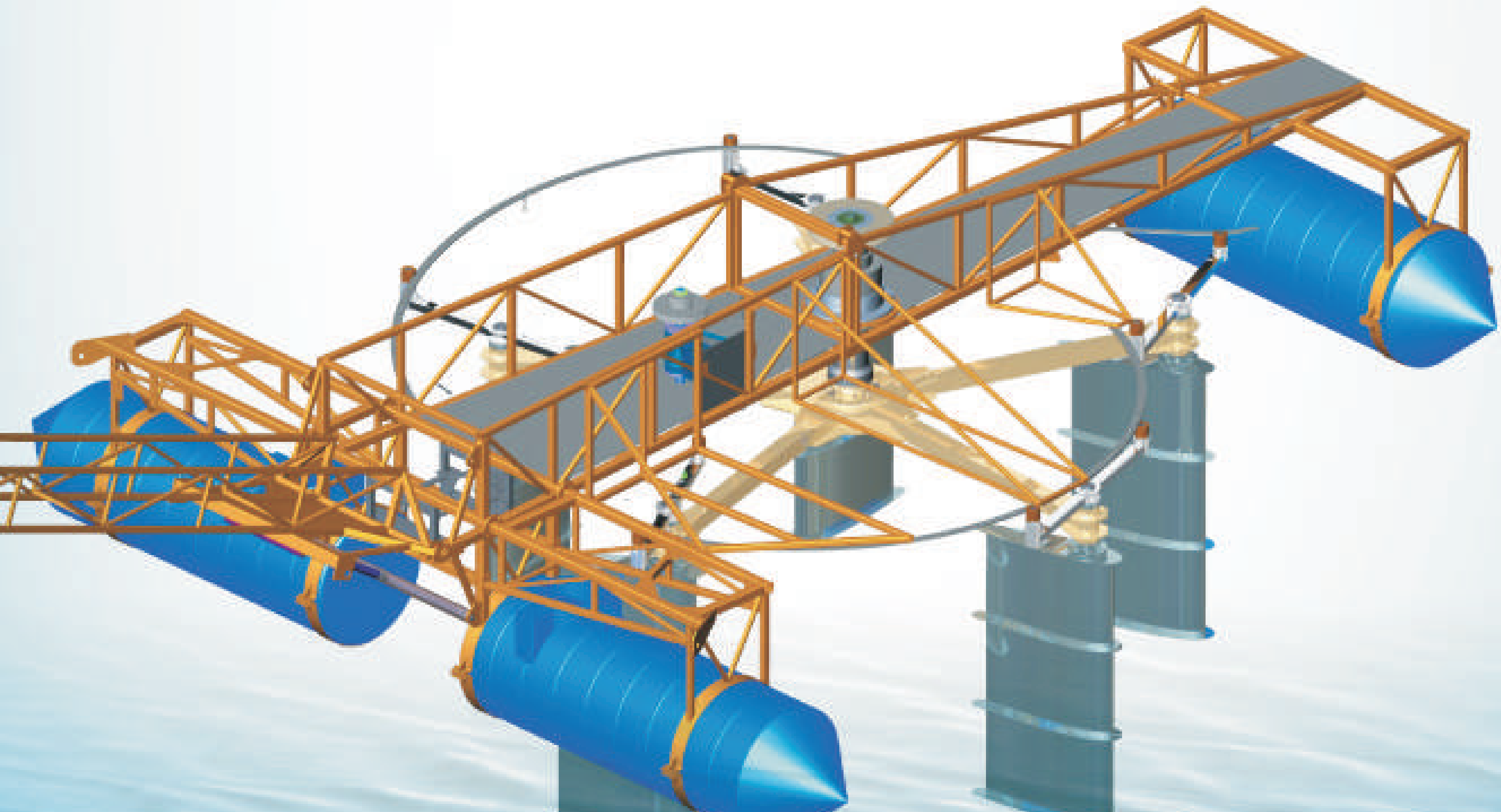
HYDROPOWER
SERVING RURAL CONSUMERS



Chisinau | September 16, 2013

HUMAN RESOURCES:

Research Team is coordinated by acad. Ion Bostan (24 researches, including 21 full time PhD and postdoctoral students).

The results of scientific research were:

- published in about 160 scientific works, including: 3 monographs, 16 patents;
- Appreciated at the International Exhibitions of Invention, Research and Technology Transfer with 36 medals, including: 29 gold, 6 – silver, 1 – bronze;
- Made in 9 research projects, including four projects in international programs.

INFRASTRUCTURE:

"Centre for Renewable Energy Conversion Systems Design" (CRECSD), including:

- Laboratory for Mechanical Systems Simulation;
- Laboratory "New Technology for hydro - dynamical blades fabrication from composite materials";
- Laboratory of Aero/Hydro-dynamics;
- Center for Creativity;
- Laboratory for tests on r. Prut, Stoieneşti.

Problem Description and Market Need

Necessity for the conversion of the flowing river kinetic energy in Republic of Moldova:

- Electric energy production for individual consumers;
- Illumination, heating, household needs;
- Irrigation of the farming lands in riverine regions;
- Vegetable gardening, fruit growing, viticulture;
- Development of small and medium size business in rural areas as well as new job opportunities;
- Minimal impact on environment.

ESTIMATIVE STUDY OF THE HYDROENERGETIC POTENTIAL IN REPUBLIC OF MOLDOVA

Nistru river: Hydroenergetic potential on section v.Naslavcea (altitude - 62m) - v. Sănătăuca (29 m). On this section there are 40 rural communities with population approx. 60 000.

Prut river: Hydroenergetic potential on section v. Criva (55 m) - v. Costuleni (27m), 45 rural communities with population of approx. 100 000.

Răut river: Hydroenergetic potential on section v. Prăjila (79m) - v. Trebujeni (23m), 50 rural communities with a population of approx. 70 000.

Rotors for conversion of kinetic energy of rivers

Conceptual design of water wheel

Conceptual design of the rotor with hydrodynamic profile of blades

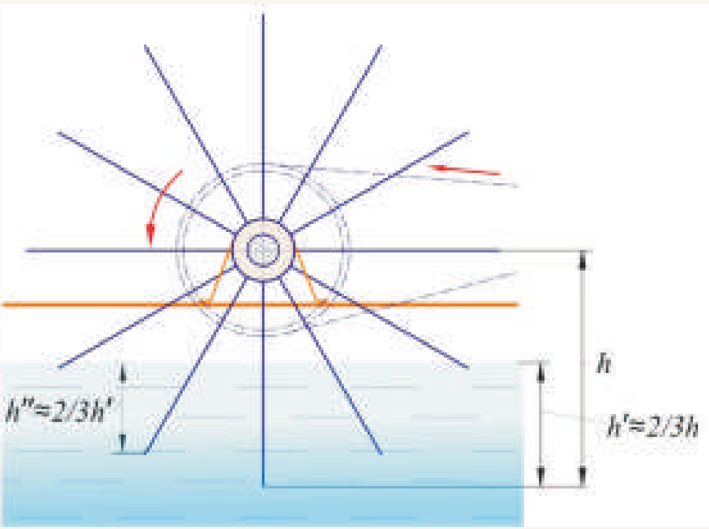


Fig. 2.

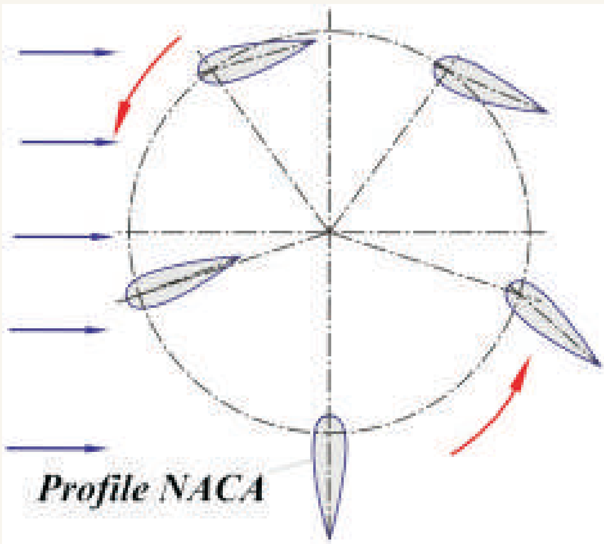


Fig. 3.

KINETICAL WATER ENERGY CONVERSION

An important reserve of renewable energy can be obtained in the result of utilisation of hydraulic micro-stations for flowing river water kinetic energy conversion into electrical or mechanical energy. It was stated that the utilisation of kinetic energy of Amazon River water would allow the satisfaction of demand for electrical energy all villages and cities located on its banks without affecting the aquatic environment by constructing dams. Micro-hydro-power stations are widely used in the world as decentralised energy sources. For example, in Switzerland there are about 7000 micro hydro power stations. About 76000 micro power stations have been mounted in the period 1970-1985.

Decentralised systems for the production of electrical or mechanical energy out of the flowing river water kinetic energy (micro-hydro-power stations) utilise turbines which do not demand construction of dams or barrages. Water kinetic energy is a recommended energy source available 24 hours per day and can be operated efficiently by micro-hydro-power stations.

The leading working element of micro-hydro-power stations is: the blade rotor with inclined axis of Garman or Darieus type or the multi-blade rotor;

In the framework of the BSEC HDF project *„Technological systems based on the utilization of water kinetikal energy for rural consumers (TESUWKERC”* micro hydro power stations has been developed.

Within this project the design concept of the turbine with modified NACA hydrodynamic profile of blades was elaborated. The blades possess individual orientation depending on the water flow rate and blade positioning concerning the turbine axle.

Theoretical research and elaboration of rotor with blades with NACA aerodynamic profile

Theoretical research was reduced to the optimization of construction parameters of blades with various symmetrical NACA profiles (0012, 0014, 0016, 0018, 63012, 63015, 63018, 66015, 66018, 67015 – 32 profiles have been researched in total), with account of the maximal moment of torsion of the rotor shaft.

The hydrodynamic force F (fig. 4) has its components in directions O′x and O′x named lift and drag forces, respectively, given by:

$$\vec{V} = (u, v) \qquad F_D = \frac{1}{2} C_D r_\infty V_\infty^2 S_p,$$

where ρ_∞ is the fluid density, V_∞ is the flow velocity, S_p=*ch* (*c* is *AB* the chord length, *h* is the blade height) represents the lateral surface area of the blade, and C_L and C_D are the dimensionless hydrodynamic coefficients, lift and drag coefficient. Coefficients C_L and C_D are dependent on the angle of attack α, the Reynolds number *Re* and the aerodynamic form of the blade profile.

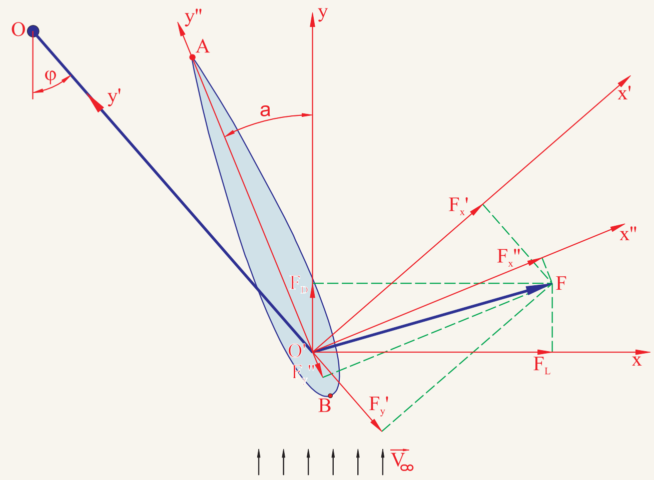


Fig. 4.

The components of the hydrodynamic force in the coordinates system *O′X′Y′* are given by

$$F_{x'} = -F_L \sin j + F_D \cos j \ ,$$
$$F_{y'} = F_L \cos j + F_D \sin j \ .$$

The torsion moment at the rotor axis *OO′* developed by the blade *i* is

$$T_{r,i} = F_{x'} \cdot |OO'|$$

and the total torsion moment developed by all blades

$$T_{r\Sigma} = \sum_{i=1}^{Npal} T_{ri}$$

where N_{pal} is the number of the rotor blades.

Since the hydrodynamic force does not have its application point in the origin of the blade axis system *O′*, it will produce a pitching moment with respect to a reference point. Following a standard convention, the reference point is located at a ¼ of the chord distance from the leading edge
B. The pitching moment, is computed by

$$M = \frac{1}{2} C_M r V_\infty^2 c S_p$$

where C_M represents the pitching moment coefficient.

Computation of the hydrodynamic coefficients

Initially, the incompressible potential flow model is considered. Velocity $\vec{V} = (u, v)$ at a field point $P(x,y)$ is given by

$$u(x,y) = \frac{\partial \Phi}{\partial x},\ v(x,y) = \frac{\partial \Phi}{\partial y},$$

where Φ is the flow potential obtained by superposition of the uniform velocity flow $\vec{V}_\infty = (V_\infty \cos\alpha, V_\infty \sin\alpha)$ and a distribution of sources and vortices over the profile C *(fig.5)*.

Therefore,

$$\Phi(P') = V_\infty x \cos\alpha + V_\infty y \sin\alpha + \int_C \frac{q(s)}{2\pi} \ln(r) ds - \int_C \frac{\gamma(s)}{2\pi} \theta ds.$$

In order to compute Φ numerically, a collocation method is implemented. Thus,

$$\Phi = V_\infty x \cos\alpha + V_\infty y \sin\alpha + \sum_{j=1}^{N} \int_{E_j} \left(\frac{q_j}{2\pi} \ln(r) - \frac{\gamma}{2\pi} \theta \right) ds.$$

with the unknowns γ and q_j, $j=1,\ldots,N$ are determined from the boundary condition and Kutta condition. The local pressure coefficient on the discrete contour of the profile is given by

$$C_{p,j} = 1 - \left(\frac{u_{t\,j}}{V_\infty} \right)^2$$

The hydrodynamic force acting on the boundary element j is given by

$$f_{xj} = C_{p,j} \left(y_{j+1} - y_j \right),\ f_{yj} = C_{p,j} \left(x_{j+1} - x_j \right),$$

and the pitching moment is computed by

$$c_{m,j} = -f_{xj} \left(\frac{y_{j+1} - y_j}{2} \right) + f_{yj} \left(\frac{x_{j+1} - x_j}{2} - \frac{c}{4} \right)$$

The total force is the sum of contributions from each boundary element

$$F_x = \sum_{j=1}^{N} f_{xj},\ \ F_y = \sum_{j=1}^{N} f_{yj},$$

and the lift and moment coefficients are given by

$$C_L = -F_x \sin\alpha + F_y \cos\alpha,\ \ C_M = \sum_{j=1}^{N} c_{m,j}.$$

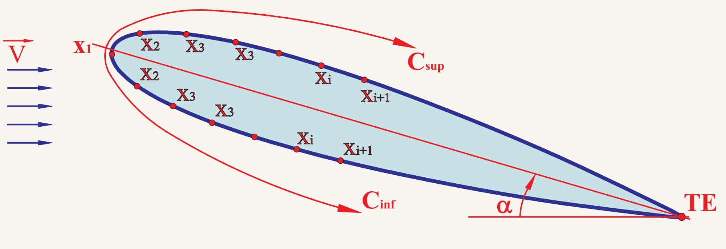


Fig. 5.

