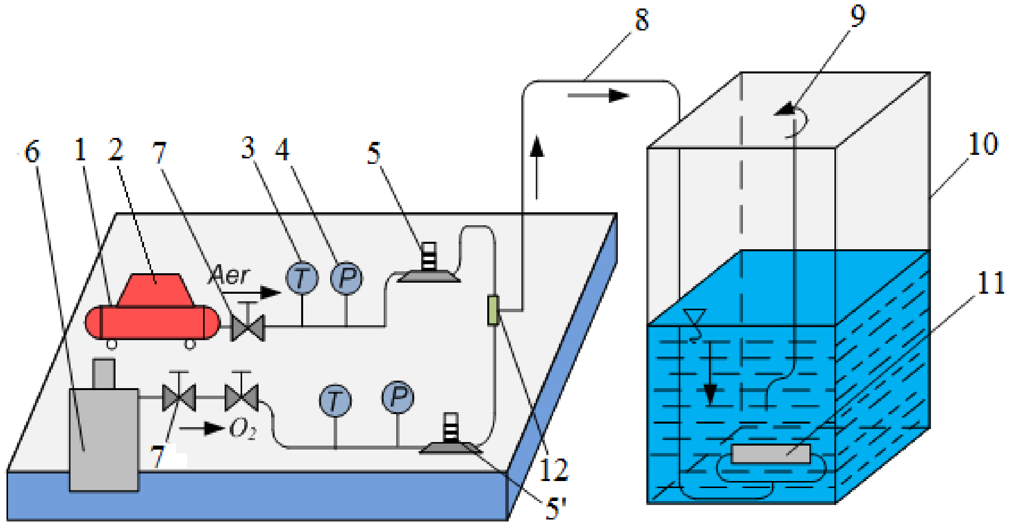

Fig. 10. Scheme of the installation that introduces a mixture of atmospheric air and oxygen into the FBG
1 - air electro compressor; 2 - compressed air tank; 3 - gas temperature measuring device with digital indication; 4 - gas pressure measuring device with digital indication; 5, 5 '- rotameters; 6 - oxygen cylinder: p = 120 bar; 7 - pressure reducer; 8 - air supply pipe + O_2 of the FBG; 9 - oxygenometer probe; 10 - water tank; 11 - fine bubble generator; 12 - mixing chamber of the two gas currents

From the compressor (1) the air is introduced into a compressed air tank (2) and subsequently into the mixing chamber (12) where it mixes with the oxygen supplied by the cylinder (6); the rotameters (5) and (5 ') are used to measure the flow rates. Finally, the mixture of atmospheric air and oxygen enters the FBG (11).

3.3 Installation using low nitrogen air

Figure 11 shows the installation scheme; the air delivered by the oxygen concentrators (1) passes through each rotameter (2) contained in the generator (1) which delivers low nitrogen content and then enters the FBG [9].

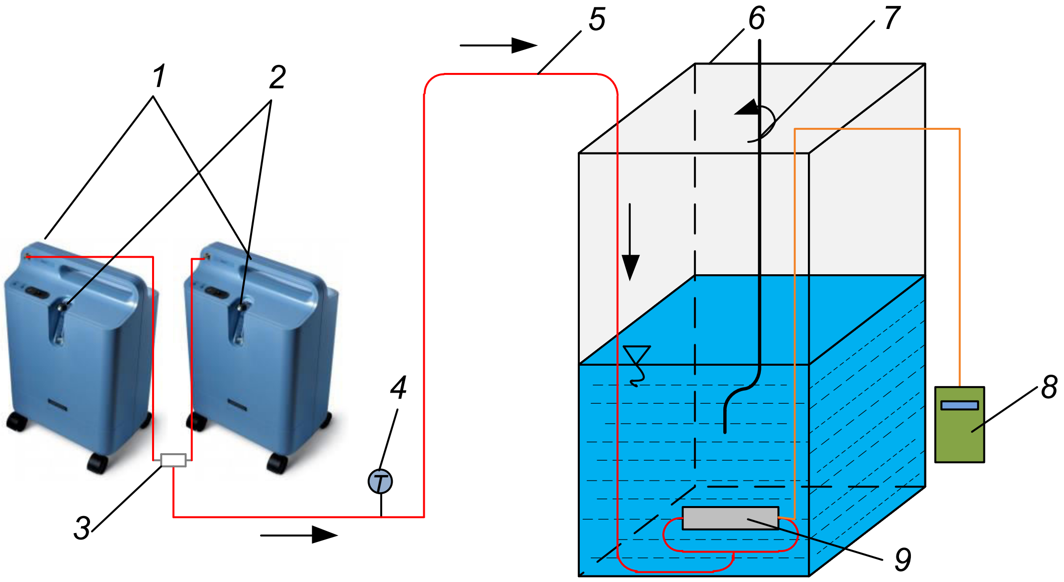

Fig. 11. Scheme of the low-nitrogen air introduction system in the FBG:
1 - oxygen concentrators; 2 - rotameters; 3 - mixing chamber of the two gas currents; 4 - gas temperature measuring device with digital indication; 5 - low nitrogen air supply pipe of FBG; 6 - parallelepiped tank with water; 7 - oxygenometer probe; 8 - gas pressure measuring device with digital indication; 9 - fine bubble generator with 152 orifices Ø 0.1 mm

Through the pipe 5 the air enters the FBG (9) which is in the water tank (6); the volume of water is 0.5 x 0.5 x 0.5 = 0.125 m^3.

3.4 Installation using a mixture of air and ozone

The scheme of the installation is shown in Figure 12 [10].

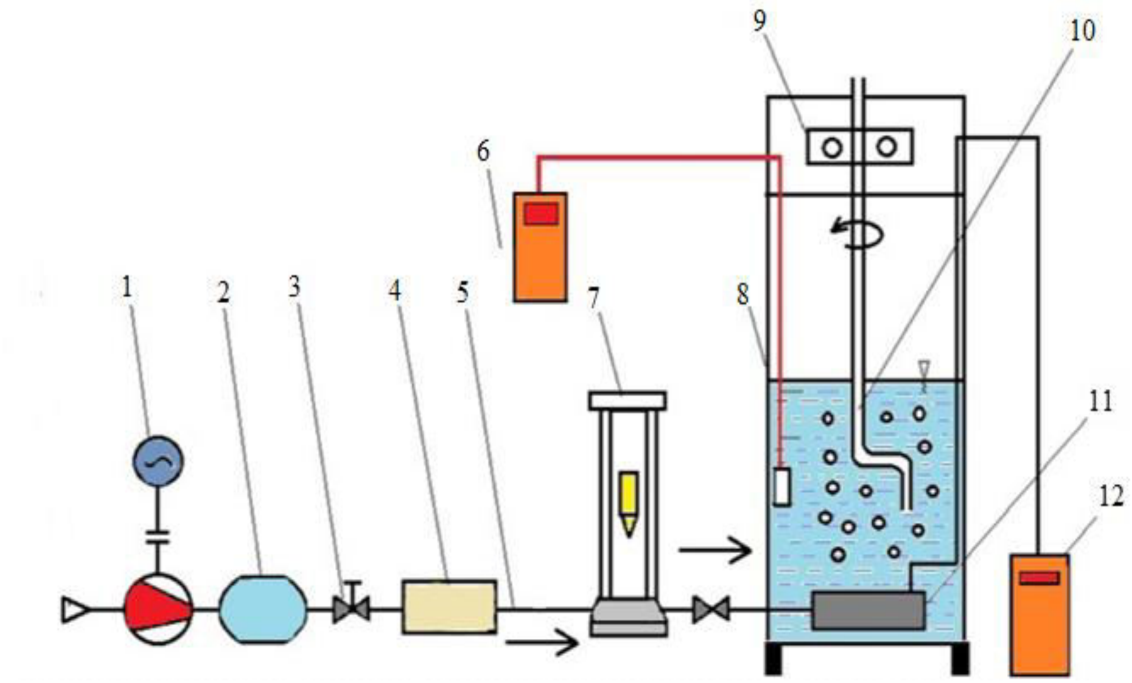

Fig. 12. Scheme of the installation for water oxygenation researches
1 - electro compressor; 2 - compressed air tank; 3 - pressure reducer; 4 - ozone generator; 5 - pipe; 6 - thermometer with digital indication; 7 - rotameter; 8 - water tank; 9 - mechanism for rotating the oxygenometer probe in water; 10 - oxygenometer probe; 11 - fine bubble generator; 12 - manometer with digital indication

The air supplied by the electro compressor (1) mixes with the ozone supplied by the generator (4) and then enters the FBG.

4. Conclusions

1. The use of FBG has the following advantages:
- Ensure a uniform distribution of air bubbles in the water volume;
- Air bubbles have the same size;
- The diameter of the air bubbles can be controlled by the size of the outlet from the perforated plate;
- The pressure losses when the air passes through FBG are much smaller than for porous diffusers made of porous materials.
2. As the diameter of the outlet of the air bubbles in the water decreases, the rate of oxygen transfer to the water will increase.

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Transfer of Heavy Metals from Soil to Vegetables in a Polluted Area: Background and Main Issue

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Abstract: *The world is in continuous state of development, but for good and healthy development to be possible, a clean-living environment is also needed. Throughout its evolution, mankind has realized that the industries whose purpose is that of extraction, much needed to be sure, have the most significant impact on life on our planet. Therefore, the industrial pollution produced for over a century has seriously damaged the Romania natural heritage as well. Among the categories of pollutants resulting from anthropogenic activities, heavy metals are stable and have long-term toxicity. Heavy metal pollution resulting from obtaining non-ferrous metals in the Baia Mare area represents a danger for the community even after a decade since the ceasing of mining activities and useful minerals processing in the area. Thus, in the Ferneziu district of the Baia Mare city, an area heavily polluted but also carefully monitored, soil samples and 6-point culture plants were taken. The concentrations of Pb, Cu, Zn and Cd were thus determined. The obtained results show the concentration levels of heavy metals, which are micronutrients, but also pollutants in the soil. That level extends, of course, also in the cultivation plants most commonly used for daily consumption by the locals.*

Keywords: *Heavy metal pollution, soil-plant transfer, polluted area, Enviromatics approach.*

1. Introduction

The actual world - as a dynamic expression of the Knowledge-based Society, is in continuous state of development, but for good and healthy community development to be possible, a clean-living habitat is also needed. In this context, the environmental data, Environmental Information Systems (EISs) and Environmental Informatics (EI) relative to the environmental quality play an important role in decision-making, being closely and intimate linked with the community requirements in time [1, 3, 4, 9, 10].

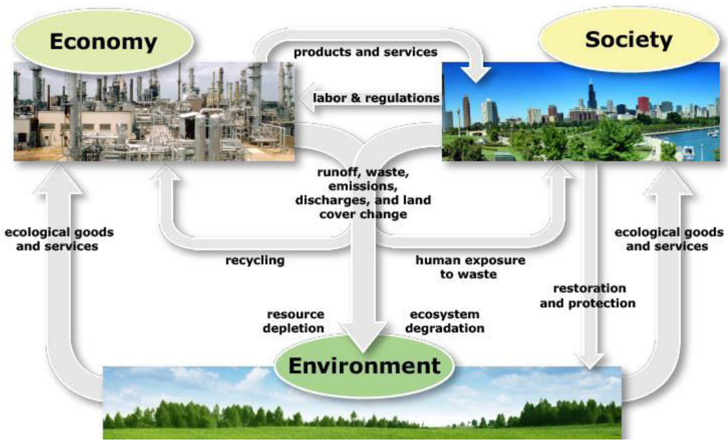

Fig. 1. The Human-Environment Interaction view as a sustainability framework

Pollution is one of the most important ways of deteriorating the natural capital [2, 13]. Of the pollutant categories, the chemically stable and highly toxic ones raise the biggest problems for the environment and the community, and heavy metals are part of this category.

In order to substantiate the decisions regarding the management of the zones and of the vegetal crops contaminated with heavy metals, it is necessary to evaluate their effects, both on the components of the natural capital and on the socio-ecological systems (as shown in Fig. 1). The first step is to characterize their distribution in the compartments of these systems.

In particular, if we are interested in evaluating the effects of heavy metals on human populations in contaminated areas, we must characterize their transfer pathways from storage compartments (soil and plant) to the human population. One of the most important such transfer routes is through the consumption of plant and animal foods produced in the contaminated area. This transfer path plays an important role especially where the source of pollution is placed near rural socio-economic systems (Fig. 2) characterized by subsistence agriculture.

In Romania there are some critical areas in terms of pollution with heavy metals (Baia Mare, Zlatna, Copșa Mică, etc.). Of these, the Baia Mare area presents a higher risk of interception of heavy metals through locally produced local food, due to the large abundance of agrosystems in the structure of socio-ecological complexes.

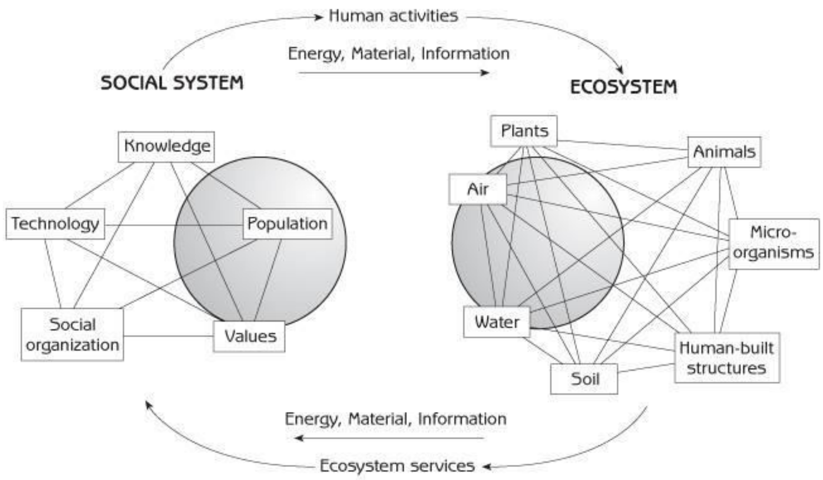

Fig. 2. Interaction of the Human Social System with the Ecosystem

In this context, the problem of assessing the risk of using contaminated land for agricultural crops and beyond is raised. Risk assessment requires the characterization of the space-time distribution of metals, but also of the exposure of the human population and of the populations from the natural capital structure to metals. This work is specifically addressed to one single stage of the ones that must be taken to evaluate the exposure of human populations in the area adjacent to the municipality of Baia Mare (respectively Ferneziu) to the heavy metals, namely their biocumulation from the soil in the crop plants most representative for the respective systems.

2. Materials and methods

Throughout its evolution, mankind has realized that the industries whose purpose is that of extraction, much needed to be sure, have the most significant impact on life on our planet. Therefore, the industrial pollution produced for over a century has seriously damaged the Romania natural heritage as well.

Among the categories of pollutants resulting from anthropogenic activities, heavy metals are stable and have long-term toxicity. Heavy metal pollution resulting from obtaining non-ferrous metals in the Baia Mare area represents a danger for the community even after a decade since the ceasing of mining activities and useful minerals processing in the area.

Thus, in the Ferneziu district of the Baia Mare city, an area heavily polluted but also carefully monitored, soil samples and 6-point culture plants were taken. The concentrations of Pb, Cu, Zn and Cd were thus determined. The obtained results show the concentration levels of heavy metals, which are micronutrients, but also pollutants in the soil. That level extends, of course, also in the cultivation plants most commonly used for daily consumption by the locals.

3. Results and discussions

The analysis of the behavior of a chemical compound in ecosystem is a complex problem [12], because its distribution is performed in both abiotic and biotic compartments (in this case in plants – as shown in Fig. 3) [7, 11].

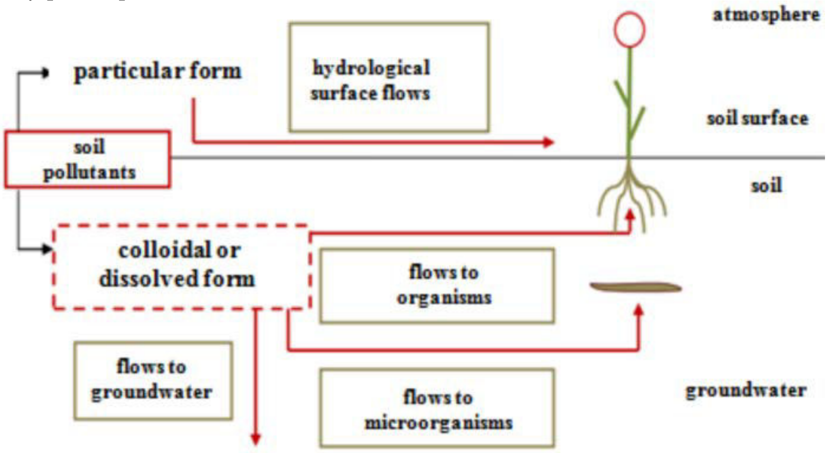

Fig. 3. The schematic presentation of the pollutants transfer to soil and plants

The processes of transport of chemical compounds can be carried out within the same compartment (water, air, soil) or between compartments through advection and/or dispersion mechanisms. Once entered the ecosystem complex for a sufficiently long period of time metals may be distributed by transfer to other abiotic compartments of the complex ecosystems or to biotic compartments of the complex ecosystems, or to other ecosystems within the complex through passive mobility populations or activate.
The transport and destination of heavy metals at large spatial scales is in causal relation with the physico-chemical properties of the metal, of the crossed environment and of the storage surface. At the ground level the metals are distributed, according to the chemical state in which, through surface flows, the hydrological flows of infiltration to the groundwater and of the fluxes to the organisms that take trophic substances from the soil, all of which can be represented by software. dedicated computers [5, 6].
Existing metals in ecological systems are available for the acquisition process in a certain proportion of the amount of metal in soil, sediment, water, atmosphere [8]. The fraction of available metal represents the amount of metal that exists at one point in a system and has the potential to come into contact or be ingested by organisms [8]. Plants easily take from the soil metals that are dissolved in the soil solution, either in ionic form, chelated or complexed.
The main features of the absorption process can be summarized as follows:

- it is carried out at very low concentrations in the solution;
- depends, in general, on the concentrations in the solution, especially on short distances;
- the adsorption rate depends decisively on the presence of H+ and other ions;
- the adsorption intensity varies depending on the species and the development stage;
- the process is influenced by certain soil parameters such as temperature, aeration and redox potential;
- may be selective for a particular ion;
- the accumulation of ions can also occur against the concentration gradient.

The absorption through the roots is the main way of transferring the metals to the plant. The ability of plants to take up metals from the growing medium is evaluated by the ratio between the concentration of the element in the plant and the concentration of the element in the soil called biological absorption coefficient, bioaccumulation index or transfer factor. The ability of plants to take up chemical elements varies across a wide range. Elements like Br, Ca, B, Cs, Rb are very easy to pick up while elements like Ba, Ti, Zr, Sc, Bi, Ga, Fe, are less available, but these aspects change depending on the particularities of the system. the soil-plant. The uptake by plants with different efficiency is also due to the different bioavailability of the metal ions.

4. Conclusions

The potential for accumulation of chemicals that can cause adverse effects and their transfer along the food chain is one of the current challenges and concerns in the field of ecotoxicology. The processes accompanying the accumulation and the transfer have been studied mainly in the aquatic systems, the situation in the case of the terrestrial systems being precariously described in terms of data consistency.

Scientific studies, which have been related to terrestrial systems, have focused mainly on the problem of transfer to the terminal levels of the food chain, especially of the transfer to mammals and birds whose food resource is in aquatic systems.

The transfer of heavy metals in the sequence of trophic levels is of importance recognized by several researchers due to the need to integrate the principles of transfer and bioaccumulation of metals in the trophic network with the establishment of toxicity and effects. Starting from the accumulation of metals in the soil, the risk of contamination occurs in the plant and animal organisms that take metals directly or indirectly, and subsequently in the organisms that meet them, through trophic relationships, via the transfer through the food chain.

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Wood Splitter for Household Use

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Abstract: *The article deals with the concrete problem of making a wood splitter that can be used in an individual household which is heated with wood. It goes without saying that there are a lot of types of wood splitters on the market, the important issue being the way of selecting the most useful technical-economic variant. The basis of the article is the choice of the constructive solution, the elaboration of the main design elements of the chosen solution and the simple way of calculating the drive installation, which in this case is a hydraulic drive.*

Keywords: *Wood splitters; Electrohydraulic Mobile; Drive*

1. Introduction

1.1 Elements for defining the subject

One of the traditional and extremely widely used energy resources has been and unfortunately still is the wood obtained by cutting forests. After the production of productive equipment for cutting trees, it seemed that the only problem left was the problem of cracking those logs, which for a long time was done with the axe. In this sense, mechanical means of breaking wood for fire began to appear in the world. In 1978 a model of a machine with a rack driven by a heat engine was patented, and in 1990 the wood crushing machine with a conical screw was patented. From this moment when the methods of breaking wood with a knife blade or with a conical screw were imposed, the problem of the operating variant of the system arose, which must be fast, strong, efficient and economical. The variants to be analyzed were mechanical, electrical and hydraulic.

1.2 Physical-mechanical properties of wood

In order to determine the quality of the wood, both the physical-chemical properties and especially the physical-mechanical ones are used. Among all these most important properties for understanding the operation and choice and design of cracking machines are [1]:
- The apparent density which represents the ratio, expressed in g / cm³, between the apparent mass and the volume of the wood. It varies from one species to another, but can also vary in the same species depending on a lot of conditions, including humidity.
- Moisture represents the water content, expressed as a percentage, of the weight of the wood. From the experience of the times it is known that wood is hygroscopic and as a result the humidity varies depending on the conditions.
- Elasticity is the property of wood to deform under the action of external loads and to return to its original shape after removal.
- Plasticity is the property of wood to deform under the action of external loads and to maintain its new shape after their removal.
- SPLIT RESISTANCE occurs due to the property of wood to divide under the action of feather-shaped cutting tools. Strength depends on the apparent density, structure of the wood and its defects (twisted, inclined fiber, knots).
- The hardness of wood is the property of opposing the penetration of a foreign body stronger than it, which could deform its surface.