Laminar boundary layer

In order to compute the drag coefficient a boundary layer analysis must be performed. The boundary layer analysis is divided into two parts: laminar and turbulent boundary layer (fig.6).

The laminar boundary layer begins in the stagnation point and follows the flow along the lower or upper sides of the profile in the direction of the trailing edge. As soon as the stagnation point is determined, consider a uniform arc length partition of the upper and lower sides with the nodes being numbered toward the trailing edge.

The Thwaites model is used for the laminar boundary layer analysis. Introduce parameters: the displacement thickness δ^* given by

$$\delta^* = \int_0^\infty (1 - \frac{u}{V}) dy,$$

the thickness of impulse loss θ defined by

$$\theta = \int_0^\infty \frac{u}{V} (1 - \frac{u}{V}) dy,$$

and the thickness of energy loss θ^*

$$\theta^* = \int_0^\infty \left(1 - \left(\frac{u}{V} \right)^2 \right) \frac{u}{V} dy,$$

where V represents the velocity of the potential flow in a given point, and u is the tangential velocity in the boundary layer at this point. Consider the Von Karman integro-differential equation

$$\frac{d\theta}{dx} + \frac{\theta}{V} \left(2 + \frac{\delta^*}{\theta} \right) \frac{dV}{dx} = \frac{1}{2} C_f,$$

where C_f denotes the local coefficient of the friction force on the profile surface given by

$$C_f = \frac{\tau_w}{\frac{1}{2} \rho V^2},\quad \text{with}\quad \tau_w = \mu \left. \frac{\partial u}{\partial y} \right|_{y=0}.$$

Introducing parameter $H = \frac{\delta^*}{\theta}$, we get

$$\frac{d\theta}{dx} + \frac{\theta}{V} (2 + H) \frac{dV}{dx} = \frac{1}{2} C_f.$$

Integrate to get the integral equation for the kinetic energy of the boundary layer

$$\frac{d\theta^*}{dx} + 3 \frac{\theta^*}{V} \frac{dV}{dx} = 2 C_d,$$

where C_D is the dissipation coefficient. Introducing the second parameter $H^* = \frac{\theta^*}{\theta}$, we obtain

$$\theta \frac{dH^*}{dx} + \left(H^* (H - 1) \right) \frac{\theta}{V} \frac{dV}{dx} = 2 C_d - H^* \frac{C_f}{2}.$$

The supplementary conditions are based on the Falkner-Skan semi-empirical relations. A resulting system of differential equations is numerically solved with a backward Euler method. The method is used either until the transition from laminar to turbulent boundary layer is predicted or until the trailing edge is reached. The transition is localized by Michel's criterion

$$\mathrm{Re}_q > \mathrm{Re}_{q\,\max} = 1.174\left(1+\frac{22.4}{\mathrm{Re}_x}\right)\left(\mathrm{Re}_x\right)^{0.46}$$

where $\mathrm{Re}_x = \mathrm{Re}\cdot V\cdot x$

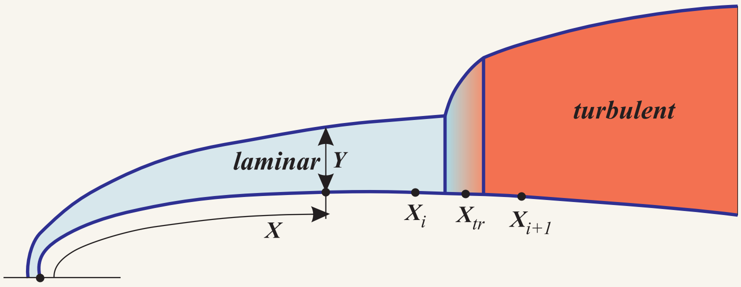


Fig.6.

Turbulent boundary layer

Similar to the laminar boundary layer, the Von Karman integral equation for turbulent boundary layer is considered. Computations of the turbulent boundary layer parameters are done by applying the Head's model. Let

$$Q(x) = \int_0^{d(x)} u\,dy$$

be the volume rate of flow through the boundary layer.

Then $d^* = d - Q/V$. Introducing the flux velocity

$E = dQ/dx$, we get $E = d\left(VqH_1\right)/dx$, where $H_1 = (d-d^*)/q$. Head supposed that the dimensionless velocity *E/V* is dependent only on $H_1 = H_1(H)$. Cebeci and Bradshaw considered the semi-empirical relations

$$\frac{E}{V} = 0.0306(H_1-3)^{-0.6169}$$

$$H_1 = \begin{cases} 3.3+0.8234(H-1.1)^{-1.287}, & H \le 1.6 \\ 3.3+1.5501(H-0.6778)^{-3.064}, & H > 1.6 \end{cases}.$$

The last equation used to find the unknowns θ, *H*, and H_1 is the Ludwieg-Tillman skin friction law

$$C_f = 0.246\left(10^{-0.678H}\right)\mathrm{Re}_q^{-0.268}.$$

Combine the Von Karman integral equation with the above equations to obtain a system of differential equations:

$$\frac{d}{dx}Y = F(x,Y) \text{ ,where } Y = \left(q, H_1\right)^T \text{ and}$$

$$F = \begin{pmatrix} -\dfrac{q}{V}(2+H)\dfrac{dV}{dx}+\dfrac{1}{2}C_f \\ -H_1\left(\dfrac{1}{V}\dfrac{dV}{dx}+\dfrac{1}{q}\dfrac{dq}{dx}\right)+\dfrac{0.0306}{q}(H_1-3)^{-0.6169} \end{pmatrix}.$$

Initial values are the final values provided by the laminar boundary layer. Numerical integration is done by a second order Runge-Kutta method. The method is applied either until the trailing edge is reached or until the separation of the turbulent layer takes place.

In order to compute the drag coefficient C_D, the Squire-Young formula is used. Given θ, *H* and *V* at trailing edge *A*, the drag coefficient is given by

$$C_D = \left(2q|_A\cdot(V|_A)^l\right)_{C_{\sup}} + \left(2q|_A\cdot(V|_A)^l\right)_{C_{\inf}}$$

with $l = (H|_A + 5)/2$.

Moment of torsion and power applied to the rotor with hydrodynamic profile blades

In what follows, we compute the hydro-dynamic coefficients for a rack profile standard, and, in particular, NACA profile with chord length *c=1,3m*. The model and numerical methods described previously are implemented in MATLAB. The coefficients corresponding to NACA0016 profile with chord length C_{ref}*=1,0m* are $C_{L,\,ref}$, $C_{M,\,ref}$ *and* $C_{D,\,ref}$. The coefficients corresponding to the profile with chord length *1,3m* are then obtained from relations

$$C_L = C_{L,ref}\cdot 1.3,$$

$$C_M = C_{M,ref}\cdot(1.3)^2,$$

$$C_D = C_{D,ref}\cdot 1.3.$$

Fig. 8 shows the hydro-dynamic power modulus *F*, which acts on the rotor blade together with its tangential and normal components F_X' , F_Y' versus the positioning angle. Fig. 9 shows the moment T_{ri} developed by one blade versus the positioning angle, and Fig. 10 represents the total moment of torsion $T_{r\Sigma}$ versus the positioning angle.

Theoretical and experimental research, digital modelling and computer simulations of the interaction effects „NACA hydrodynamic profile of blades-fluid" allow the optimisation of blade profile constructive parameters. Also the turbine kinetic parameters are optimised by decreasing the turbulence effects, as well.

The maximum hydrodynamic effect is obtained by optimum orientation of blades under the action of the fluid with the utilisation of a "feedback' system with KNOW-HOW elements.

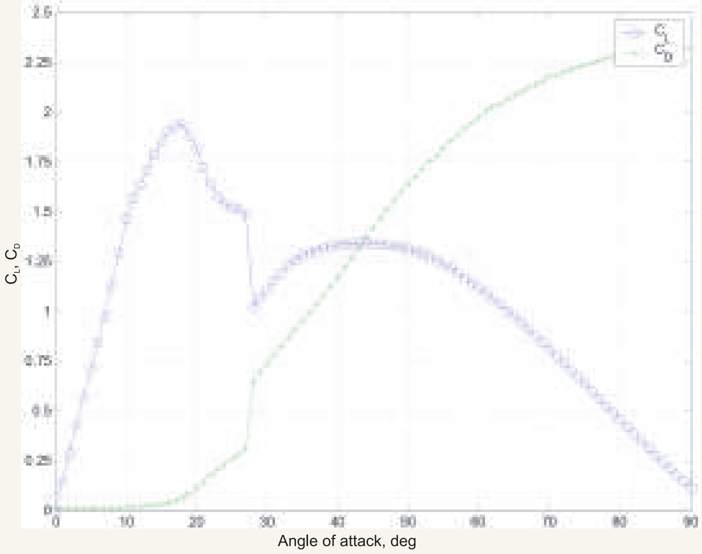


Fig. 7. Lift and drag coefficients C_L and C_D.

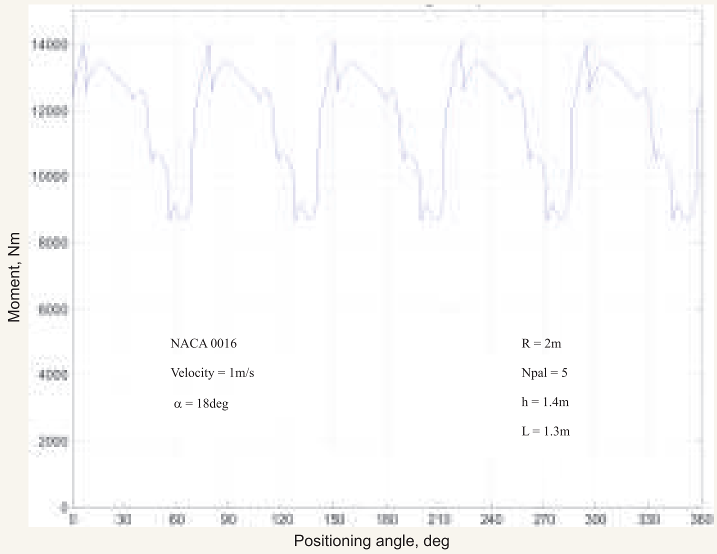


Fig. 10. Total moment of torsion $T_{r\Sigma}$ vs positioning angle φ.

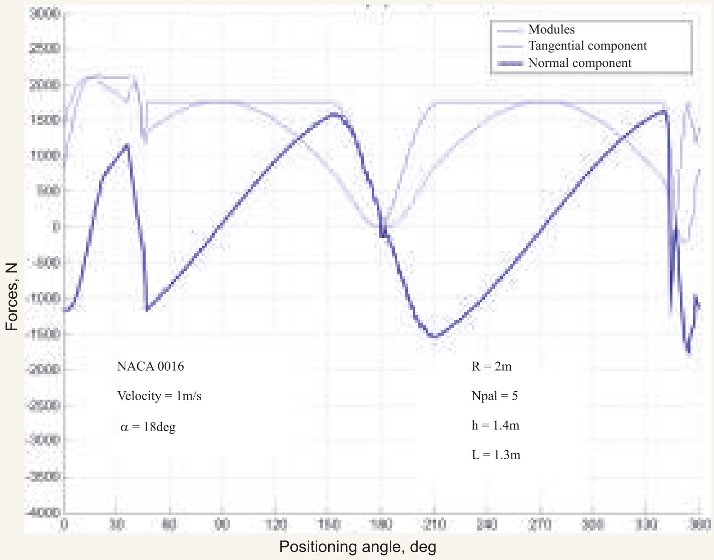


Fig. 8. Hydrodynamic force vs positioning angle φ.

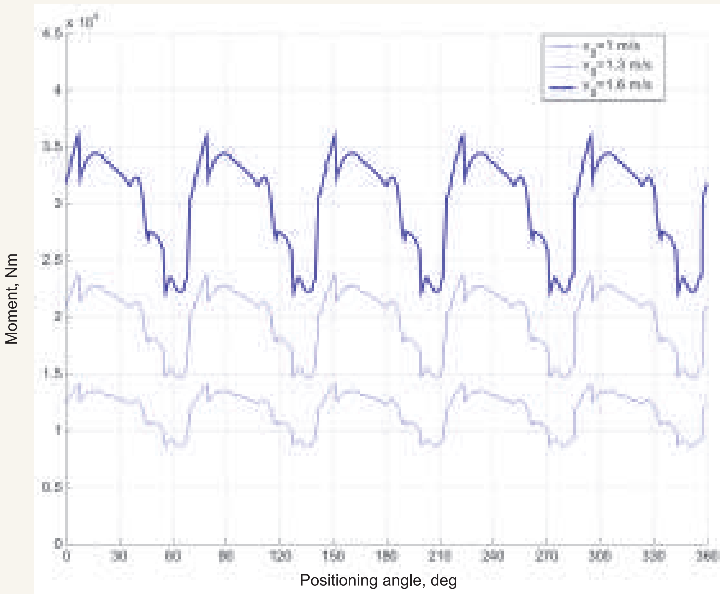


Fig. 11. Total moment T for different flow velocities. NACA 0016.

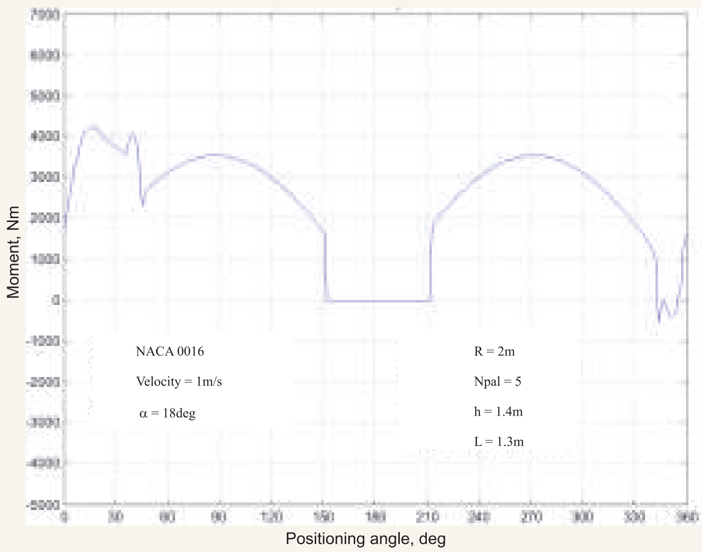


Fig. 9. Moment of torsion T_{ri} vs positioning angle φ.

Based on the research results there were developed and fabricated the industrial prototypes of the generator with permanent magnets (*N=3kW*) and of the hydro pump (*Q=20m3/hour, H=10m*) with a frequency of *300 min*$^{-1}$ revolutions.

The modified micro hydro power station is fabricated. After its testing in real conditions on the PRUT River at a flow rate of (*0,8-1,2m/s*) we will develop the industrial prototype of the micro hydro power station which will be produced in the Republic of Moldova (see pictures in the prospectus, pages 9 – 12.

The novelty of the technical solutions is protected by 16 patents and author copyright.

Numerical modelling of the blade with hydrodynamic profile

Using the finite element computer programme ANSYS 11.0, the strain and tension of the hydrodynamic NACA 0016 blade coating was studied corresponding to the flow velocity

$$V_{\infty}=2m/s.$$

Blade coating (Fig. 12) can be modelled by mathematical theory of plates, namely, the theory of elastic linear plate Kirchhoff-Love. Plate element, shell63, has 4 nodes, placed in the median plane of the plate.

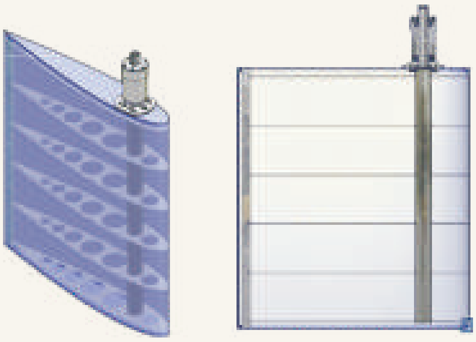


Fig. 12.

Element thickness, S, will be considered constant. Each node has 6 degrees of freedom: displacements ux, uy, uz, and rotations rxy, rxz, ryz. Local coordinate system has its origin at the first node, x and y axes being placed in the median plane of the element.

Fig. 13 shows the strain of the blade. As result of numerical analysis of the state of deformation of the blade coating with a thickness of 1 mm by 3, 4 and 5 transverse stiffeners, it was established that coating deformation in the maximum immersion areas is 7,8, 5,1 and 3.5 mm.

In order to assess the state of stress in the coating of the hydrodynamic NACA 0016 blade with a thickness of 1.5 mm (Fig. 14 a, b) the main stresses s1, s2 and s3 are considered, which are the own values of the strain tensor arranged in descending order . Fig. 14 shows the main stresses s1 (a) and s3 (b). Also, the intensity of stress is considered calculated by the formula:

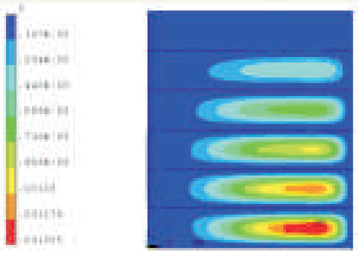


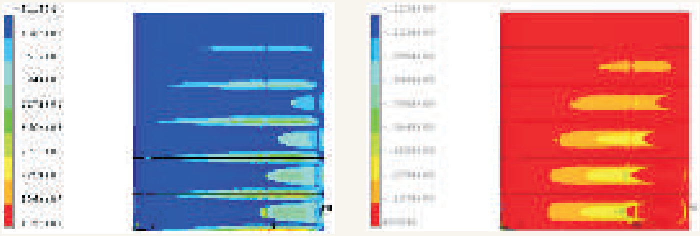
Fig. 13.

$$\sigma_I=\frac{1}{\sqrt{2}}\left[(\sigma_1-\sigma_2)^2+(\sigma_2-\sigma_3)^2+(\sigma_1-\sigma_3)^2\right]^{1/2}$$

and Von Mises deformation, calculated by the formula:

$$\varepsilon_e=\frac{1}{1+\nu}\left(\frac{1}{2}\left((\varepsilon_1-\varepsilon_2)^2+(\varepsilon_2-\varepsilon_3)^2+(\varepsilon_1-\varepsilon_3)^2\right)\right)^{1/2},$$

small radius of curvature (rates 1337-402 mm) to the zone of the bigger radius of curvature (rates 402-0 mm). It is necessary to take into account this behaviour of stresses and Von Mises strains for composite coatings, giving variable thickness of the blade coating from composite materials in the adjacent zone of rate 402 mm on the cord length.



a. **b.**

Fig.14.

Fig. 15 shows the main stresses: σ1 (a), σ2 (b) and σ3 (c) (Pa). Maximum value of the main stresses is approximately 38 MPa. It shows that the strain and tension has a similar distribution with the hollow blade and metal coating. Fig. 16 shows displacements of the polyurethane injected blade fragment and composite material coating of thickness S=2,6 mm: ux(a), uy(b) and uz(c), maximum defined displacement is 0,01 mm.

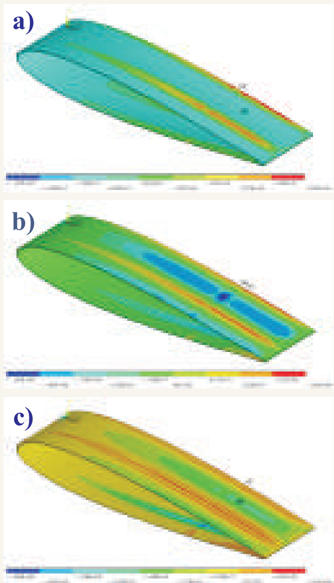


Fig.15.

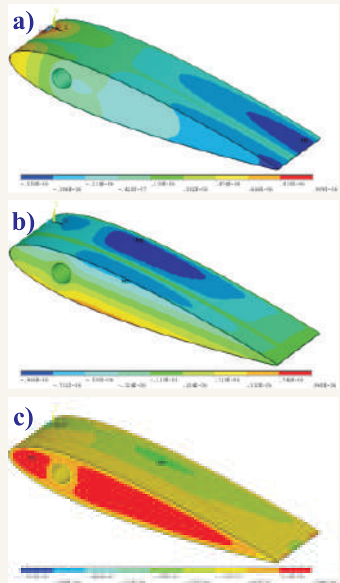


Fig.16.

Composite blade manufacturing technology has been developed and manufactured experimental prototypes of blades.

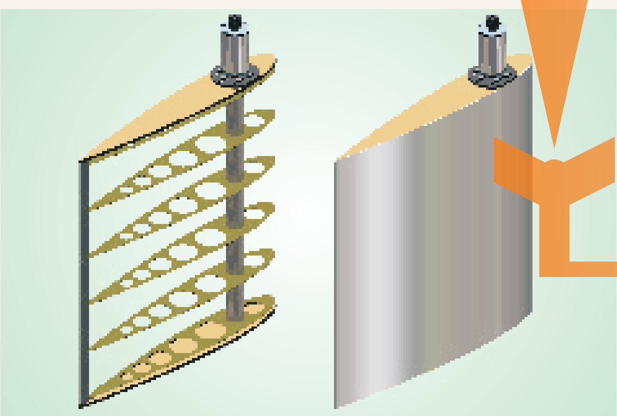
Composite materials manufacturing technology for hydrodynamic blades

a) Manufacture of NACA profile form 0016 inversat.

b)Installation of membrane and vacuum accessories into the form.

d) Extraction of semi profiles.

c) Resin infusion into the vacuum bag.



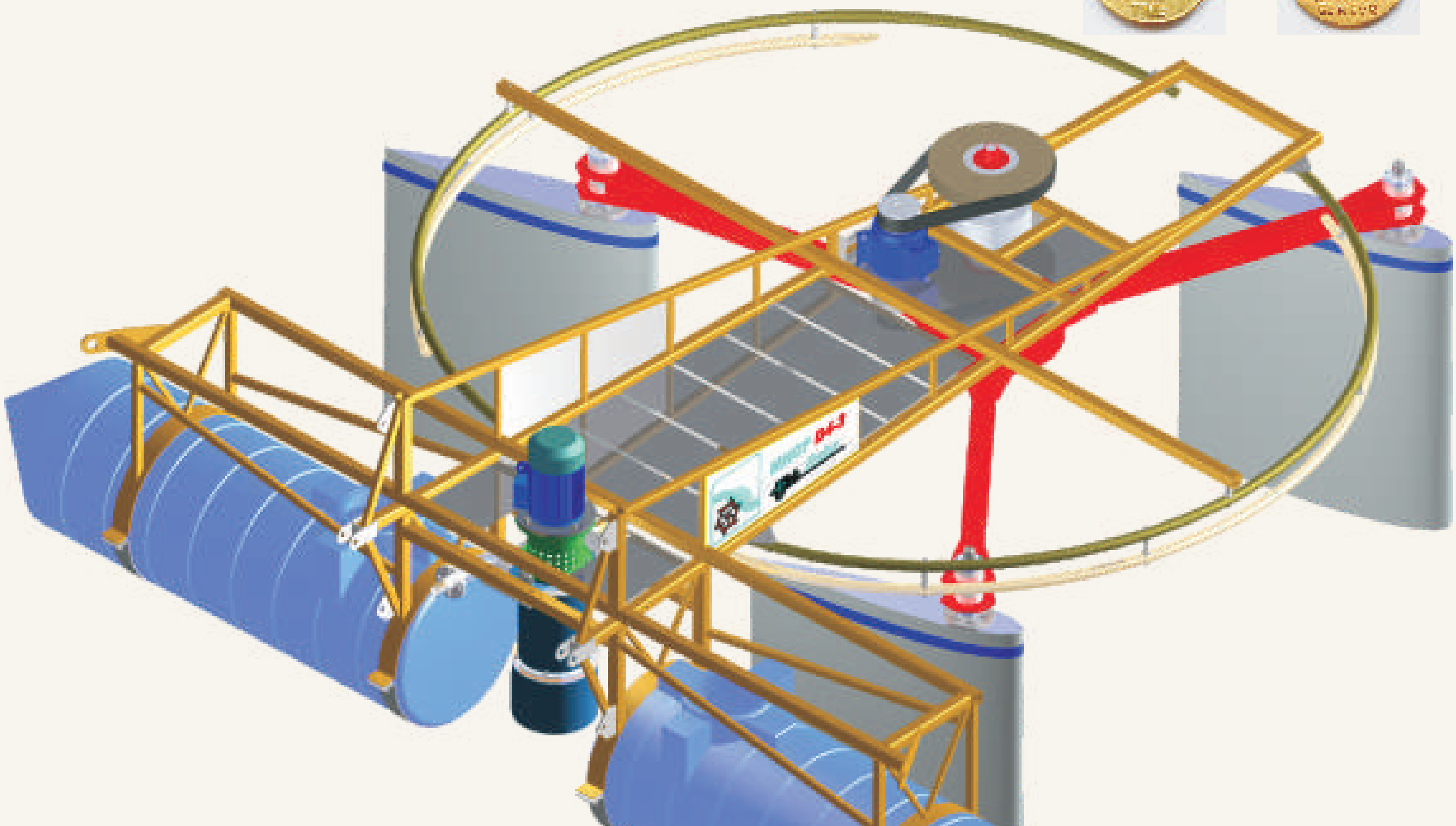
e) Assembling of resistance structure and hydrodynamic semi profile.

f) Assembled 5-blade hydrodynamic rotor.

Application of composite fabrication technology on an industrial scale to manufacture machine parts:

- with increased complexity of geometrical shape;
- exploitation under high humidity and aggressive chemical action;
- with form of housing, profiled spatial bars, with form of curvilinear plate, etc;
- with mass restriction, fatigue, etc.

MICRO HYDRO POWER PLANT WITH HYDRODYNAMIC ROTOR FOR CONVERSION OF RIVER KINETIC ENERGY INTO ELECTRICAL AND MECHANICAL ENERGY MHCF

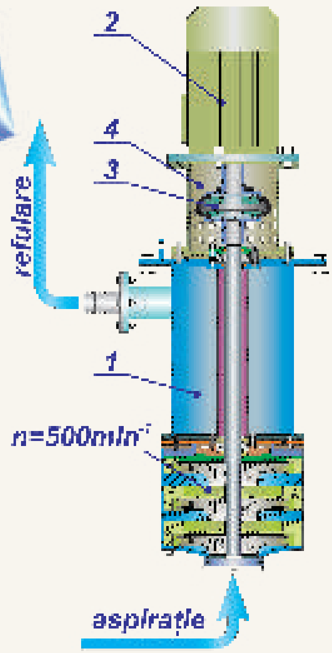



Construction parameters:

- Rotor diameter, mm...4000
- Number of hydrodynamic NACA 0016 blade...........3
- Blade submersible height, mm 1400
- Blade cord length, mm... 1300

Functional parameters:

- Conversion efficiency, % 43-50
- Allowable range of water velocity V, m/s 0,8-2,0
- Yield of electrical energy use, % 0,736
- Yield of mechanical energy use, % 0,596
- Water pumping flow (for V=1,3m/s and H=10...15m)... $40 m^3/h$



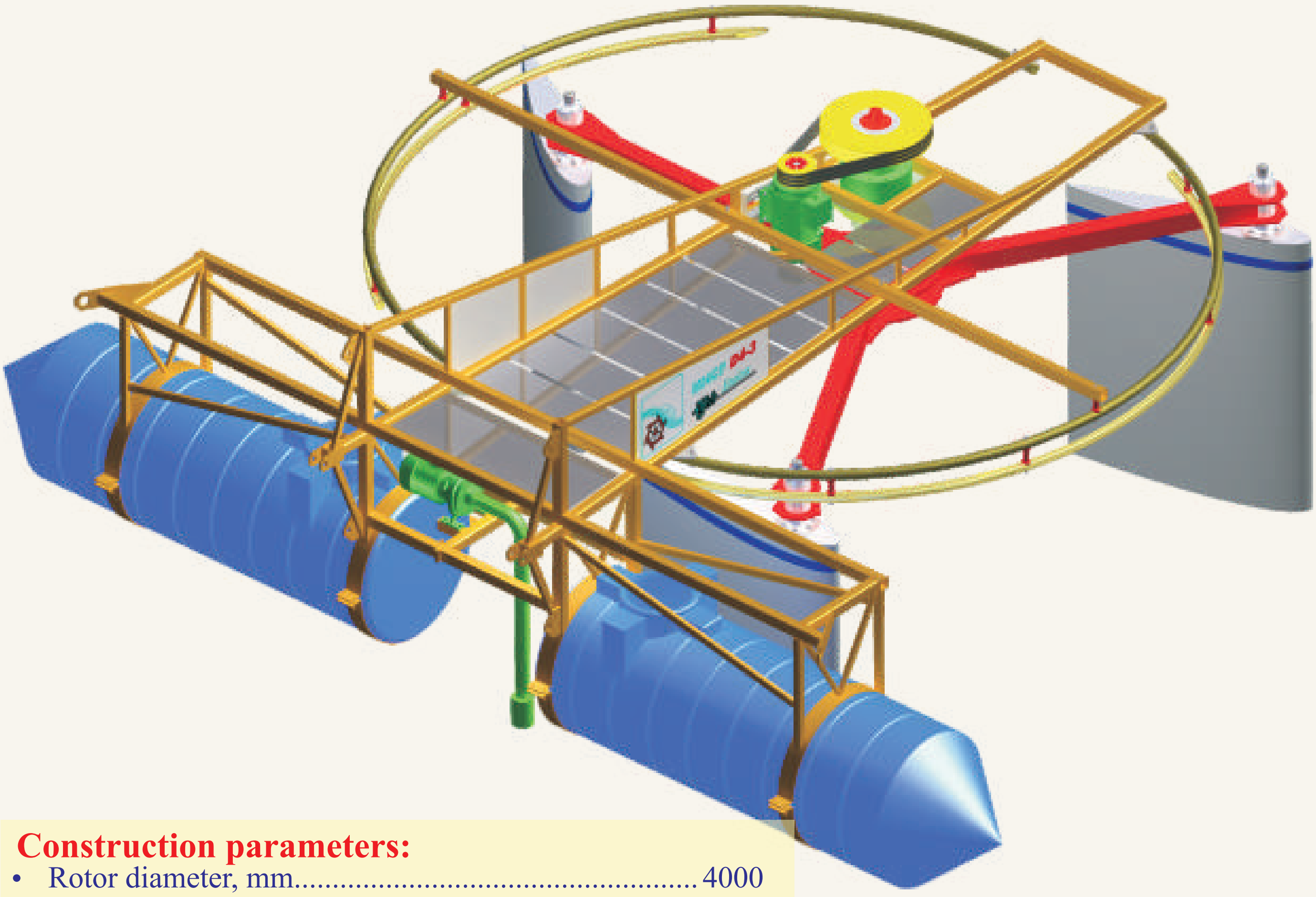
1. **Hydraulic pump.**
2. **Permanent magnet generator.**
3. **Toroid coupling.**
4. **Casing.**

Areas of application:

for individual consumers: electrical lighting of houses and streets, central heating, water pumping into irrigation and drainage systems, water pumping into sewage system, etc.