1.3 Density of wood to be cracked

Depending on the species, the density of wood is between 0.04 g / cm³ and 1.40 g / cm³ with the specification that the density of wood in Romania varies between 0.35g / cm³ and 0.98 g / cm³ [2].
There is in the literature the division of wood types into several classes and subclasses:
- light ones (with several subclasses) having a density up to 0.60 g / cm^3; for example, alder, fir, chestnut, red fir, juniper, spruce, walnut, pine, poplar, willow, linden, etc.;
- the semi-gray ones that have a density up to 0.70 g / cm³; for example, hazelnut, maple, cherry tree, mulberry, larch, birch, great maple, plane tree;
- heavy ones with a density of 0.70 g / cm^3; for example, mountain alder, hornbeam, horn, beech, ash, field maple, great maple, plum, acacia, oak, elm, yew, etc.

2. Technical solutions for wood splitters

2.1 Selection criteria

The choice of a wood splitter starts from the needs of the amount of heat that each user has and therefore from the amount of wood to be processed. In this sense, a first choice starts from the energy consumption of the machine [3].
• Wood splitter with a maximum power of 2 kW - it is suitable for heating 1-2 rooms per day, for which a maximum of 10 m^3 of wood is used. For this, you can also use the traditional method of cracking wood with an axe;
• Wood splitter with a minimum power of 2 kW - it is used for homes of 100-120 m^2, which have a minimum of 3 stoves or which use wood-fired heating plants for which between 20 and 25 m^3 of wood are used.
• Wood splitter with a power of at least 3 kW - ideal for homes with high wood consumption, with a need of 25-30 m^3. Generally, these types of devices are electric or gasoline.
Another criterion for choosing a wood splitter is the one that is made according to the crack resistance of the wood to be split and which determines the size of the tonnage of the machine which is practically the maximum pressing force necessary to crack it. Starting from this criterion for solving the problems addressed by this article, it can be considered that it is good to choose:
• Heavy-duty wood splitter (over 7 tons) - ideal for thick and freshly cut logs;
• Medium tonnage wood splitter (4-7 tons) - suitable for normal wood in diameter and already cut to lengths below 50 cm [2].

2.2 Operating variants of wood cracks

Currently the market offers three types of wood splitters in the class of those approached by the article: electric, with thermal and manual motors. In the manual ones, which work on the basis of human strength, the effort is great, but the price of the product is low. Its advantage is that it can be used anywhere and anytime, without the need for expensive traditional energy sources, but effort and time can be totally restrictive criteria [4].
Electrically operated equipment is therefore dependent on a power source, and if more than 3 kW is needed, power problems are complicated for small and medium-sized households [5].
Heat-powered machines have the advantage of productivity and mobility, but also the disadvantage of price.

3. 2.5 kW mobile electrohydraulic splitter

The role of the equipment is to replace the efforts made manually, with the axe, in the activity of cracking, or breaking wood of lengths between 20 cm and 60 cm and thicknesses (diameters) of up to 30 cm. Although the solution is for any user of cracked wood, it is good for the staff working with the machine to specialize in such work.

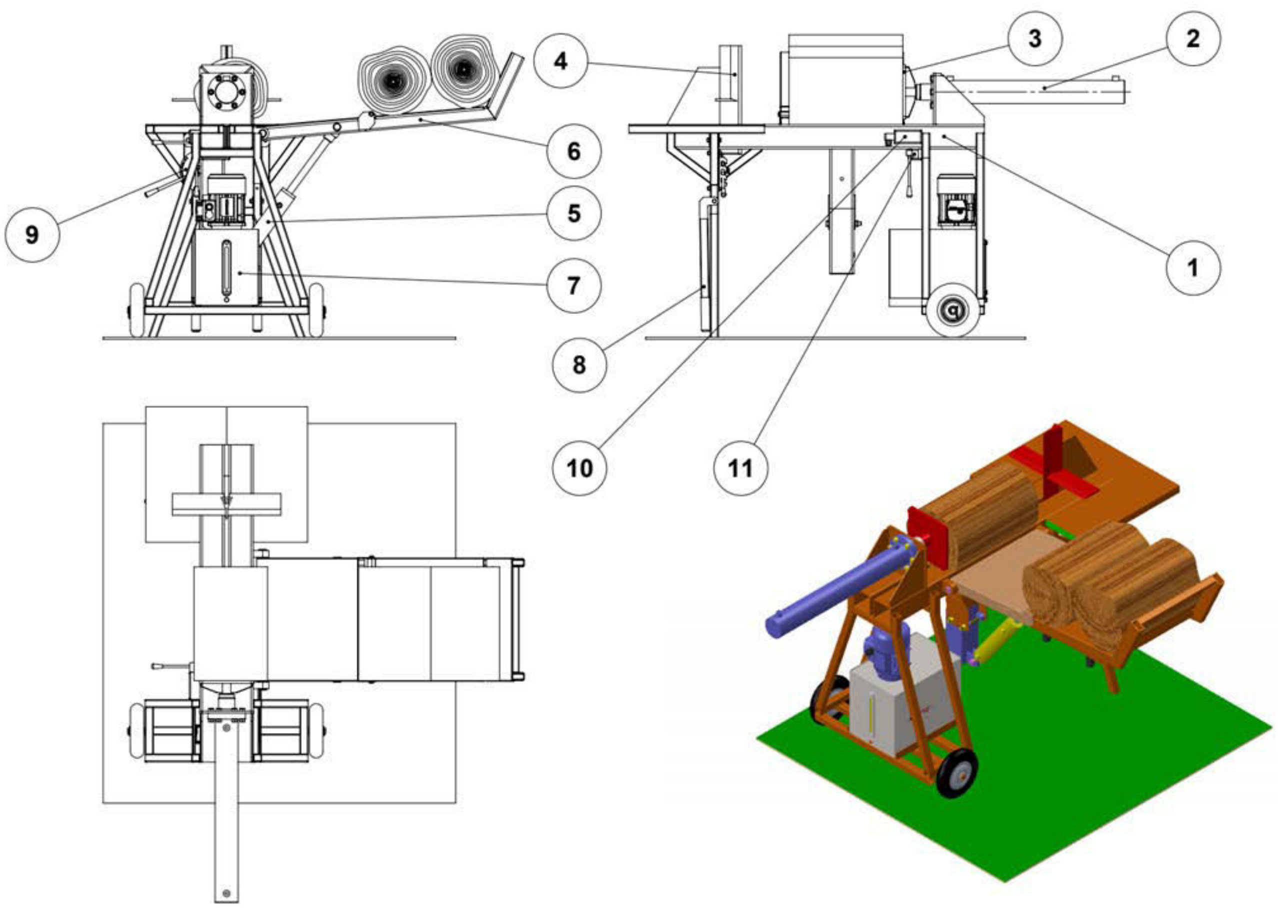
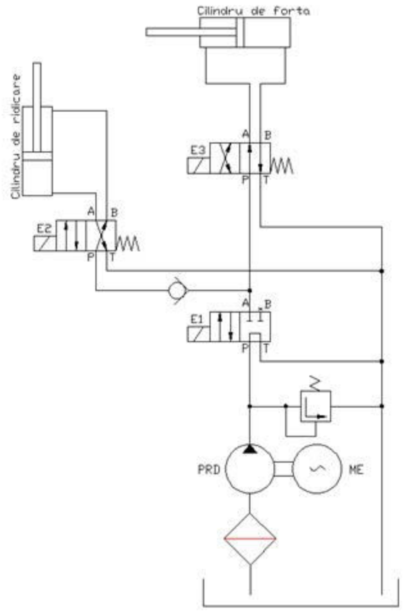


Fig. 1. Splitter overview diagram

Fig. 1 shows a general assembly of the proposed wood splitter solution. The whole assembly is placed on the frame (1), which in turn is equipped with two transport wheels and a set of lifting arms (9) for transport. Transport can be done by pushing by workers, by tying to a low-power vehicle, or even by pulling with the help of animals. When the machine is positioned for work, a large enough place is chosen to be able to carry out all the phases from loading to completion. The mains supply does not require special preparations but the normal ones for starting any 2 ... 3kW machine. The first phase in the working mode is to start the hydraulic group (7) and then to lift 2…4 wood with the help of the lifting platform (6) at the maximum level, meaning at 30 degrees above the horizontal. From here a wood is transferred manually on the frame. The next step is to position the knife (4) in the appropriate position in height by means of a lever. Next, the hydraulic directional control valve (10) is actuated to start the movement of the working cylinder towards the wood. Immediately the wood is pushed towards the knife by the pusher plate (3) and the wood will be cracked. If cracking does not begin immediately, the force in the cylinder (2) will increase by increasing the working pressure to 150 bar. This pressure will increase the pushing force up to 7 tf, sufficient for any type of wood. After the wood has cracked, it is ordered by means of the directional control valve (10) to remove the cylinder rod and the pusher plate while the broken (cracked) wood is thrown on the ground.
For the exact understanding of the operation, the hydraulic diagram from fig. 2 can also be used.



Splitting force (tonnage), F, 5tf

Splitting length (cm) , L , 50

Splitting diameter (cm), d , 25

Electric motor power (W), N_e, 2 kW

Type of single-phase motor 230V, …50Hz

Splitting speed (cm/s),… 5

Retraction speed (cm/s),…9

Fig. 2. Hydraulic schematic diagram

4. Calculation elements for the 2.5 kW mobile electrohydraulic splitter

The splitting consists in the penetration of a wooden feather in the direction of the fibre, which it crushes and compresses in the transverse direction.
Splitting force - is the pressing force generated by the hydraulic cylinder. This depends on the internal section of the hydraulic cylinder and the pressure in the hydraulic system [6].
The splitting force varies within very large limits depending on the structure of the wood, its length and diameter, knots, the length of the splitting feather, species, fibre distribution, etc.
For the calculation of the dimensioning of the splitting equipment, the force necessary for the splitting process is started (1).

$$\mathrm{F} = \mathrm{k} \cdot \mathrm{p} \cdot \mathrm{L} \cdot \mathrm{d} \tag{1}$$

where:
k - a coefficient that takes into account the feather angle and the state of sharpening, the species of the wood, the humidity of the wood and the dimensions of the support on which the splitting wood is placed; indicative values between 0.003 and 0.009;
p - specific resistance to splitting; the resistance to compression parallel to the fibre has values between 30 - 90 N/mm^2, depending on the essence of the wood.
L, d - length and diameter of the wood that splits;

For the calculation, slightly above average values will be chosen (2):

$$\mathrm{F} = 0.005 \cdot 70 \cdot 500 \cdot 250 \tag{2}$$

$$\mathrm{F} = 43750\mathrm{N} = 4375 \text{ kgf}$$

For the calculation we consider:

$$\mathrm{F_{max}} = 5000 \text{ kgf} \tag{3}$$

To achieve this force, a hydraulic cylinder will be used that admits a maximum pressure of 200 bar (kgf / cm²).

$$D_p = \sqrt{\frac{4 \cdot 5000}{3.14 \cdot 200}} = \sqrt{31.84} = 5.64 \text{ cm} = 56 \text{ mm} \tag{4}$$

where D_p is piston diameter

We choose a series cylinder with:

$D_{p_a} = 60$ mm, where D_{p_a} is chosen piston diameter (5)

$D_{t_a} = 40$ mm, where D_{t_a} is chosen rod diameter (6)

For the calculation of the pump flow, Q_n it is considered that the maximum speed of the force cylinder, v_{cf}:

$$v_{cf} = 5 \text{ cm/s} \tag{7}$$

Using the actual area of the cylinder, A_{rc}:

$$A_{rc} = \frac{\pi}{4} D_{p_a}^2 = 28 \text{ cm}^2 \tag{8}$$

$$Q_n = A_{rc} \cdot v_{cf} = 140 \text{cm}^3/\text{s} = 8400 \text{cm}^3/\text{m} = 8.4 \text{ l/min} \tag{9}$$

For the calculation of the pump, it is considered with the rotative speed of the electric drive motor, n:

$$n = 1500 \text{ rev /min} \tag{10}$$

$V_g = \frac{Q}{n} = 5.6$ cm³ / rev, where V_g is geometric volume (11)

We choose a pump with $V_{ga} = 6$ cm³ / rev (chosen geometric volume) that will give a maximum flow (real), Q_r:

$$Q_r = n \cdot V_{ga} = 9 \text{ l/min} \tag{12}$$

The electric motor has the power, N_e :

$$N_e = \frac{p \cdot Q}{612} = \frac{200 \cdot 9}{612} = 2.94 \text{ kW} \tag{13}$$

A 3-kW single-phase electric motor with a speed n = 1500 rpm will be chosen.
The equipment also has a lifting device that uses a hydraulic cylinder with a much lower force approx. 200 kgf, which from the calculation would be with D_p between 10 and 15mm, but taking into account the working conditions will be chosen by ϕ32 or ϕ 40.
All hydraulic equipment will be chosen by size Dn 6.