Patent: nr. 3845 (MD).

MICRO HYDRO POWER PLANT WITH HYDRODYNAMIC ROTOR FOR CONVERSION OF RIVER KINETIC ENERGY INTO ELECTRICAL ENERGY MHCF D4x1,5 E



Construction parameters:

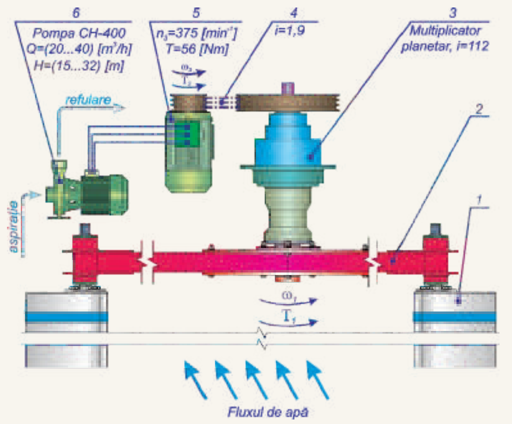
- Rotor diameter, mm.. 4000
- Number of hydrodynamic NACA 0016 blade............ 3
- Blade submersible height, mm 1400
- Blade cord length, mm.. 1300

Functional parameters:

- Conversion efficiency, % 43-50
- Allowable range of water velocity V, m/s 0,8-2,0
- Yield of electrical energy use, % 0,736
- Yield of mechanical energy use, % 0,67
- Water pumping flow (for V=1,3m/s and H=15...30m.. 40m^3/h

Areas of application:

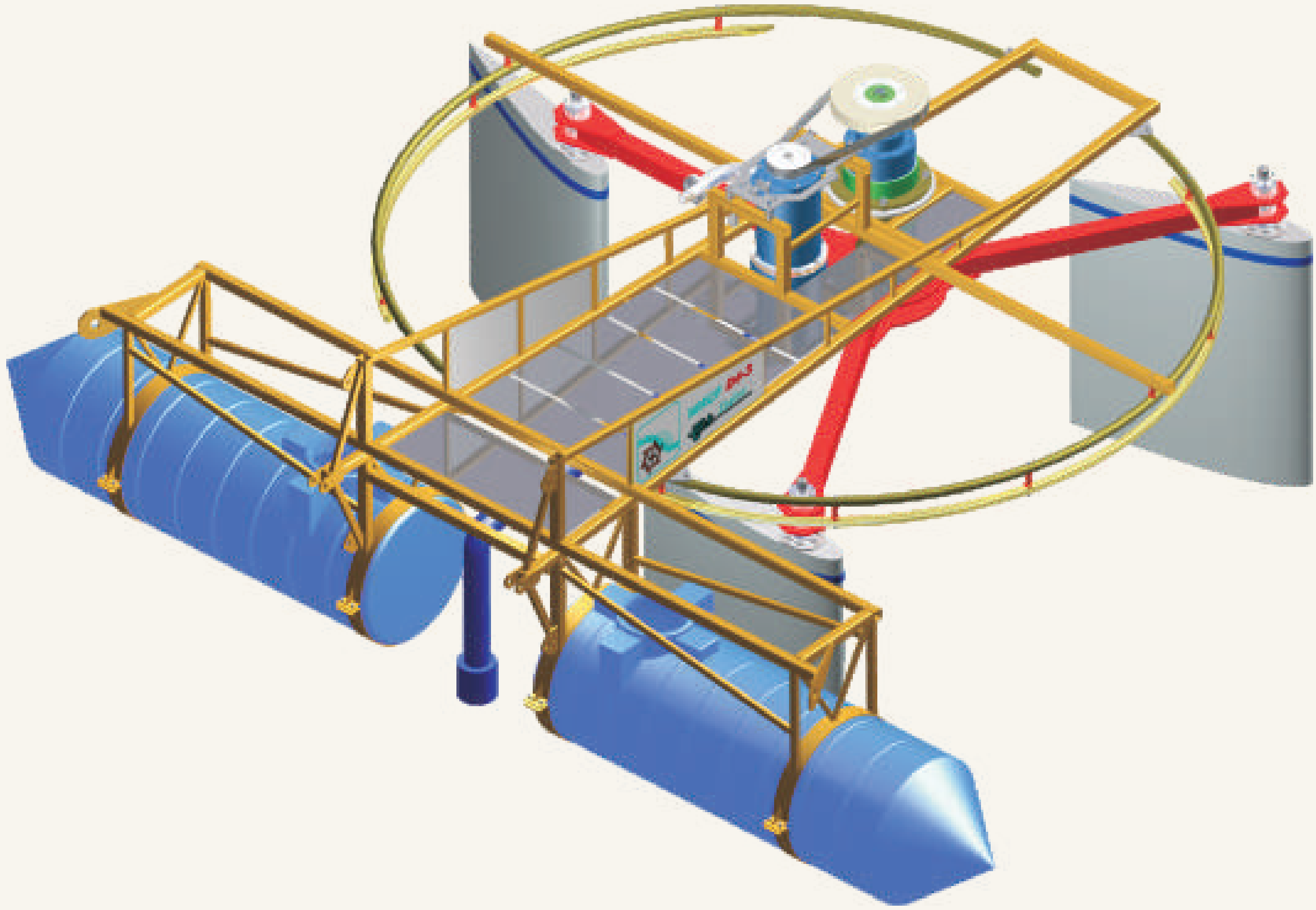
for individual consumers: electrical lighting of houses and streets, central heating, water pumping into irrigation and drainage systems, water pumping into sewage system, etc.



1. Blade with hydrodynamic profile
2. 3 blades rotor.
3. Planetary multiplicator.
4. Belt transmission.
5. Permanent magnet generator.
6. Hydraulic pump.

Patents: nr. 2992 (MD); nr. 2981 (MD).

MICRO HYDRO POWER PLANT WITH HYDRODYNAMIC ROTOR FOR CONVERSION OF RIVER KINETIC ENERGY INTO MECHANICAL ENERGY MHCF D4x1,5 M



Construction parameters:

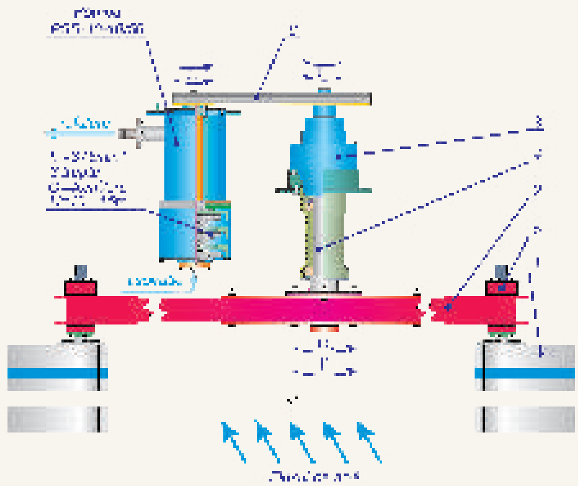
- Rotor diameter, mm.. 4000
- Number of hydrodynamic NACA 0016 blade........... 3
- Blade submersible height, mm 1400
- Blade cord length, mm... 1300

Functional parameters:

- Conversion efficiency, % 43-50
- Allowable range of water velocity V, m/s 0,8-2,0
- Yield of electrical energy use, % 0,846
- Water pumping flow (for V=1,3m/s
and H=10...15m)... 40m^3/h

Areas of application:

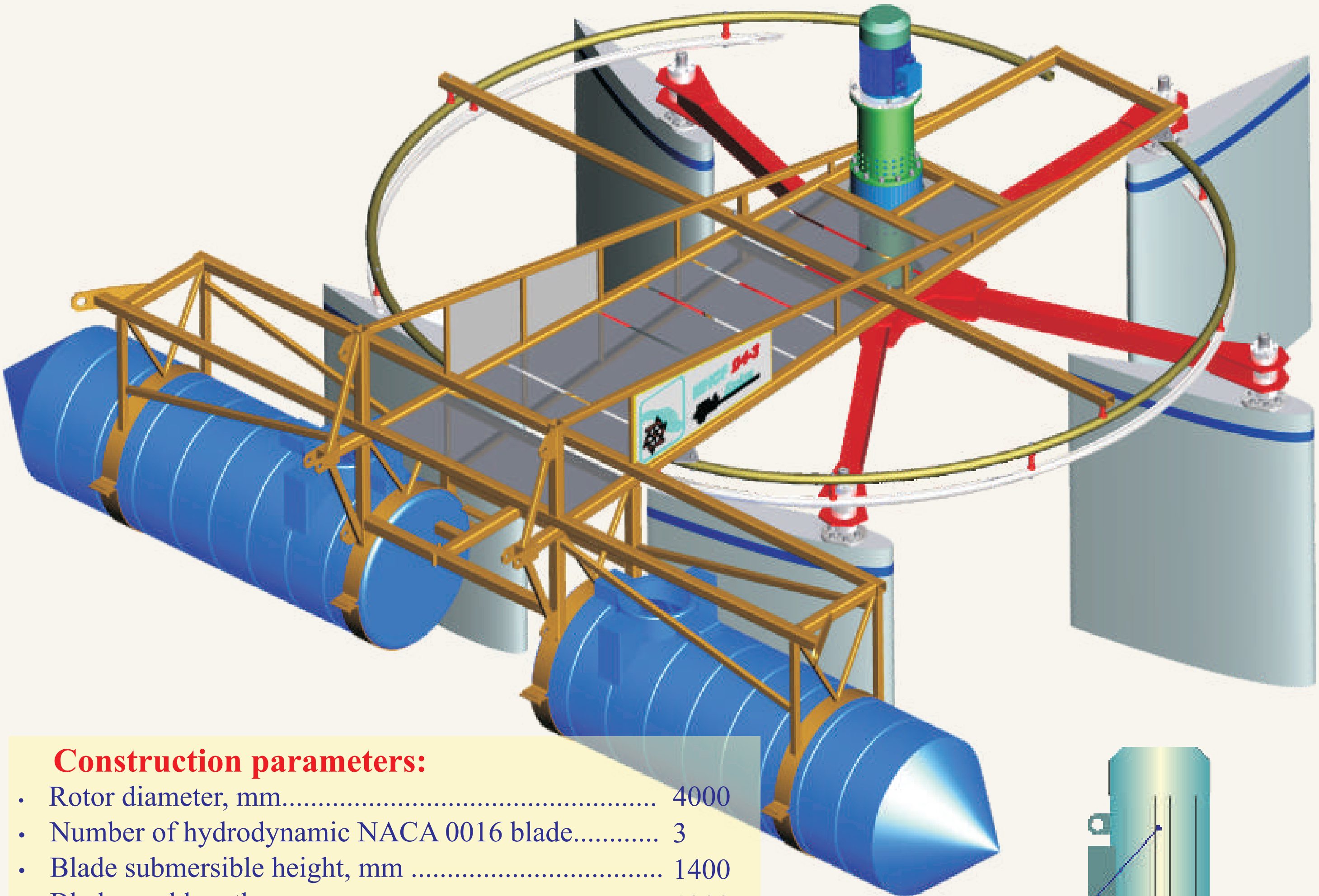
water pumping into irrigation and drainage systems, water pumping into sewage system, etc.



1. Blade with hydrodynamic profile
2. 3 blades rotor.
3. Planetary multiplicator.
4. Intermediate shaft.
5. Device for blade orientation.
6. Belt transmission.

Patent: nr. 2992 (MD).

MICRO HYDRO POWER PLANT WITH HYDRODYNAMIC ROTOR FOR CONVERSION OF RIVER KINETIC ENERGY INTO MECHANICAL ENERGY MHCF D4x1,5 M

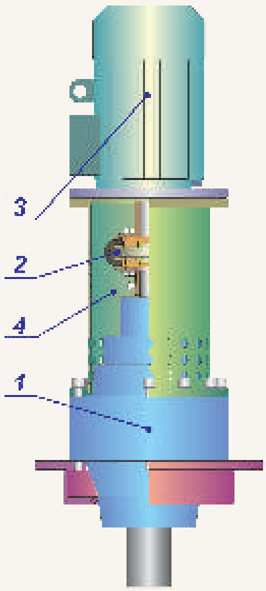


Construction parameters:

- Rotor diameter, mm.. 4000
- Number of hydrodynamic NACA 0016 blade............ 3
- Blade submersible height, mm 1400
- Blade cord length, mm... 1300

Functional parameters:

- Conversion efficiency, % 45-53
- Allowable range of water velocity V, m/s 0,8-2,0
- Yield of electrical energy use, % 0,775
- Power, kW:
  - -V=1,3m/s... 3,85
  - - V=1,6m/s.. 7,5
  - - V=2,0m/s.. 14,0



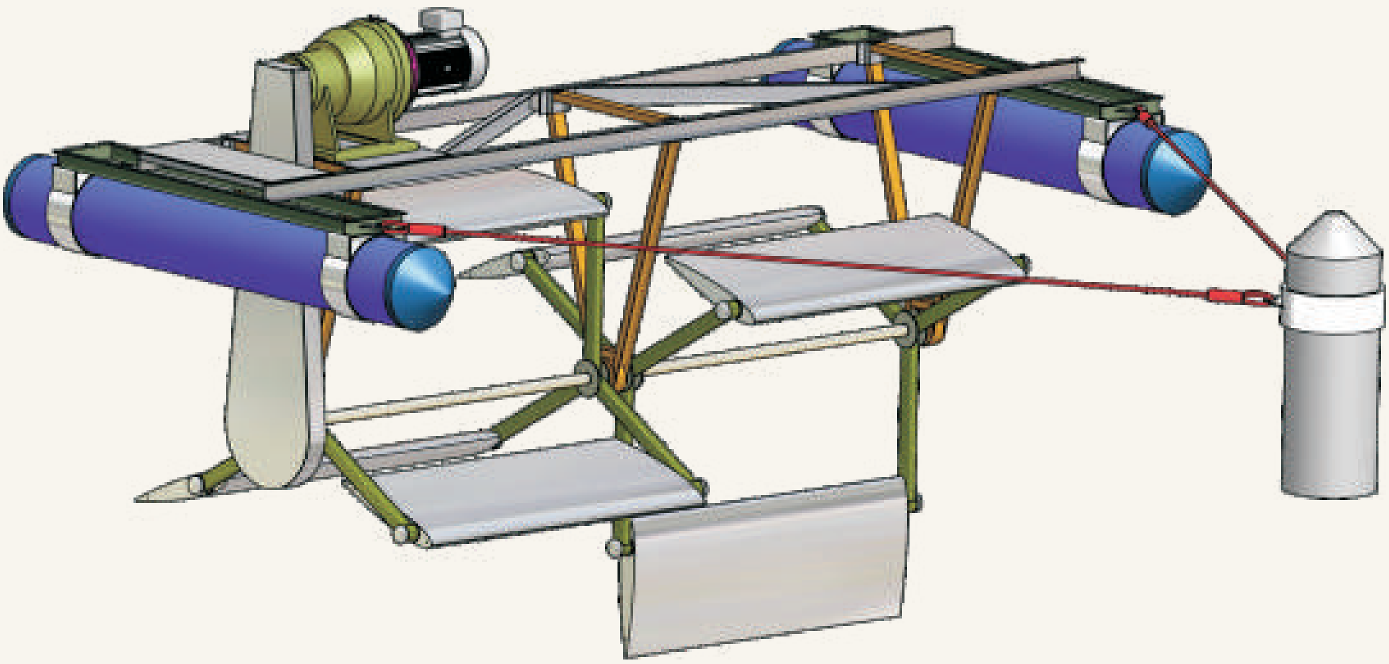
Areas of application:

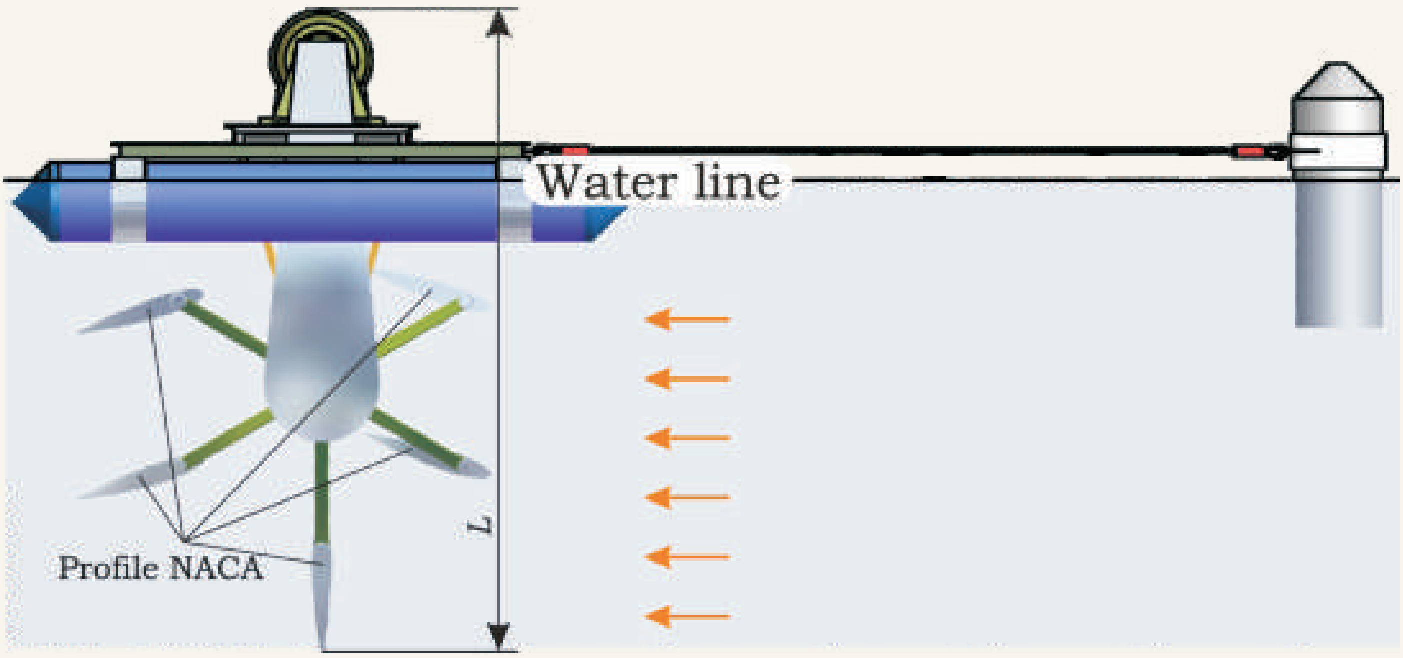
for individual consumers: electrical lighting of houses and streets, central heating, water pumping into irrigation and drainage systems, water pumping into sewage system, etc.

1. Planetary multiplicator.
2. Toroid coupling
3. Permanent magnet generator.
4. Casing.

Patents: nr. 3104 (MD); nr. 2993(MD); nr.2991 (MD).

FLOATABLE MICRO HYDRO POWER STATION WITH HORIZONTAL AXLE FOR RUNNING WATER KINETIC ENERGY CONVERSION





Advantaje: Turbine fully immersed in the flowing water stream.

Patent: nr.3846 (MD).

MICRO HYDRO POWER PLANT WITH HYDRODYNAMIC ROTOR FOR RIVER KINETIC ENERGY CONVERSION INTO MECHANICAL ENERGY (ROTOR DIAMETER D=4m, SUBMERGED HEIGHT OF BLADE h=1,4m, BLADE CHORD LENGHT l=1,3m), (MHCF D4X1,5 M)

MICRO HYDRO POWER PLANT WITH HYDRODYNAMIC ROTOR FOR RIVER KINETIC ENERGY CONVERSION INTO ELECTRICAL AND MECHANICAL ENERGY (ROTOR DIAMETER D=4m, SUBMERGED HEIGHT OF BLADE h=1,4m, BLADE CHORD LENGHT l=1,3m), (MHCF D4X1,5 M)

Flotable Micro Hydro Power Station for conversion of kinetic energy of river's flowing water installed on r. Prut near v. Stoenesti

Flotable Micro Hydro Power Station for conversion of kinetic energy of river's flowing water installed on r. Prut near v. Stoenesti

Computational Fluid Dynamics (CFD) simulations of a modified hydrofoil

Previous studies of the flow-blade interaction of the micro-hydro power station and experimental testing in lab and real conditions performed in the past revealed large separation areas at the endpoints of the blade and consequently there were proposed several design elements in order to minimize these effects and contribute to the increase of energy conversion efficiency. One of the new design elements are the horizontal screens placed at the ends of the blade module (see Fig.17) with a range of geometric parameters.

The computer simulations of the flow-blade interaction of the micro-hydro power station have been performed in the academic version of the commercial CFD packages ICEM CFD and ANSYS CFX. In this study three-dimensional simulations have been conducted for a hydrofoil used in micro hydro power station placed in a water stream at various angles of attack with different geometric parameters.

The geometry of the hydrofoil consists of a modified NACA 0016 profile with chord length c=0,8m and height of one section h=0,3m. Two sections have been considered with both horizontal screens and without. Also the hydrofoil was rotated to impose several angles of attack: 0Deg, 5Deg, 10Deg, 25Deg, 45Deg.

Mesh discretisation of the domain have been conducted in ICEM CFD. The mesh is a hybrid mesh containing tetrahedrons and very fine prism elements for modeling the boundary layer near blade walls as presented in fig. 18 and 19. The parameters of the mesh constructed using path conforming method with mapped facing applied to box sides tin face sizes in the range 0.005m to 0.18m. As for the blade the mesh size is in the range 0.001m to 0.005m. The boundary layer is discretised with 20 prism element layers with geometric rate 1.115 and total thickness of 0.015m, fig. 18 and 19. The first boundary layer has a height of 0.00045 m. The corresponding

$$y^{+} = \frac{\sqrt{\frac{\tau_w}{\rho}}\,y}{\nu},$$

The entire computational domain was meshed with a total number of approx 5.9 million elements for the hydrofoil with horizontal screens and approx. 5 millions for the plain hydrofoil. Spatial convergence tests identified this discretisation as sufficient for convergence and optimal for computational costs.

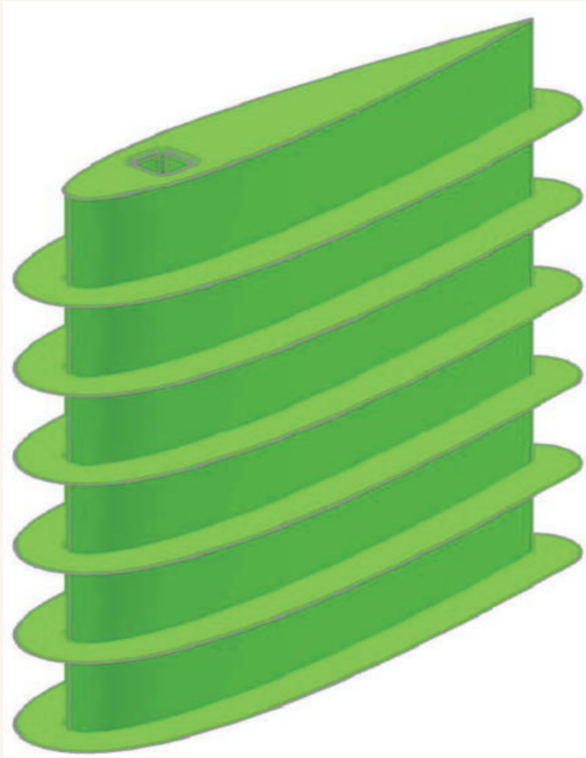


Fig. 17

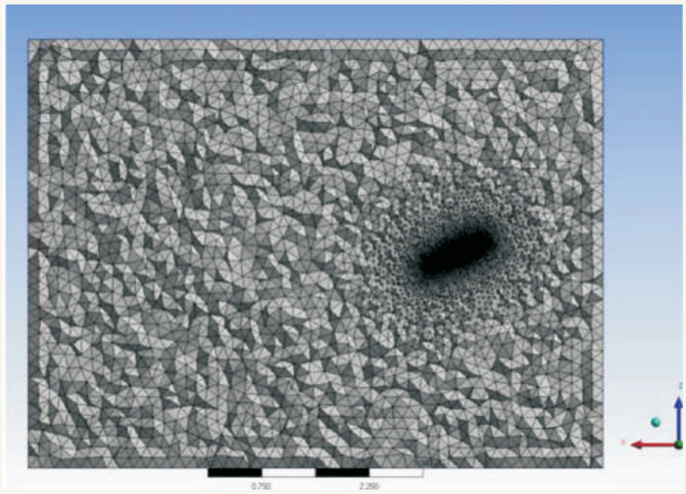


Fig. 18

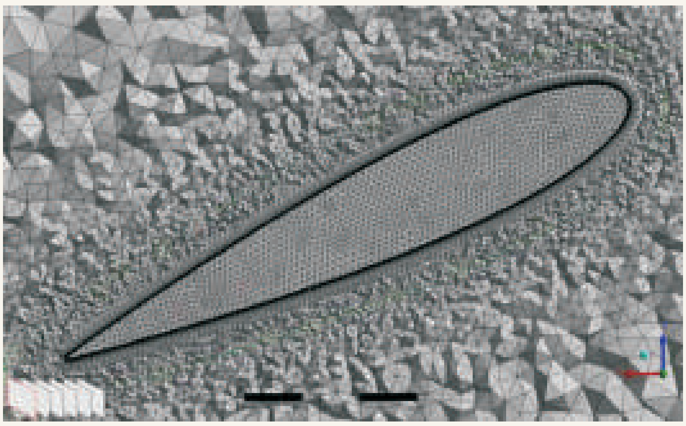


Fig. 19

Thus, a mesh with 12 million elements was also considered and the numerical results yielded similar values for variables of interest.

The post-processing of the numerical results was performed in CFX post. In fig. 20-21 were presented the streamlines starting at different depths from the inlet parallel to fluid flow for the plain hydrofoil. Fig. 20-23 are presenting the streamlines for the hydrofoil with horizontal screens. In fig. 24 there is presented the turbulence kinetic energy contours at various depths for plain hydrofoil that are being compared with turbulence kinetic energy contours for hydrofoil with screens, fig. 25. Transition Reynolds number contours for plain hydrofoil are being represented in fig. 26, while those for hydrofoil with screens are shown in fig. 27. Also Fig. 28-29 show the distribution of transition Reynolds number on the surface of the hydrofoil with screens.