5. Conclusions

The variant proposed for the realization of the horizontal wood splitter, with hydraulic drive, has a 2-kW single-phase electric motor, easy to connect to any household network.
The machine can be equipped with directional control valve with electric or manual control of nominal size Dn6.
The machine is designed to be able to develop higher forces for short periods than those stated in the data sheet.

The article is a practical solution for designing and making wood splitting equipment, easy to maintain and use by households that use wood for heating.

Acknowledgments

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Monitoring of Electromagnetic Radiation with an Impact on the Human Factor

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Abstract: *The strong media coverage of the negative consequences of the polluting factors has created in the society a culturalization of the population in this direction. Real-time knowledge of indoor and outdoor air quality, water quality, noise pollution level, or electromagnetic radiation level are requirements of today's society. The demand for devices to monitor these pollutants has increased substantially in recent years. Electromagnetic radiation monitoring devices are also part of the increasingly demanded devices. The current market offers such devices, which have a high cost price, which can usually indicate only the presence of electromagnetic radiation but do not indicate the volume or area of radiation and do not even integrate their amount.*

Summarizing these inconveniences makes such equipment rare, monitoring the amount and sources of radiation being difficult or even impossible to achieve, the volume of data being small and inaccurate can not help achieve a correct picture of the phenomenon and adopt correct prevention policies or combat the phenomenon.

Thus, the need to develop a universal device for monitoring electromagnetic radiation called (EMR-MUD) has arisen. It complements the family of universal monitoring devices Indoor Air Quality Monitoring Universal Device (IAQ-MUD) and Outdoor Air Quality Monitoring Universal Device (OAQ-MUD) improving the image of pollutants.

It is able to monitor several areas of interest in the spectrum of electromagnetic radiation, built for indoor and outdoor spaces, to be reduced in volume, (possibly) portable, low price, maintenance close to zero, Internet connectivity for data acquisition and creation of databases for the elaboration of strategies for prevention and reduction of the monitored phenomena. With this device made in our own laboratory we can make:

- *Recording individual values for each monitored area;*
- *Local registration of monitored data and values;*
- *Issuing alarms when the limit values are exceeded;*
- *Online access to data for processing and analysis;*
- *IoT compatibility.*

Keywords: *IoT, IAQ, OAQ, 5G, Electromagnetic Radiation*

1. Introduction

The interaction of electrical or electronic equipment - electromagnetic environment is a dynamic reality and permanence. There is a continuous evolution of this interaction. New technologies create vulnerabilities in equipment that did not exist in the past and at the same time change the structure of the electromagnetic environment. The electromagnetic immunity of electrical and electronic equipment must constantly keep pace with technology, to cope with the dynamism and evolution of the equipment-environment interaction.

On the other hand, the requirements that electrical and electronic equipment must meet in terms of immunity and electromagnetic emission in order to be marketed have been regulated by national and international bodies. The regulations established the mandatory characteristics of the stands and test equipment in order to reproduce the reality as accurately as possible. But a closer look at immunity standards identifies their limits in mirroring a much more nuanced reality [1,2]. It also identifies inconsistencies and possibilities to unify the evaluation of similar phenomena. For accuracy and repeatability, current standardized testing methods and techniques must be used correctly [3]. At the same time, new ones need to be developed.

Restrictions and regulations on exposure to electromagnetic fields are based on information accumulated in recent decades and reflect the current state of understanding of the levels of these fields to be considered safe.
The EMF (electromagnetic fields) effect evaluation sequence begins with the evaluation of electric and / or magnetic field sources. The source is not in itself a problem, being generally known along with its technical characteristics [4].
Our field of analysis is exposure. Exposure only exists when one or more people work or live in the fields produced by these sources, one can talk about EMF exposure. Exposure is "complicated" by factors such as the movement of the exposed person in the field, its spatial variations, and many possible combinations of exposure parameters [5]. In case of exposure to electromagnetic radiation, it is necessary to take into account the resulting internal fields. The internal magnetic fields are almost identical to the external ones, because the magnetic permeability of the body is close to unity. On the contrary, the electric fields inside the body differ considerably from the external ones, being reduced by about six orders of magnitude. At the same time, the alternating magnetic fields induce by Faraday effect electric fields with important values [6].
In addition, there are endogenous electric fields that can be comparable in amplitude. By combining all these factors and taking into account the extremely complex electrical properties of body tissues, the resulting problem is particularly complex. This leads to the difficult problem of understanding internal exposure: the cells and tissues of the body are affected by the fields created inside and not by the external ones, which can be measured.
The research of electromagnetic fields from the point of view of health effects brings to the fore, for the engineer and physicist, a problem of the first magnitude, that of the exposure dose and, consequently, of its effect.
Laboratory research can isolate a single parameter for investigation. In reality there are a multitude of parameters that need to be investigated. It is therefore necessary to take an approach close to the real world.
However, the human body is suitable for types of experiments that can be much more relevant, namely the way in which electromagnetic radiation influences / interferes with human electrical and magnetic activity [7, 8].
According to ICNIRP [2], exposure to electromagnetic fields of radio frequency below 100 kHz has the effect of negligible energy absorption. In contrast, exposure to electromagnetic fields with frequencies higher than 100 kHz can lead to significant energy absorption and temperature increases. In general, exposure to uniform electromagnetic fields (flat wave) has the effect of a very uneven distribution of them in the body and, implicitly, of energy absorption. Taking into account the physical-chemical properties of the human body, unevenly distributed (in relation to the area of the body and age) it results that energy absorption must be evaluated by dosimetric measurements and calculation.
From the point of view of energy absorption by the human body, uniform electromagnetic fields can be classified / 3 / into four categories, taking into account their frequency range:

- 100 kHz - 20 MHz; energy absorption decreases rapidly with frequency, but significant absorption may occur in the neck and limbs;
- 20 MHz - 300 MHz; there is a relatively pronounced absorption throughout the body, higher values may occur in certain areas due to resonances;
- 300 MHz - 10 GHz; significant local absorption occurs;
- over 10 GHz; energy absorption is manifested mainly on the body surface.

Experimental results and theoretical studies conducted so far internationally have shown that the adverse biological effects of exposure to microwave fields are thermal in nature [7]; they occur if the power absorption in the tissues is greater than 4 W / kg, mediated for the whole body. Against this threshold, the maximum level of occupational exposure is set by international standards or regulations at 0.4 W / kg, for the whole body [8].
Given the fact that the population may be permanently exposed and implicitly accepting a cumulative effect of microwave exposure, also taking into account other environmental factors or the increased sensitivity of some population groups, the exposure limit of the population has been reduced of international standards in the ratio 1/5 to the occupational exposure limit, i.e. it is 0.08 W / kg, for the whole body. Local exposure limits (for body parts) are also deduced based on

thermal criteria. According to the European legislations, the specific energy absorption rate (SAR) limit for localized exposure is ≤ 8 W / kg for occupational exposure and ≤ 1.6 W / kg for population exposure [4, 6].

2. Methods and researches

2.1 The notion of the specific energy absorption rate SAR

The concept of a normalized mass ratio of the rate of absorption of energy produced by a microwave source was strongly introduced in the late 1960s and early 1970s. In 1981 the National Council for Radiation Protection and Measurements officially introduced the term specific absorption rate (SAR). The American National Institute of Standards, ANSI was the first organization to consider SAR as a key parameter in dosimetry, within a standard for radiation exposure protection. SAR is formally defined as the time derivative of incremental energy (dW) absorbed (and dissipated) in an incremental mass (dm) contained in a volume (dV) of known density (ρ).

SAR is expressed in units of Watts / kg and is given by the expression [9, 10]:

$$SAR = \frac{d}{dt}\left(\frac{dW}{dm}\right), \qquad \text{[W/kg]} \qquad (1)$$

SAR is a function of the electric field induced in the tissue, being expressed by the relation [11, 12]:

$$SAR = \frac{\sigma}{\rho}E^2, \qquad \text{[W/kg]} \qquad (2)$$

where: E represents the mean square root value of the induced electric field strength [V / m] in the tissue, ρ is the tissue density, expressed in [kg / m^2], σ is the dielectric conductivity of the tissue [Siemens / m] [7].
SAR is highly dependent on both frequency and distance as well as the H field and the strength of the equipment under test. It is also dependent on tissue composition as well as other factors. The relationships that are established in the case of mobile equipment are complex, being generally non-linear.
The limits set for SAR legislation (Table 1) (Figure 1) are:

Table 1: The limits set for SAR

Professional / Controlled Exposure 100kHz-6GHz	**General / Uncontrolled Exposure 100kHz-6GHz**
<0.4W/kg-whole body	<0.08W/kg-whole body
< 8W/kg-body parts	< 1.6W/kg-body parts

ELVs for the 0-1 Hz frequency range are defined in terms of magnetic induction external (Table A1 of Annex II to the EMC Directive). ELV for sensory effects are set to prevent vertigo and other perceptions. These are determined in mainly by the electric fields induced in the tissues when the body moves in a strong static magnetic field, although there is currently some evidence that they can appear in the absence of movement. Therefore, for a controlled work environment in which movement in the field is limited and workers are informed, overtaking may be allowed temporary ELV for sensory effects, provided that this is justified by the practice or process in question. In this case, the exposures shall not exceed ELV for health effects.
ELVs for the 1 Hz-10 MHz frequency range are defined in terms of electric fields body-induced (Table A2 and Table A3 of Annex II to the EMC Directive).
For frequencies up to 400 Hz, there is both ELV for sensory effects and ELV for health effects. ELV for sensory effects aims to prevent retinal phosphenes and minor transient changes in brain

function. Thus, they apply only to the tissues of the central nervous system (CNS) at the level of the head of an exposed worker.
ELV for health effects applies to all frequencies between 1 Hz and 10 MHz and are intended to prevent stimulation of peripheral and central nerves. Thus, these ELVs apply to all tissues in the body of an exposed worker.

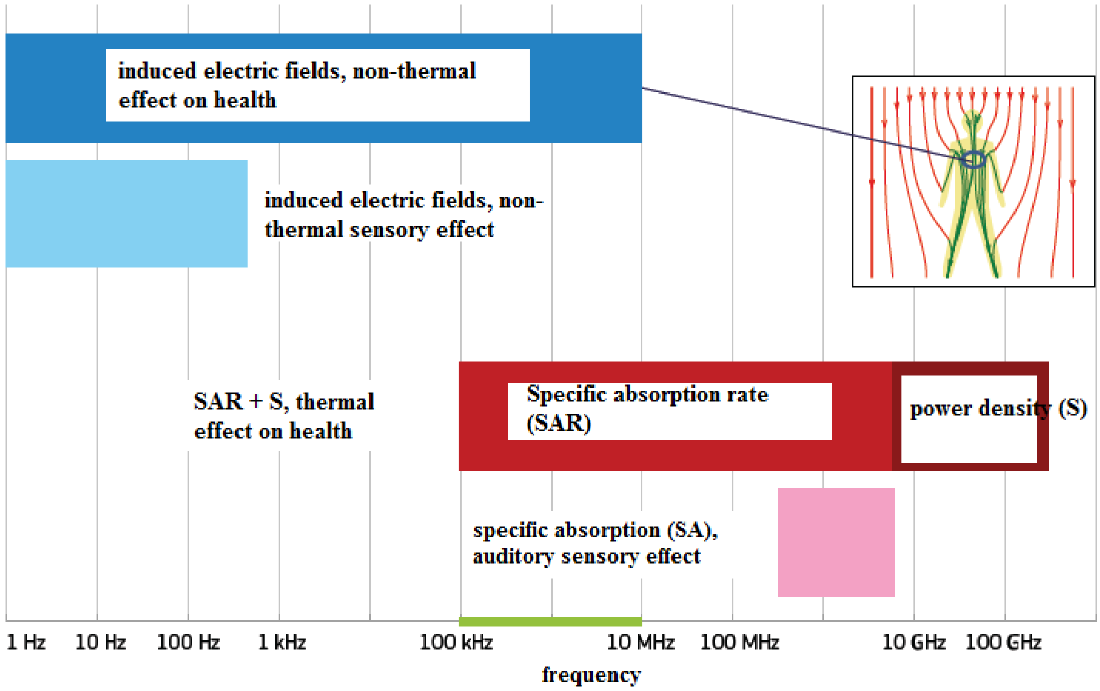

Fig. 1. The range of frequencies in which different ELVs are used

Note: Blue bars indicate non-thermal effects, and red bars indicate thermal effects.

For the 100 kHz-6 GHz frequency range, the degree of heating due to exposure depends on the rate at which energy is absorbed into the tissues. This is defined by the specific energy absorption rate (SAR), which is used to specify the ELV for health effects, with separate values for whole body exposure and those located (Table A1 in Annex III to the EMC Directive). Values for the whole body protect from heat stress and heat shock and are applied to the calculated SAR value as an average for the whole body. Localized values protect against the thermal damage of some specific tissues and apply to the SAR value averaged over any mass of 10 g of contiguous (or connected) tissue. Both whole-body SAR and localized SAR are averaged over a six-minute time frame.
For the 300 MHz-6 GHz frequency range there is also an ELV for effects that are designed to prevent "microwave" phenomena caused by exposure to pulsating fields (Table A2 in Annex III to the Directive on EMF). These are specified in terms of calculated specific absorption (HS) as an average for a mass of 10 g of tissue at the head.
The penetration of the electromagnetic field (EMC) into the body decreases with frequency in the radio frequency range, so that, for frequencies above 6 GHz, the field is mainly absorbed on body surface. This means that there is a lot for those frequencies more relevant to limit the power density incident on the body surface than the rate at which energy is absorbed into a mass of tissue. The power density is calculated as an average for 20 cm^2, within the maximum limit calculated as an average for any surface of 1 cm^2. For the 6-10 GHz frequency range, the power density is calculated as an average for any period of six minutes. Beyond this value, the average calculation time decreases with increasing frequency, reflecting the decrease depth of penetration (Table A3 in Annex III to the EMC Directive).
Warming the body by more than 1^{o} C can have health-altering effects (e.g. decreased psycho-motor performance). The effects of local heating depend on the sensitivity of the exposed area; for example, temporary warming of the limbs has no effect on health, but warming of the testicles by more than one degree can lead to infertility, and heating of the eyeball area by 1-2 ^{o} C favors the

production of cataracts [7], [8]. In determining the maximum permissible values for SAR as a basic restriction, safety factors were taken into account (compared to the 4 W / kg limit mentioned above): a factor of 10 for occupational exposure (limited and controlled), above which applied another factor of 5 for the uncontrolled exposure of the population (taking into account the existence of more sensitive categories: children, the elderly, sick people or with a delicate physical condition) [8].
Thus, the ICNIRP norm recommends the maximum allowable SAR level for the population, at the exposure of the whole body, at the value of 0.08 W / kg. Higher values are allowed for partial exposure: max. 2 W / kg in the head and torso area and max. 4 W / kg in the limb area. In the case of power density S (for frequencies> 10 GHz) the maximum permissible value is 10 W / m^2. All values corresponding to controlled exposure in occupational environments are 5 times higher (SAR values of 0.4 W / kg for the whole body, 10 W / kg for the head and torso, 20 W / kg for the limbs, respectively S of 50 W / m^2) [9]. It should also be noted that all SAR specific strength values are considered to be mediated over an exposure time interval of 6 minutes, and the values required for partial exposure are considered to be mediated over a volume corresponding to 10 g of tissue around the maximum local value. The power density S is considered to be spatially mediated on a surface of 20 cm^2 of the exposed body (around the local maximum value) and temporally over an interval of 68 / f1.05 minutes (where the frequency f is introduced in GHz). [14]

2.2 The experimental research

Electromagnetic radiation is the energy radiated in the form of a wave, which occurs as a result of the interaction between the electric field and the magnetic field, and occurs due to the acceleration of electric charges.
The electromagnetic field has two complementary components, namely the electric field and the magnetic field, whose values are directly proportional to the distance from the source that causes the electromagnetic disturbance.
The operation of electrical equipment can be characterized by useful electrical signals and disturbing electrical signals (disturbances). The disturbing electrical signal causes some unwanted effects, with minor consequences, or with damage / destruction of equipment.
Depending on the geometry of the circuit and its dimensions relative to the wavelength, either only the electric field, or only the magnetic field, or both fields are predominant. Depending on the characteristics of the circuit generating the field, the field energy is mainly found in the electrical component or the magnetic component, or in equal proportions in both components.
Real-time knowledge of indoor and outdoor air quality, water quality, noise pollution level, or electromagnetic radiation level are requirements of today's society. The demand for devices to monitor these pollutants has increased substantially in recent years. Electromagnetic radiation monitoring devices are also part of the increasingly demanded devices. The current market offers such devices, which have a high cost price, which can usually indicate only the presence of electromagnetic radiation but do not indicate the volume or area of radiation and do not even integrate their amount.
Summarizing these inconveniences makes such equipment rare, monitoring the amount and sources of radiation being difficult or even impossible to achieve, the volume of data being small and inaccurate can not help achieve a correct picture of the phenomenon and adopt correct prevention policies or combat the phenomenon.
Thus, the need to develop a universal device for monitoring electromagnetic radiation called (EMR-MUD) (Figure 2, Figure 3) has arisen. It complements the family of universal monitoring devices Indoor Air Quality Monitoring Universal Device (IAQ-MUD) [11] and Outdoor Air Quality Monitoring Universal Device (OAQ-MUD) by improving the image of pollutants [12].
It is able to monitor several areas of interest in the spectrum of electromagnetic radiation, built for indoor and outdoor spaces, to be reduced in volume, (possibly) portable, low price, maintenance close to zero, Internet connectivity for data acquisition and creation of databases for the elaboration of strategies for prevention and reduction of the monitored phenomena.
Monitored radiation areas:
• zone 1 100 kHz - 7 Ghz
• zone 2 925 Mhz - 960 Mhz

• zone 3 1805 Mhz - 1880 Mhz
• zone 4 2110 Mhz - 2170 Mhz.

Functions:

• Records individual values for each monitored area
• Local recording of monitored data and values
• Issuing alarms when the limit values are exceeded
• Online access to data for processing and analysis
• IoT compatible.

The novelty is that a modular equipment has been made, an option not found in other equipment, composed of the basic unit with the role of interpretation, storage, display, online retransmission of information, received from one or more sensory modules, with a narrow spectrum, specialized for the area of interest to be monitored. These sensor modules are connected to the base unit via the I_2C communication line via the quick sockets, which allow them to be changed in a few seconds.

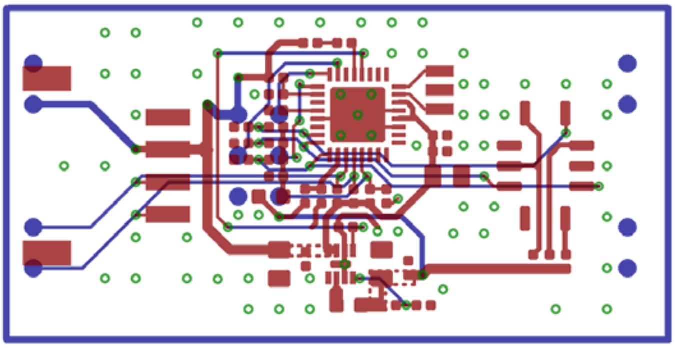

Fig. 2. PCB prototype for Atmega 328 8-Bit microcontroller adapter

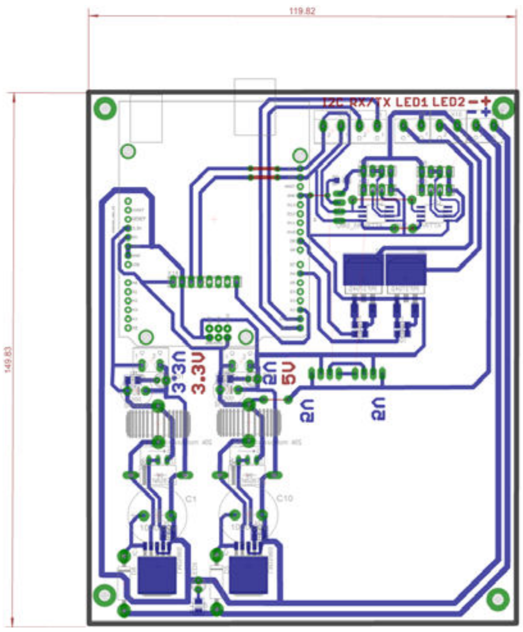

Fig. 3. Prototype PCB EMR-MUD equipment

The storage capacity of the 4MB ESP8266 microcontroller as well as its Internet connectivity facilities allow the creation of an HTML page and its loading in the processor's memory. Thus, the data obtained can be accessed in real time. The wiring of the prototype was made in our own laboratory.