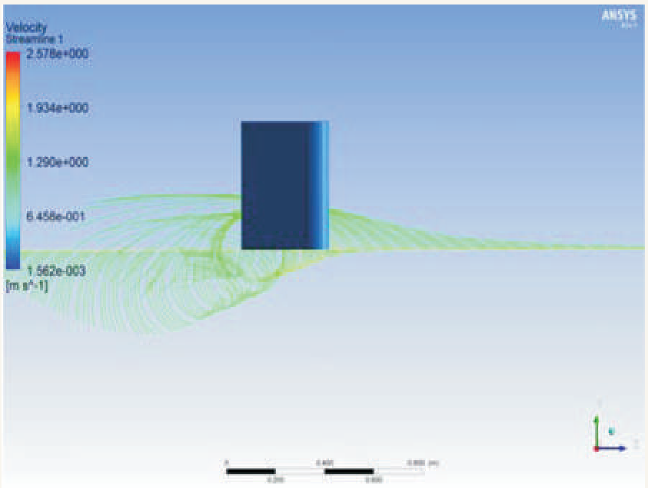


Fig. 20

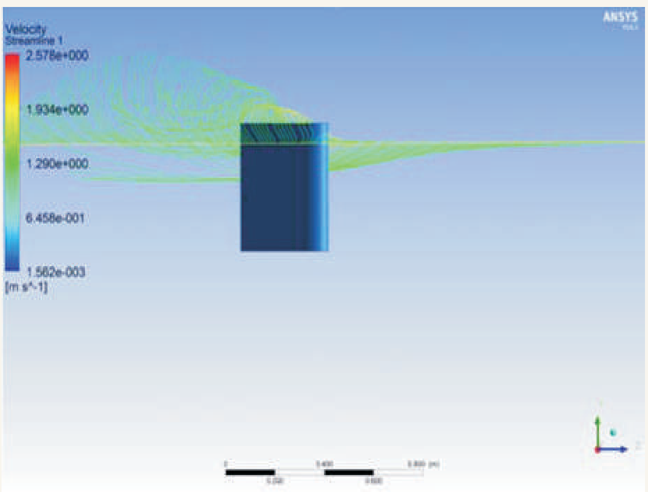


Fig. 21

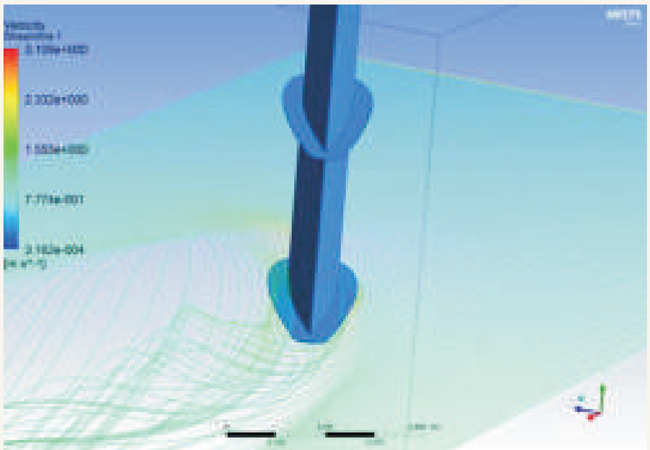


Fig. 22

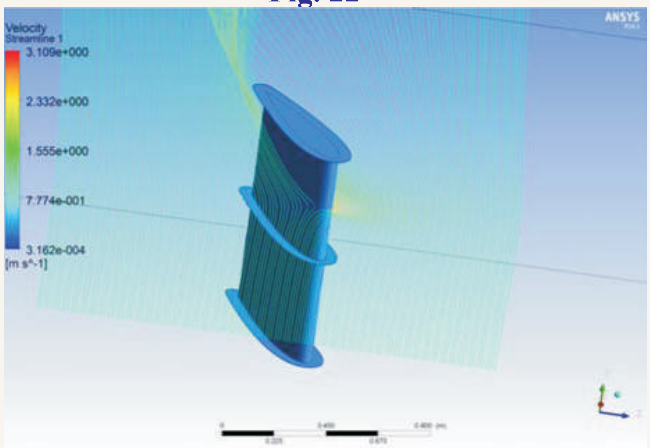


Fig. 23

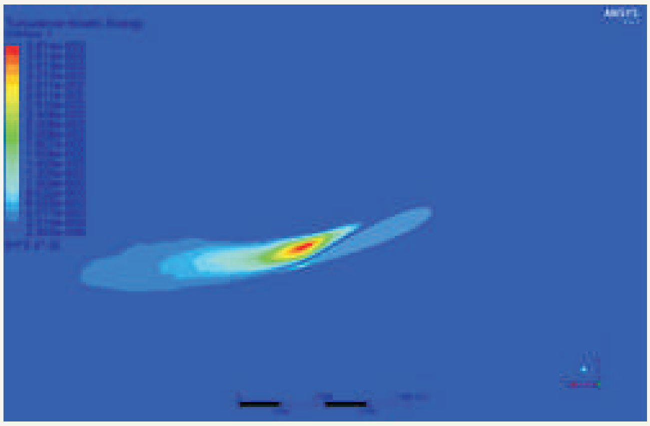


Fig. 24

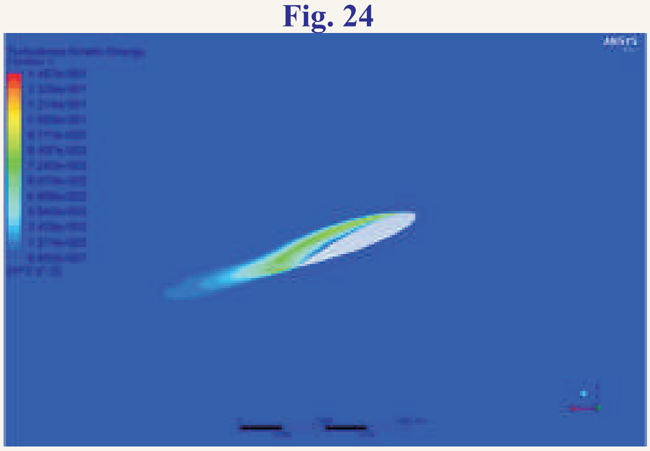


Fig. 25

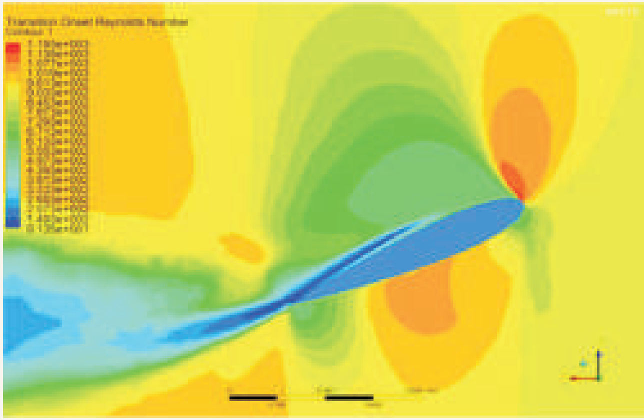


Fig. 26

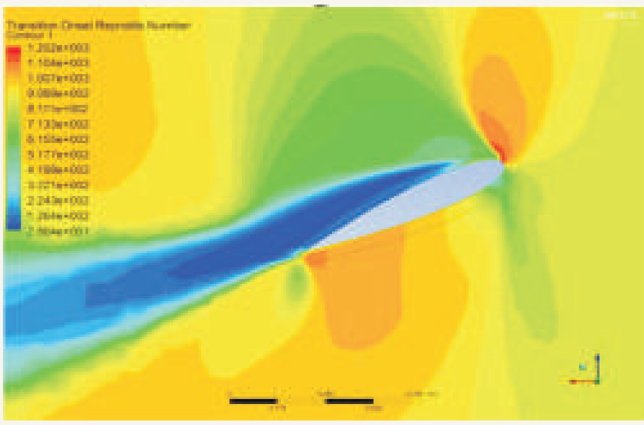


Fig. 27

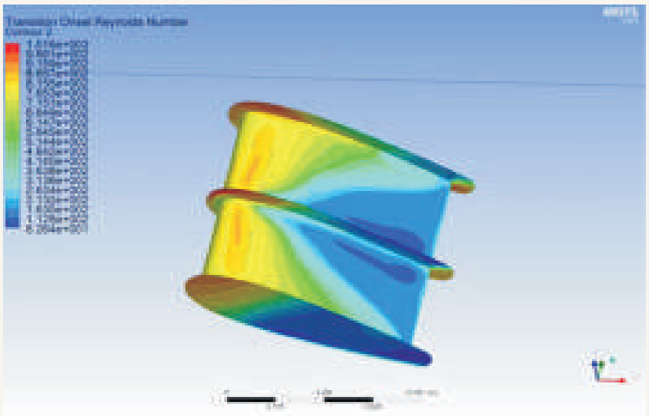


Fig. 28

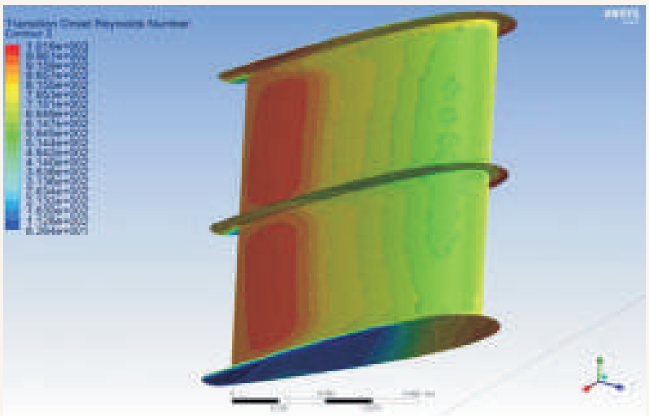


Fig. 29

Deformation-stress analysis of a modified hydrofoil made from composite materials

In order to validate the composite material sandwich used for the hydrofoil with horizontal screens a deformation-stress analysis has been performed in ANSYS structural mechanics software. The geometry of the hydrofoil section is similar to the section described previously and is shown in fig. 30. A laminated composite material shell composed of the following layers: first layer bidirectional lining of type E fiberglass and polyetheric resin matrix; second layer has two sub-layers consisted of chopped fiberglass linings with an armored polypropylene lining between them; third layer is again a chopped fiberglass lining in a polyetheric matrix; and the fourth is a gelcout covering layer.

The interior of the hydrofoil is injected with polyurethane foam of high density. The discretisation is performed with finite elements Solsh190 for lateral cover and Solid45 elements for interior and it is shown in fig. 31.

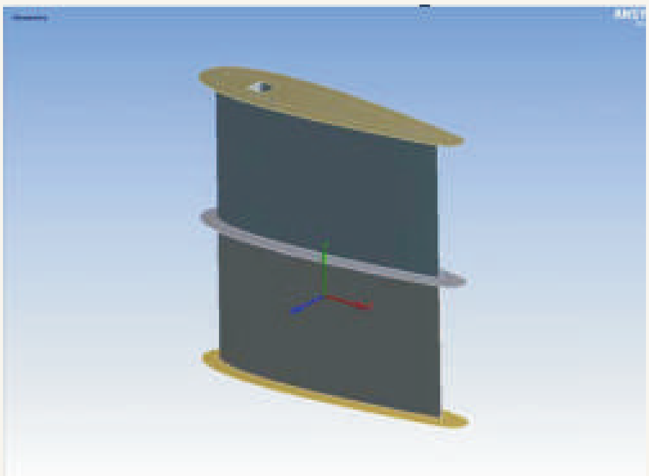


Fig. 30

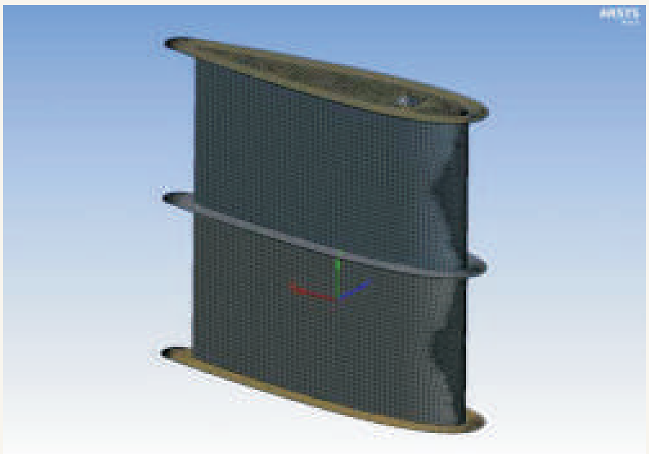


Fig. 31

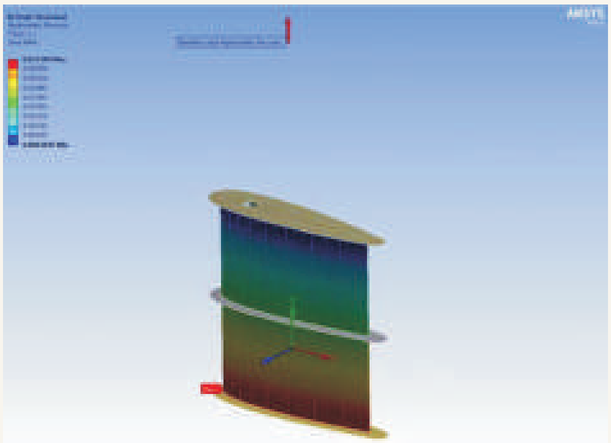


Fig. 32

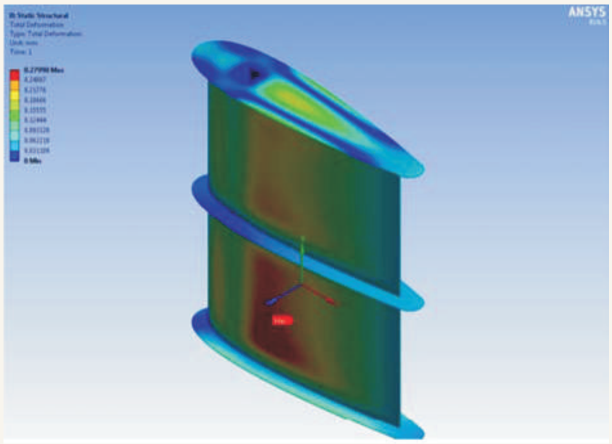


Fig. 36

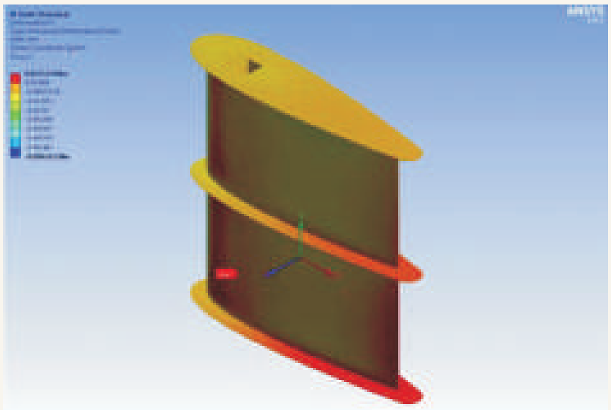


Fig. 33

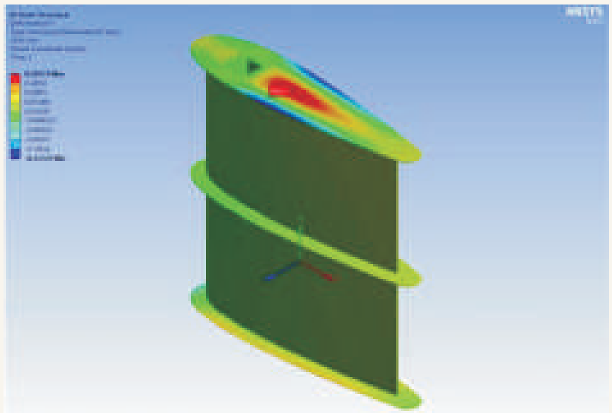


Fig. 37

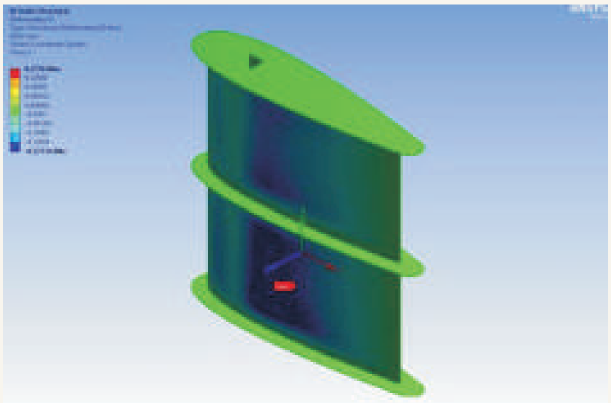


Fig. 34

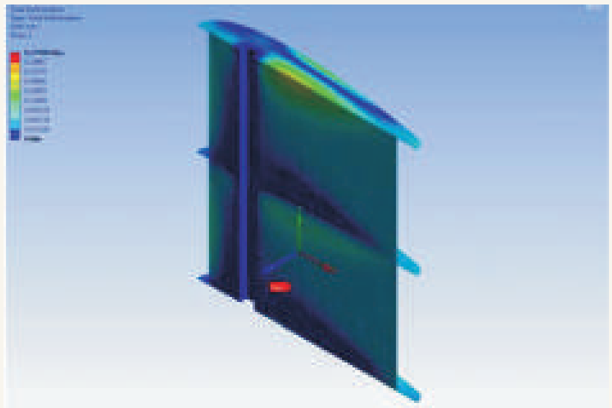


Fig. 38

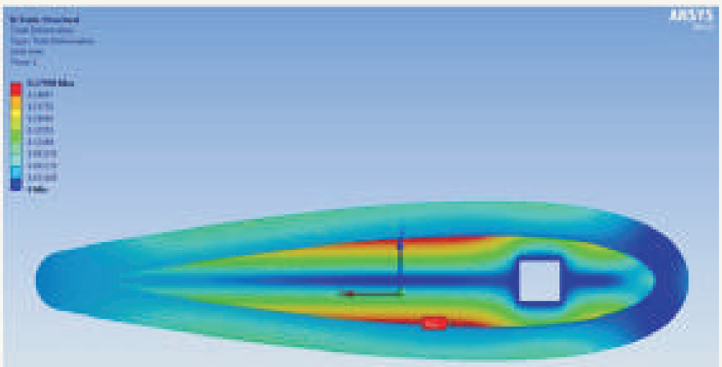


Fig. 35

On lateral sides the hydrostatic pressure corresponding to the depth of 2m was imposed together with a distribution of hydrodynamic force corresponding to the flow velocity of 2m/s, as shown in fig. 32. The total deformations are presented in fig. 33, while fig. 34-38 show the x-, y-, z- deformations, respectively.