Thus, one or more sensors can be attached depending on the area or areas to be monitored, thus achieving an exact identification of the area and the source generating electromagnetic radiation. Interconnectability and compatibility with the two devices in the same family of environmental quality monitoring equipment is also a novelty that we have not found in any other device. This equipment basically wants to replace a spectral analyzer, expensive equipment with relatively large dimensions, impossible to mount in several locations simultaneously due to the huge investment. The equipment that is closest to what we wanted to achieve in this work is the Narda SRM-3006 Selective Radiation Meter (Figure 4).

Fig. 4. SRM-3006 Selective Radiation Meter

In the testing phase of the equipment, it was installed in the electronics laboratory where it was created and where the radiation emitted by the electrical and electronic equipment in this space was monitored. The identified radiation generating sources are: power supplies for printers (4) and computers (2), wireless routers (1), frequency converters for electric motors (1), mobile phones (4), microwave oven (1) (Figure 5).

Fig. 5. The electronics laboratory with equipments

2.3 The experimental results and interpretations

The daily average of the readings from a week is shown in Table 2 & Fig. 6-daily average of SAR; Table 3 & Figure 7-Power Density (W / m^2) daily average of readings in a week.

Table 2: The daily average of SAR

Day	Zone 1 SAR (V/m)	Zone 2 SAR (V/m)	Zone 3 SAR (V/m)	Zone 4 SAR (V/m)
Monday	1.83	0.67	1.13	1.08
Tuesday	3.51	4.32	0.64	1.9
Wednesday	2.23	3.12	1.24	1.07
Thursday	1.32	2.43	1.01	0.86
Friday	0.95	0.47	0.35	0.25
Saturday	0.14	0.51	0.11	0.28
Sunday	0.13	0.52	0.12	0.27

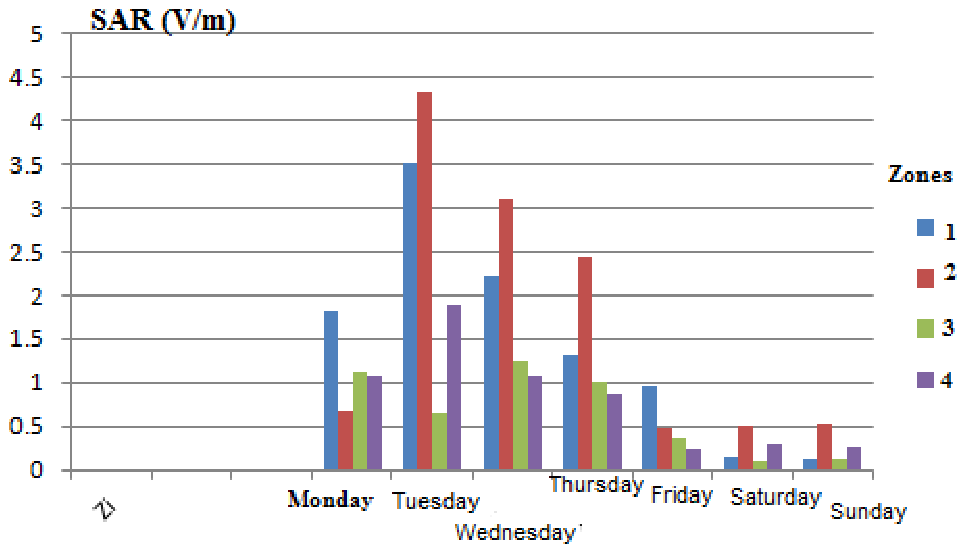

Fig. 6. The daily variations of SAR in lab

Table 3: The daily average of power density

Day	Zone 1 PD (W / m^2)	Zone 2 PD (W / m^2)	Zone 3 PD (W / m^2)	Zone 4 PD (W / m^2)
Monday	0.053953	0.049502	0.001086	0.009576
Tuesday	0.049502	0.058477	0.001376	0.009981
Wednesday	0.039802	0.050011	0.001244	0.008213
Thursday	0.038491	0.051201	0.001388	0.007214
Friday	0.004641	0.048971	0.001032	0.007009
Saturday	0.002414	0.000621	0.000351	0.000186
Sunday	0.002394	0.000586	0.000325	0.000166

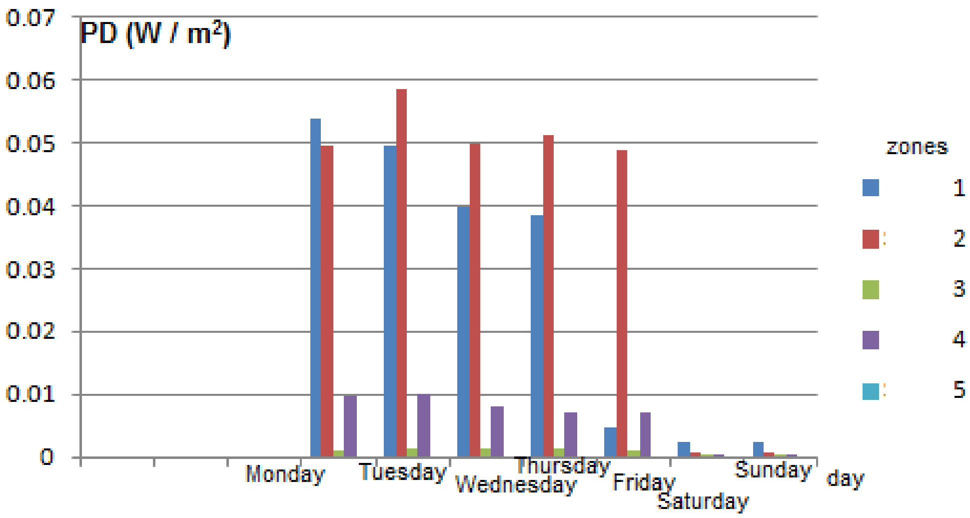

Fig. 7. The Power Density - daily average of readings in a week

The data acquisition was made through the "Tera Term" program, which offers the possibility of accessing data both on a local serial communication and accessing data via the Internet (over IP).

The obtained data can be synchronized with the local time (LT) or with the Coordinated Universal Time (UTC) and can be imported in tabular programs for further analysis.

3. Conclusions

The need to monitor electromagnetic emissions on areas of interest has led to the design and implementation of this versatile, adaptable, easy-to-use and maintenance equipment that can be used in different environments to be monitored. The energy consumption is low; the supply can be done both from the electricity grid and from batteries. The small physical dimensions allow for easy installation and low production costs, making it the ideal device for multiplication. After checking the sensor readings (calibration with certified equipment) we can say that the equipment successfully fulfils the main objectives, i.e. the readings performed by the sensors fall within the fields specified by their manufacturer.
In the future we want to increase the monitoring areas by adapting new I2C compatible sensors, e.g. Geiger counter, sound level meter.

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From Classical Systems Thinking to Modern Dynamic Systems Theory: Beyond the System Modelling, Analysis and Behaviour Interpretation

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Abstract: *In many practical cases the excitations acting on a system or structure are random in nature, and as a result the response of the system or structure can no longer be satisfactorily described and quantified. From Classical Systems Thinking to Modern Dynamic Systems Theory, beyond defining and understanding the conceptual delimitations of system, respectively the system structure, properties and classification, there followed a series of papers that focus on the system analysis, modelling and behaviour interpretation. In the same context, the mathematical model of a system - as a set of mathematical relationships and equations that allow the description of system behaviour, input-output or input-state-output transfer - is presented. A wide range of models associated with the systems, based on which the behaviour of the systems is analysed and interpreted, are also presented.*

Keywords: *Dynamic Systems Theory, system modelling, specific system behaviour, model analysis.*

1. Introduction

In many practical cases the excitations (as part of perturbations) acting on a system or structure (physical, real) are random in nature, and as a result the response of the system or structure can no longer be satisfactorily described and quantified, in deterministic way [1]. Thus, the excitement induced by the unevenness of the road on a car moving at a constant speed (Fig. 1), earthquakes, turbulence in air or water, the action of wind or waves are just a few examples of excitations (although at first glance they are considered simple events and / or phenomena) which by their nature give the systems and structures with which they come into contact a random character.

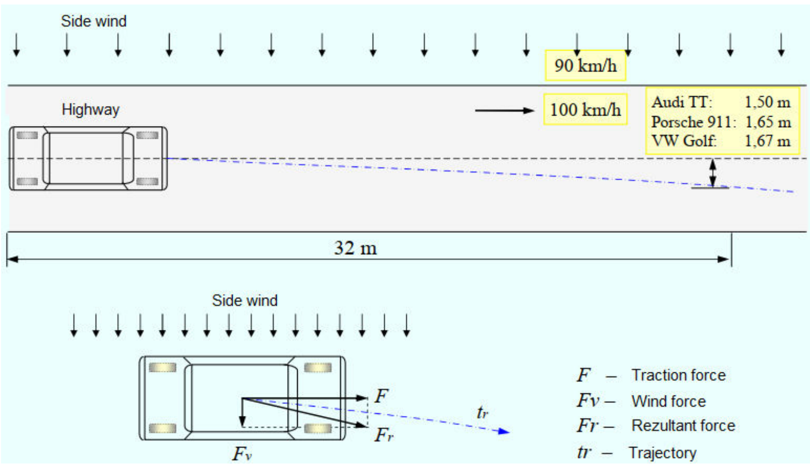

Fig. 1. Schematic representation of the excitement induced by the side wind on a car moving

As far as systems theory is concerned, this is still a very current field of science; many articles have been published in this field in specialized magazines and many books in prestigious publishing houses. For this reason, no matter how perfected the modern means of information, it is

practically impossible to keep up-to-date information in this field, to select and write this information, starting from definition and classification in a form easily accessible to the general public [2, 3].
Writing about a field of great relevance, such as systems theory or, as the case may be, dynamic systems [4, 5], is, from this point of view, a great risk, because by its nature the information is, at least, at least partially outdated at the time of publication. Aware of this shortcoming, we tried to arouse the interest of the general public for a current field of science, through the synthetic exposition of the main results obtained - see an example in Fig. 2 [5].

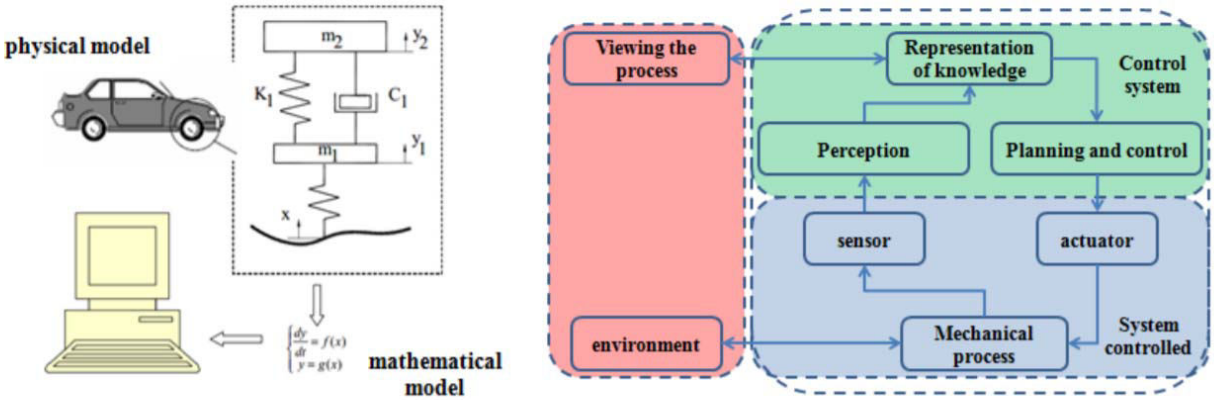

Fig. 2. Schematic representation of dynamic model analysis in relation to Dynamic Models Theory

Without being a popularization study, this material presents in addition to a series of mathematical statements, which are still taught in some of the faculties of technical higher education, with reference to systems theory and their characteristics. Systems theory, together with its consequences, is reflected in current technical sciences, and not only, as a new point of view, as a new integrative approach. Until recently, some researchers believed that the secrets of nature, and implicitly of the associated shadow technique, are in the microcosm and competed to discover elementary particles of matter (carriers of energy and information), while others have sought in the macrocosm, in the world of galaxies, black holes and other formations in the vast universe, and both leaving the environmental world in which we still live. Both considered that they were at the top of modern research, not taking into account the research of those who dealt with the phenomena of the environmental world.
This paper is part of the introduction to Dynamic Systems Theory and analysis of their behavior, being dedicated to familiarizing the reader with the diversity of fundamental concepts and development stages specific to Dynamic Systems Theory, respectively with a review of definitions and characteristics of existing systems in the literature [6, 7]. Also in this study found a natural place and a presentation of the properties that systems can meet, respectively a non-exhaustive classification of models, starting from the systems they represent in an abstract form, depending on their linearity. , the reporting to the time variable, the number of input-output variables, the behavior over time or taking into account other aspects. Also, the issue and the need to study dynamic systems are reviewed, as well as the implications of the analysis of the dynamic behavior that the considered systems may have.

2. Modelling, analysing and interpreting the behaviour of a system

The behavior of a system in dynamic regime (which includes the steady state and the transient regime) can be described with the help of a mathematical model, consisting of algebraic equations and differential or differential equations, as the system is continuous or discrete time. In the general theory of systems, as we have mentioned, two distinct ways of representing systems in the time domain are used: by equations of type I-O (input-output) and by equations of type I-S-O (input-state-output). As such, the mathematical model of a system is set of mathematical relationships and equations that allow the description of system behavior, input-output transfer or input-state-output [8-10].

A dynamic system (memory system) can be associated with a dynamic model - for the characterization of the dynamic operating mode, and a stationary model - for the characterization of the stationary operating mode. The stationary regime can be of static type (when the system variables are constant in time) or of permanent type (when the form of variation in time of the system variables is constant - of ramp type, of sinusoidal type etc.). Next, we will consider the stationary model as being associated with the static stationary regime.
Static systems models (without memory) and stationary models of dynamical systems consist of algebraic equations, while models of dynamic systems consist of differential equations (for continuous systems) or equations with differences (for discrete systems).
The dynamic model, by reference to the static model (see Fig. 3) [3] on the other hand, also includes the stationary model, the latter can be obtained from the former by a convenient customization (by canceling the time derivatives of the variables - to continuous systems, respectively by matching the values of each variable at all times - to discrete systems).

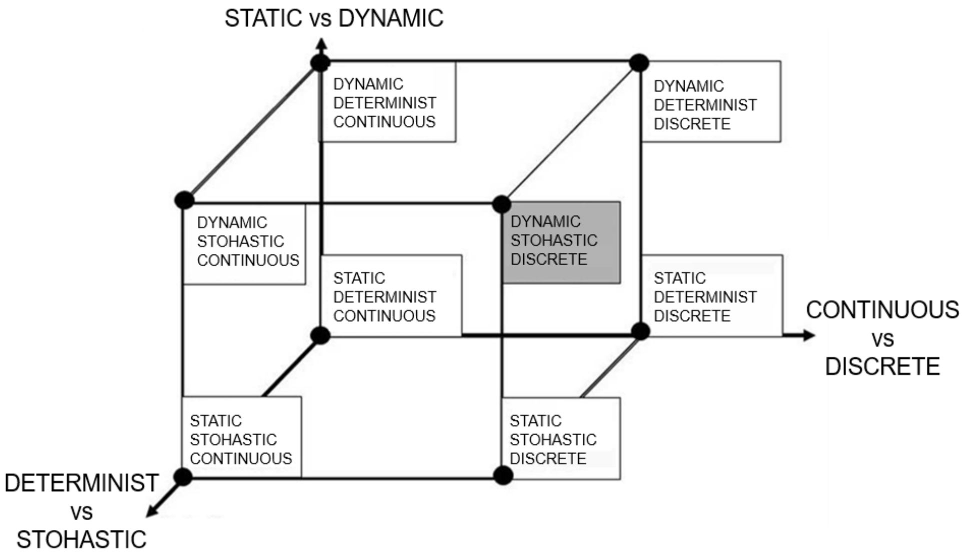

Fig. 3. Schematic representation of dynamic models in relation to static models

The stationary model (static type) does not contain the time variable. Linear systems correspond to linear models (consisting of linear equations), and to nonlinear systems - nonlinear models (which contain at least one nonlinear equation). In most practical applications, to simplify mathematical formalism, systems with weak nonlinearities are associated with linear or linearized models on portions of the working field.
The modeling of a physical system, ie the operation of obtaining the mathematical model, can be performed by analytical, experimental or numerical methods. Simulation is the operation of describing the behavior of a system based on its model. The simulation accuracy is given mainly by the accuracy and precision of the mathematical model. Regardless of the method, the modeling operation is based on taking into account working hypotheses, with a simplifying role. According to the way of choosing the simplifying hypotheses and the degree of their concordance with the real phenomenon, the obtained model is simpler or more complex, reflecting the physical reality with a greater or lesser degree of precision.
The analytical modeling of the technical systems is performed based on the general and particular laws that govern the specific physico-chemical phenomena of the real system (the law of conservation of mass / volume / energy / impulse / electric charge, the laws of physico-chemical balance etc). Experimental modeling (also called identification) involves performing direct tests on the physical system, allowing either global identification of the system (in the case of black box systems) or only determining the value of some parameters of the model, when knowing the structure and shape of the model (from analytical modeling).
Numerical modeling combines analytical and experimental methods and procedures. A variant of mixed modeling is one in which the shape of the model is determined analytically, and some unknown parameters or with a high degree of uncertainty are determined experimentally.

In the field of technical sciences, as mentioned, experiment and observation are essential aspects for a system that is developed iteratively. Ultimately, the elaboration of a theory represents the construction of a verbal or mathematical model of reality. The model is therefore, in these conditions, the representation of knowledge, of the essential aspects of a system in a usable form. The model is a simplified, approximate representation of the real system. It is usually neither possible nor necessary to make a detailed description of all internal mechanisms. It is enough for the model to mimic, to behave close enough to the real system.
There are several types of models (see Fig. 4 and Fig. 5), namely: physical models (empirical or small-scale - for example, a technology is developed in the field of chemistry, a micro pilot, the technological process is tested on this physical model and conclusions are drawn), phenomenological models (conceptual - the respective systems are described by certain laws), functional models (formal - the system is represented by functional relations, functional schemes) and mathematical models (analytical).

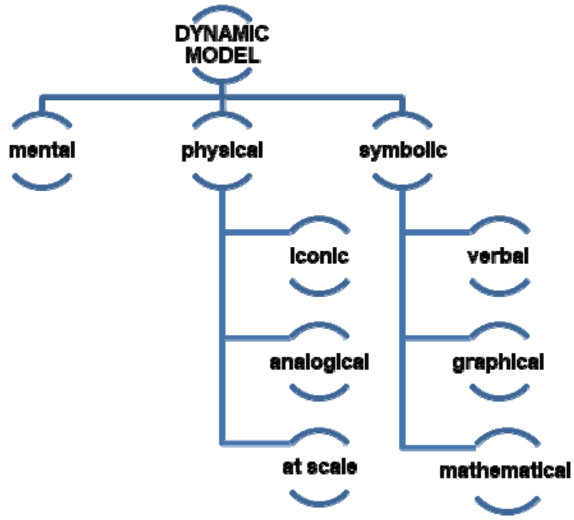

Fig. 4. Schematic representation of dynamic models' classification (I)

The model must be in a usable form (which is not an end in itself). It is a basis for analysis, decision making and in this sense the model must be as small as possible. If the number of simplifying hypotheses considered is large, then the model obtained is simple, robust, easy to process and interpret, but less accurate.

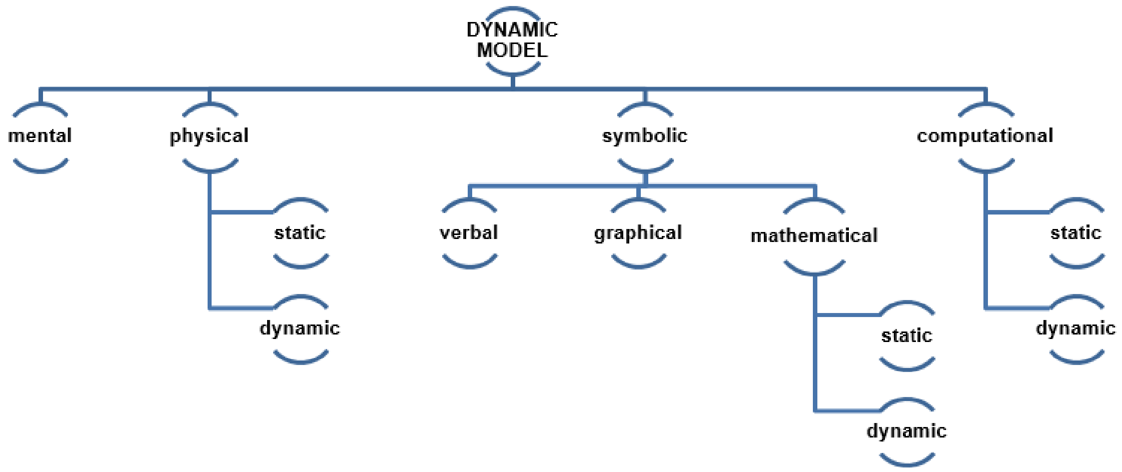

Fig. 5. Schematic representation of dynamic models' classification (II)

Even very complicated models, regardless of the classification they fall into (see Fig. 6), are not recommended, due to the lack of accuracy in determining some parameters, the impossibility of analytical calculation, rounding and truncation errors that occur in numerical processing, etc.