Fabrication technology for blades with hydrodynamic profiles from composite materials

The proposed hydrodynamic blade structure is presented in fig. 39 and it is based on the carried out computer CFD simulations of fluid-blade interactions, deformation-stress analysis of the blade made from composite materials and available technology. The technological process for fabrication of the blade is presented in Table 1 shown at the end of appendices. Each section of the blade is composed from three sub-modules glued and assembled on the vertical shaft.

Elaboration of the CAD model for lateral cover. First stage for the elaboration of the fabrication technology consists in CAD modeling of the lateral cover with hydrodynamic profile and optimal geometric parameters shown in fig. 40 and the second stage comprises the elaboration of the strategy for cutting process using the 5-axis cutting machine, fig. 41.

Fabrication of the molding form. After the cutting process the prepared surface is covered with a polymeric hardener in order to reduce the overall porosity and left to be impregnated for the depth of approx. 1 mm. The impregnation and drying process is presented in fig. 42, 43. Next stage consists in a wax cover with Oskar`s Wax W50 and Norslipp 9880.

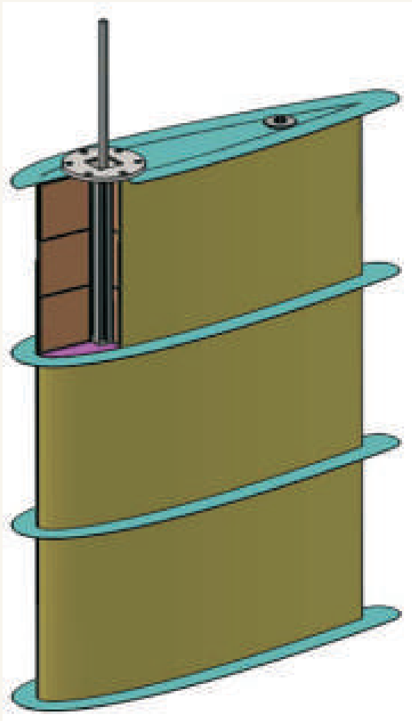


Fig. 39 Hydrodynamic blade structure.

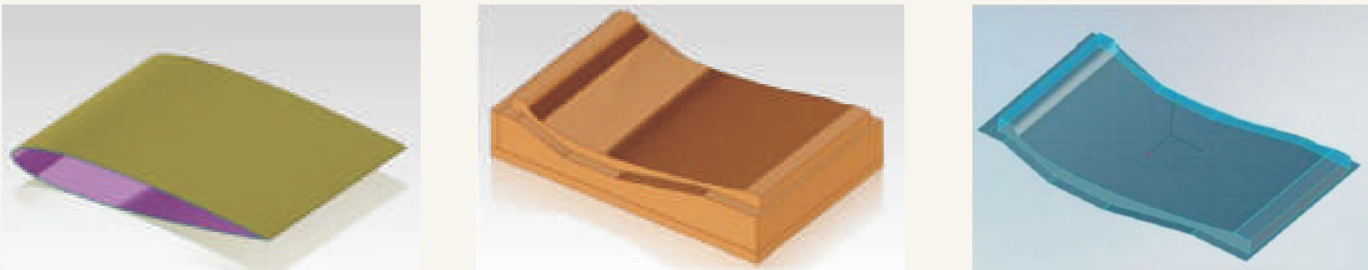


Fig. 40 CAD modeling of the lateral cover.

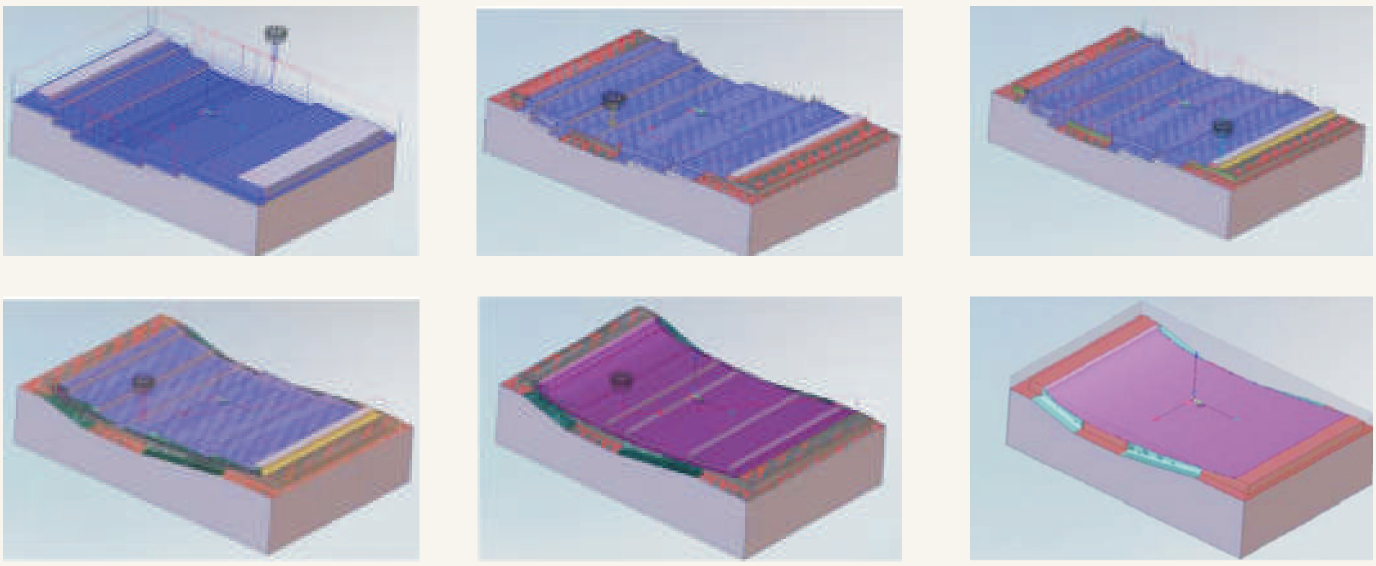


Fig. 41 Strategy for cutting process using the 5-axis cutting machine MotionMaster TB 105.

Fig. 42 Fabrication of the hydrodynamic blades.

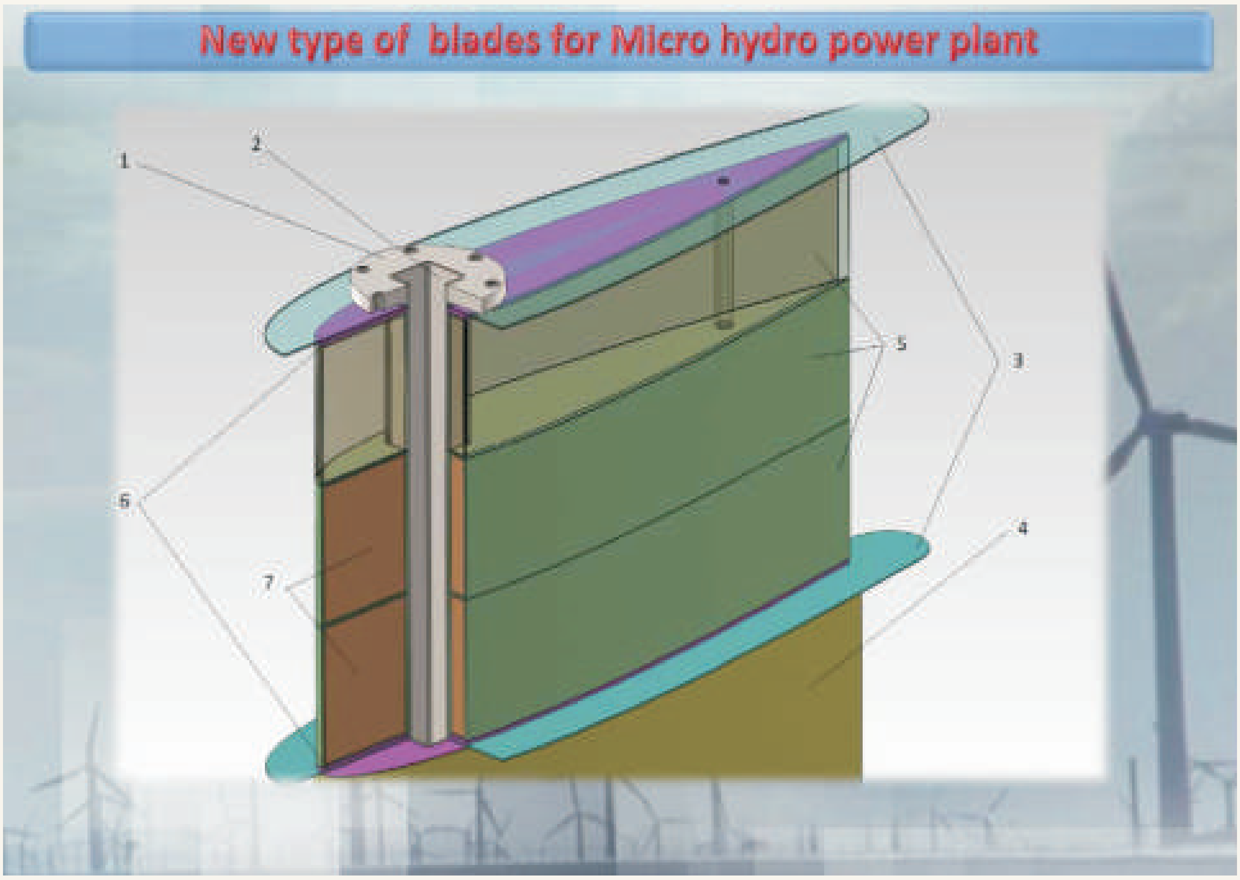
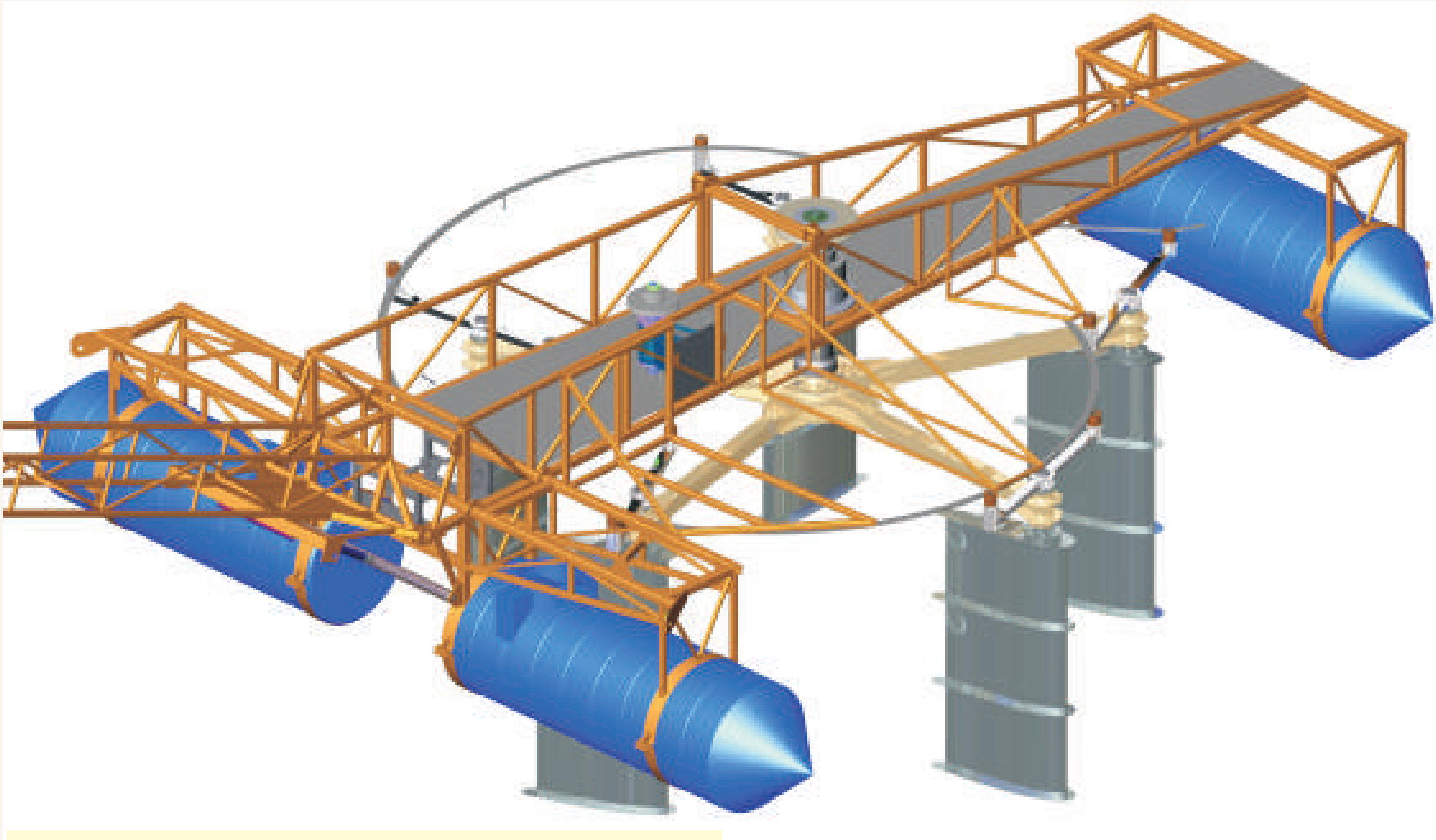


Fig. 43 Fabrication of the hydrodynamic blades.