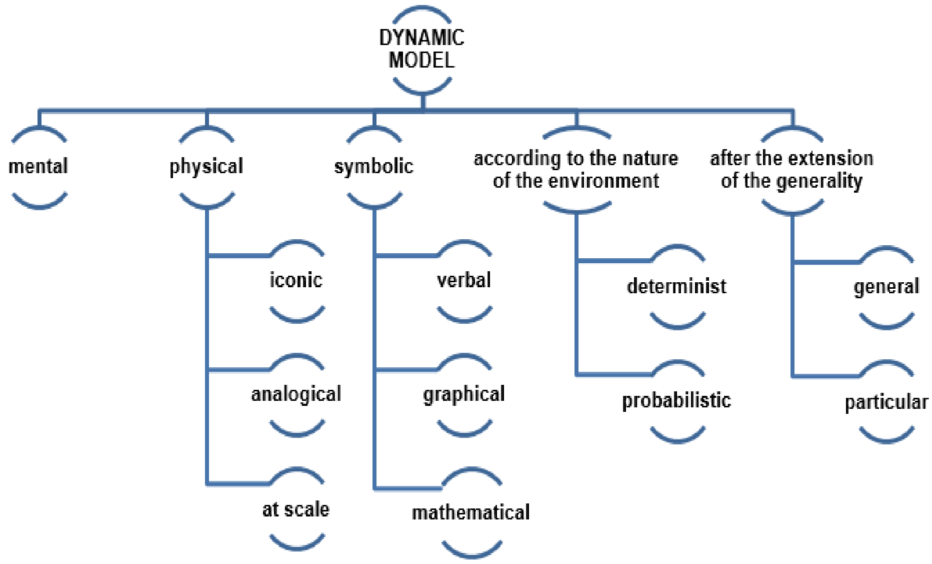

Fig. 6. Schematic representation of dynamic models' classification (III)

The model is a material or ideal object, which replaces in the research process the original object, keeping some essential characteristics (geometric, physical, dynamic, basic functional), important for the research process; depending on these characteristics the model can fall into different classes of models. The ideal modeling has a theoretical character. When certain sets of symbols are used for modeling, the modeling is called symbolic. Schemes, graphs, formulas, etc. may appear as symbols. Under these conditions, we say that mathematical modeling involves researching the object through a model formulated in mathematical terms and notions, using mathematical methods.

Mathematical modeling uses simplified mathematical representations of real world systems, processes, or theories. Mathematical models are created to facilitate the understanding, prediction and control of a system. A mathematical model is symbolic and is used to express ideas and clarify problems. A good model is a faithful replica of reality. The validation of the model implies the confirmation of the simplifying working hypotheses, of the quality of the experimental data through the obtained results and the conclusions drawn. Mathematical modeling is used successfully in extreme situations, when experimentation is too expensive, too dangerous or virtually impossible. The synthesis of an experiment in a mathematical model and its use instead of the experiment is the real success of this activity.

The mathematical model is a fundamental working tool for an engineer. It consists of a set of mathematical relations able to correctly describe the interdependence of process variables. By mathematical relations is meant any abstract means capable of quantitatively describing the interdependence of variables such as: equations, inequalities, tables, diagrams, chemical equations, computational subroutines or even computational programs.

Deterministic models are made up of property conservation equations to which the constitutive equations and the equations specific to the phenomenon and terms of the equations are attached. The complexity of these models and the practically insurmountable difficulties in solving them limit their applicability. The development of computational techniques and numerical methods for solving systems of differential equations, representative of this type of models, synthesized in high-performance computational algorithms provides, mainly, predictive character to these models.

Statistical models are models with simple mathematical expression, which explains their successful use in practice (see the examples presented in Fig. 7 and Fig. 8). It represents the mathematical synthesis of a practical experiment and for this reason their use is made only within the limits within which the experiment took place. Any extrapolation is not recommended.

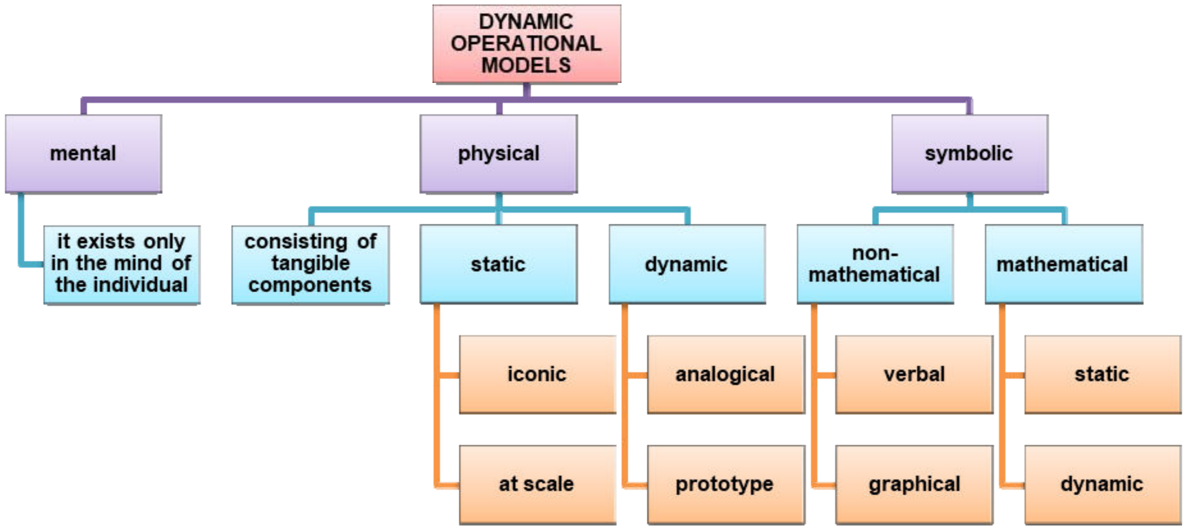

Fig. 7. Schematic representation of dynamic models' classification specific to operational research

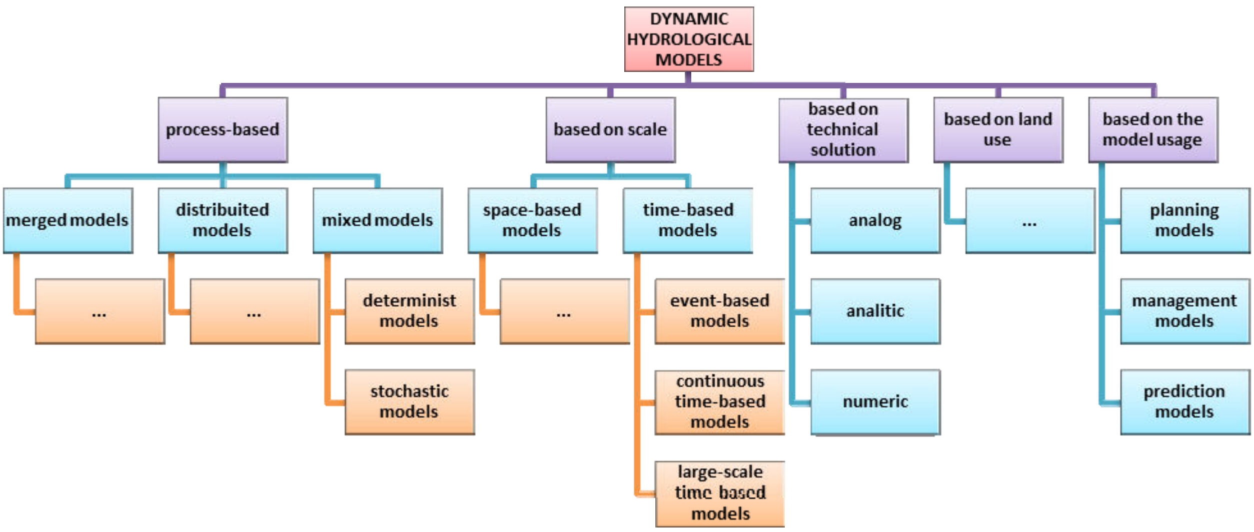

Fig. 8. Schematic representation of dynamic models' classification specific to hydrological research

The mathematical modeling of operations and in general of the processes of the surrounding reality is almost always accompanied by the existence of two opposite tendencies: on the one hand it is sought that the model reflects as accurately as possible the real process, and on the other hand, it is desired to obtain a model. as simple as possible, allowing the complete solution of the problem. Resolving this contradiction is equivalent to finding the balance between "oversimplification" and "overcrowding".

3. Systems behavior analysis - object of study and methods of investigation

The analysis and methods themselves, of analysis of the behavior of dynamic systems (with reference mainly to mechanical systems), as well as of the random vibrations associated with them have known a continuous development, lately, due to the high needs of design of structures and equipment. superior functional performance and high reliability to the extremely complex requirements to which they are subjected during operation. Examples of such stresses are those caused by the turbulent flow of fluids, the dynamic loads produced by the action of seismic movements, wind or waves, or the excitations induced by the unevenness of the runways.

A common feature of these types of requests is the impossibility to describe their evolution, in a deterministic way, due to the behavioral dynamics of the whole system, an aspect that gives rise to concepts such as white box, gray box and black box. The dynamic behavior of mechanical systems with random parameters is described by stochastic differential equations whose treatment depends essentially on the way in which the random factors intervene:

- differential equations with random initial conditions - important role in statistical mechanics, statistical thermodynamics, a priori analysis of spacecraft trajectories etc;
- differential equations with random coefficients - used in the study of systems whose parameters have imprecise values due to inherent material or execution imperfections or vary randomly as in the case of the mass of material on a conveyor belt;
- differential equations in which the random part enters as a non-homogeneous term - representing the external perturbation applied to the system as a random function of time (random process).

The last category of differential equations have the widest field of applications, being used in modeling the dynamic behavior of most mechanical structures encountered in practice (road and rail vehicles, ships, aircraft, civil and industrial construction, machinery, machine tools, etc.).

The whole approach of system analysis methodologies is based on the idea of the existence of possibilities for continuous improvement and improvement of the performance of any system, through an activity of analysis of the existing system and design of a more efficient system. To achieve this goal, system analysis uses a set of methods to achieve the specific stages of each methodology of analysis and design of systems, which make the transition from the physical model (real) to the mathematical model.

By its nature, system analysis uses the systemic approach method, which is based on the concepts of general systems theory and logically combines the system analysis stage with the synthesis one, as well as a series of methods specific to the stages necessary to develop the new system. such as:

a) modeling method - uses a set of statistical-mathematical techniques, heuristic techniques, in order to determine an isomorphic representation of objective reality.
b) simulation method - technique of testing, evaluation and manipulation of a real system through computer experimentation of mathematical and logical models in order to observe and study the dynamics of system behavior in the future.

Depending on the problematic area it addresses, the diagnostic analysis can be general, when considering the whole system, and partial or specialized, when analyzing one or some of the basic areas. An essential element in the diagnostic analysis is the analysis of information in order to know how the system works and its state.

c) computer methods - ubiquitous in the analysis and design of more efficient systems, in general, as well as for the realization of expert systems and support systems for decision support, in particular.

To achieve its objectives, system analysis uses or combines some of these methods for any of the methodologies used. Choosing the most suitable models and the appropriate modeling technique is an important aspect.

4. Conclusions

Because most natural and technical systems are nonlinear dynamical systems, ie systems characterized by the presence of chaotic (non-deterministic) behavior, the study, respectively their definition and characterization, the classification and the analysis of the control possibilities require the use of the most diverse working methods. There are suitable methods of modeling, simulation, analysis-diagnostics - mostly informative, current methods and with the possibility of approaching some multicriterial analysis sequences.

Mechanical dynamic systems used in the technique for over a century have the mathematical formalism of input-state-output. It refers to dynamics involving many state variables that make modeling difficult in itself. Current work techniques - program sequences, software, applications - make it possible to create more and more fidelity representations, and application results increase the interest of research for dynamic systems in many fields of activity to limit negative effects and dysfunctions, both in inside the system considered, and in the external environment.

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