Micro hydropower station with modified hydrodynamic rotor

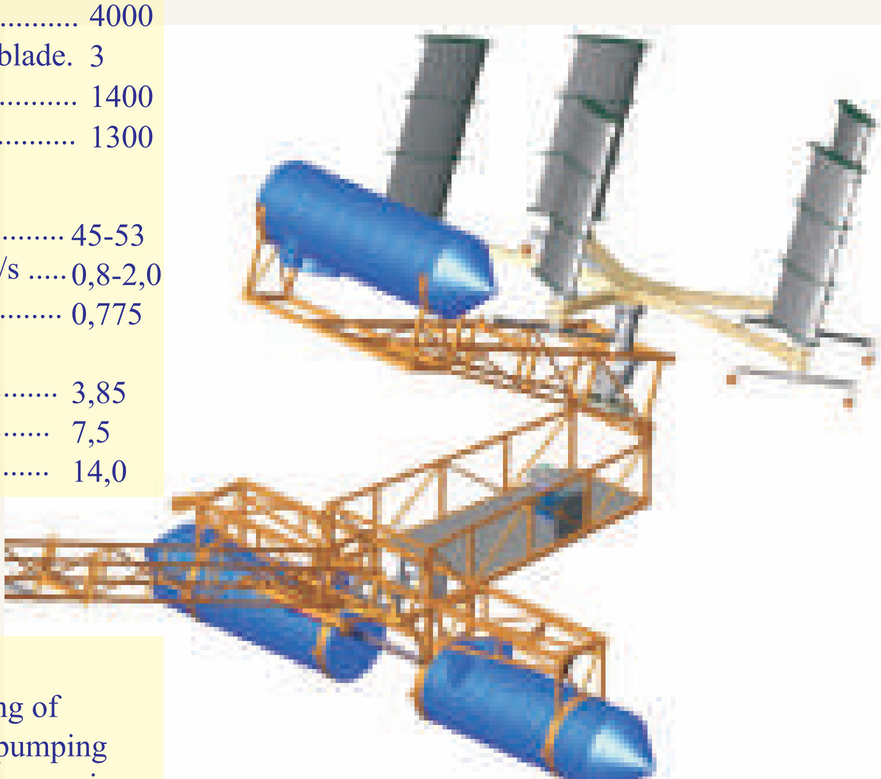


Construction parameters:

- Rotor diameter, mm.. 4000
- Number of hydrodynamic NACA 0016 blade. 3
- Blade submersible height, mm 1400
- Blade cord length, mm.................................... 1300

Functional parameters:

- Conversion efficiency, % 45-53
- Allowable range of water velocity V, m/s 0,8-2,0
- Yield of electrical energy use, % 0,775
- Power, kW:
  - -V=1,3m/s.. 3,85
  - - V=1,6m/s.. 7,5
  - - V=2,0m/s.. 14,0



Areas of application:

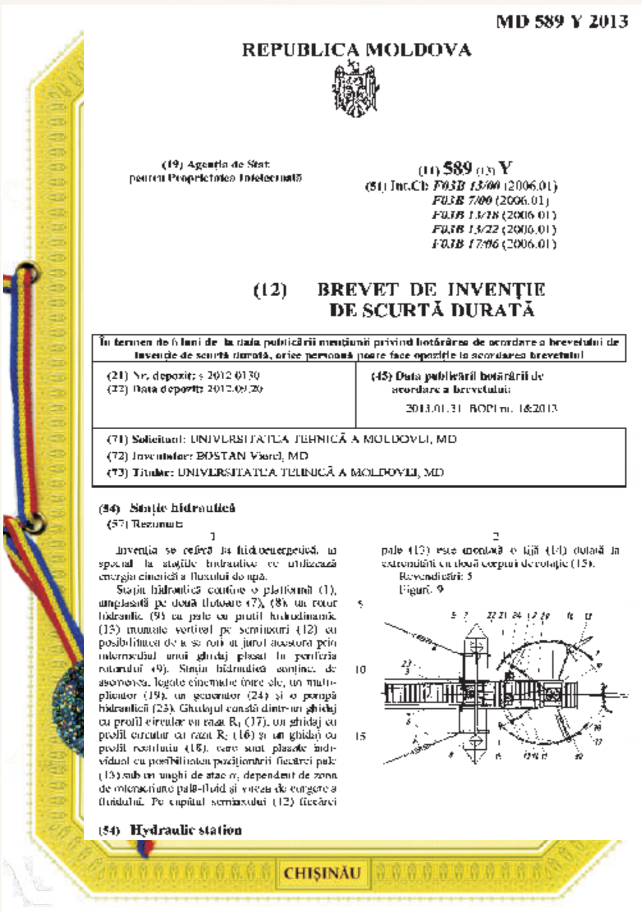
for individual consumers: electrical lighting of houses and streets, central heating, water pumping into irrigation and drainage systems, water pumping into sewage system, etc.

Patents: nr. 601Y; 589 Y (MD)

Micro hydropower station with modified hydrodynamic rotor

Micro hydropower station with modified hydrodynamic rotor

PATENTS



MD 589 Y 2013

REPUBLICA MOLDOVA

(19) Agenţia de Stat pentru Proprietatea Intelectuală

(11) 589 (13) Y

(51) Int.Cl: *F03B 13/00* (2006.01)
F03B 7/00 (2006.01)
F03B 13/18 (2006.01)
F03B 13/22 (2006.01)
F03B 17/06 (2006.01)

(12) BREVET DE INVENŢIE DE SCURTĂ DURATĂ

În termen de 6 luni de la data publicării menţiunii privind hotărârea de acordare a brevetului de invenţie de scurtă durată, orice persoană poate face opoziţie la acordarea brevetului

(21) Nr. depozit: s 2012 0130
(22) Data depozit: 2012.09.20

(45) Data publicării hotărârii de acordare a brevetului:
2013.01.31, BOPI nr. 1/2013

(71) Solicitant: UNIVERSITATEA TEHNICĂ A MOLDOVEI, MD
(72) Inventator: BOSTAN Viorel, MD
(73) Titular: UNIVERSITATEA TEHNICĂ A MOLDOVEI, MD

(54) **Staţie hidraulică**

(57) Rezumat:

1

Invenţia se referă la hidroenergetică, în special la staţiile hidraulice ce utilizează energia cinetică a fluxului de apă.

Staţia hidraulică conţine o platformă (1), amplasată pe două flotoare (7), (8), un rotor hidraulic (9) cu pale cu profil hidrodinamic (13) montate vertical pe semiaxuri (12) cu posibilitatea de a se roti în jurul acestora prin intermediul unui ghidaj plasat în periferia rotorului (9). Staţia hidraulică conţine, de asemenea, legate cinematic între ele, un multiplicator (19), un generator (24) şi o pompă hidraulică (23). Ghidajul constă dintr-un ghidaj cu profil circular cu raza R_1 (17), un ghidaj cu profil circular cu raza R_2 (16) şi un ghidaj cu profil rectiliniu (18), care sunt plasate individual cu posibilitatea poziţionării fiecărei pale (13) sub un unghi de atac α, dependent de zona de interacţiune pală-fluid şi viteza de curgere a fluidului. Pe capătul semiaxului (12) fiecărei

2

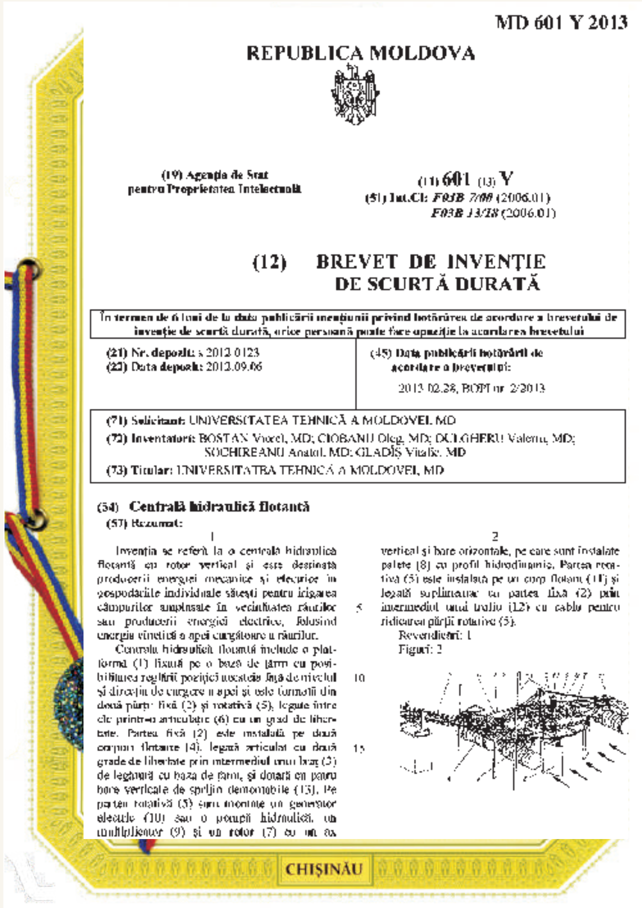
pale (13) este montată o tijă (14) dotată la extremităţi cu două corpuri de rotaţie (15).

Revendicări: 5

Figuri: 9

(54) **Hydraulic station**

CHIŞINĂU



MD 601 Y 2013

REPUBLICA MOLDOVA

(19) Agenţia de Stat pentru Proprietatea Intelectuală

(11) 601 (13) Y

(51) Int.Cl: *F03B 7/00* (2006.01)
F03B 13/18 (2006.01)

(12) BREVET DE INVENŢIE DE SCURTĂ DURATĂ

În termen de 6 luni de la data publicării menţiunii privind hotărârea de acordare a brevetului de invenţie de scurtă durată, orice persoană poate face opoziţie la acordarea brevetului

(21) Nr. depozit: s 2012 0123
(22) Data depozit: 2012.09.06

(45) Data publicării hotărârii de acordare a brevetului:
2013.02.28, BOPI nr. 2/2013

(71) Solicitant: UNIVERSITATEA TEHNICĂ A MOLDOVEI, MD
(72) Inventatori: BOSTAN Viorel, MD; CIOBANU Oleg, MD; DULGHERU Valeriu, MD; SOCHIREANU Anatol, MD; GLADÎŞ Vitalie, MD
(73) Titular: UNIVERSITATEA TEHNICĂ A MOLDOVEI, MD

(54) **Centrală hidraulică flotantă**

(57) Rezumat:

1

Invenţia se referă la o centrală hidraulică flotantă cu rotor vertical şi este destinată producerii energiei mecanice şi electrice în gospodăriile individuale săteşti pentru irigarea câmpurilor amplasate în vecinătatea râurilor sau producerii energiei electrice, folosind energia cinetică a apei curgătoare a râurilor.

Centrala hidraulică flotantă include o platformă (1) fixată pe o bază de ţărm cu posibilitatea reglării poziţiei acesteia faţă de nivelul şi direcţia de curgere a apei şi este formată din două părţi: fixă (2) şi rotativă (5), legate între ele printr-o articulaţie (6) cu un grad de libertate. Partea fixă (2) este instalată pe două corpuri flotante (4), legată articulat cu două grade de libertate prin intermediul unui braţ (3) de legătură cu baza de ţărm, şi dotată cu patru bare verticale de sprijin demontabile (13). Pe partea rotativă (5) sunt montate un generator electric (10) sau o pompă hidraulică, un multiplicator (9) şi un rotor (7) cu un ax

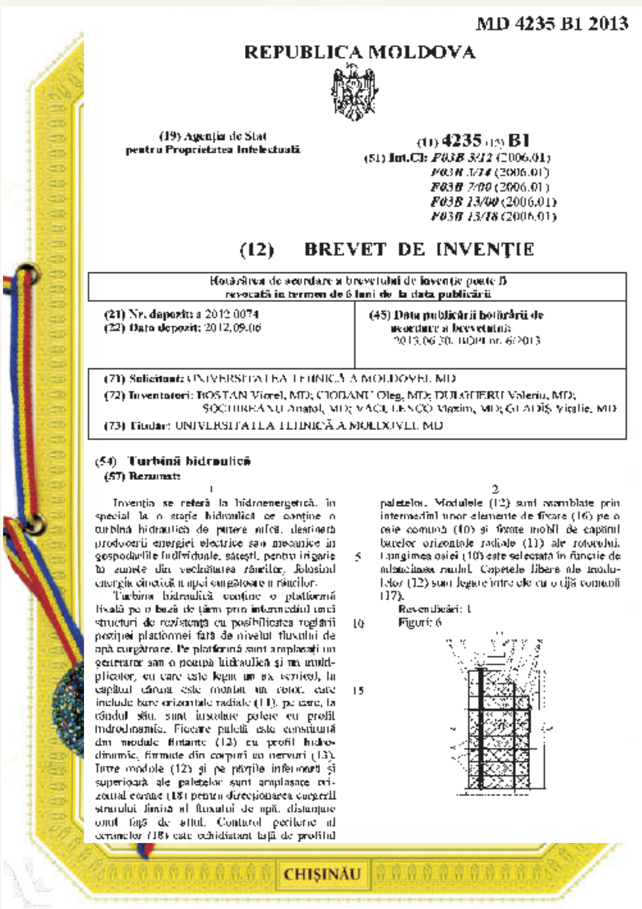
2

vertical şi bare orizontale, pe care sunt instalate palete (8) cu profil hidrodinamic. Partea rotativă (5) este instalată pe un corp flotant (11) şi legată suplimentar cu partea fixă (2) prin intermediul unui troliu (12) cu cablu pentru ridicarea părţii rotative (5).

Revendicări: 1

Figuri: 2

CHIŞINĂU



MD 4235 B1 2013

REPUBLICA MOLDOVA

(19) Agenţia de Stat pentru Proprietatea Intelectuală

(11) 4235 (13) B1

(51) Int.Cl: *F03B 3/12* (2006.01)
F03B 3/14 (2006.01)
F03B 7/00 (2006.01)
F03B 13/00 (2006.01)
F03B 13/18 (2006.01)

(12) BREVET DE INVENŢIE

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(21) Nr. depozit: a 2012 0074
(22) Data depozit: 2012.09.06

(45) Data publicării hotărârii de acordare a brevetului:
2013.06.30, BOPI nr. 6/2013

(71) Solicitant: UNIVERSITATEA TEHNICĂ A MOLDOVEI, MD
(72) Inventatori: BOSTAN Viorel, MD; CIOBANU Oleg, MD; DULGHERU Valeriu, MD; SOCHIREANU Anatol, MD; VACULENCO Maxim, MD; GLADÎŞ Vitalie, MD
(73) Titular: UNIVERSITATEA TEHNICĂ A MOLDOVEI, MD

(54) **Turbină hidraulică**

(57) Rezumat:

1

Invenţia se referă la hidroenergetică, în special la o staţie hidraulică ce conţine o turbină hidraulică de putere mică, destinată producerii energiei electrice sau mecanice în gospodăriile individuale, săteşti, pentru irigarea în zonele din vecinătatea râurilor, folosind energia cinetică a apei curgătoare a râurilor.

Turbina hidraulică conţine o platformă fixată pe o bază de ţărm prin intermediul unei structuri de rezistenţă cu posibilitatea reglării poziţiei platformei faţă de nivelul fluxului de apă curgătoare. Pe platformă sunt amplasaţi un generator sau o pompă hidraulică şi un multiplicator, cu care este legat un ax vertical, la capătul căruia este montat un rotor, care include bare orizontale radiale (11), pe care, la rândul său, sunt instalate palete cu profil hidrodinamic. Fiecare paletă este constituită din module flotante (12) cu profil hidrodinamic, formate din corpuri cu nervuri (13). Între module (12) şi pe părţile inferioară şi superioară ale paletelor sunt amplasate orizontal ecrane (18) pentru direcţionarea curgerii stratului limită al fluxului de apă, distanţate unul faţă de altul. Conturul periferic al ecranelor (18) este echidistant faţă de profilul

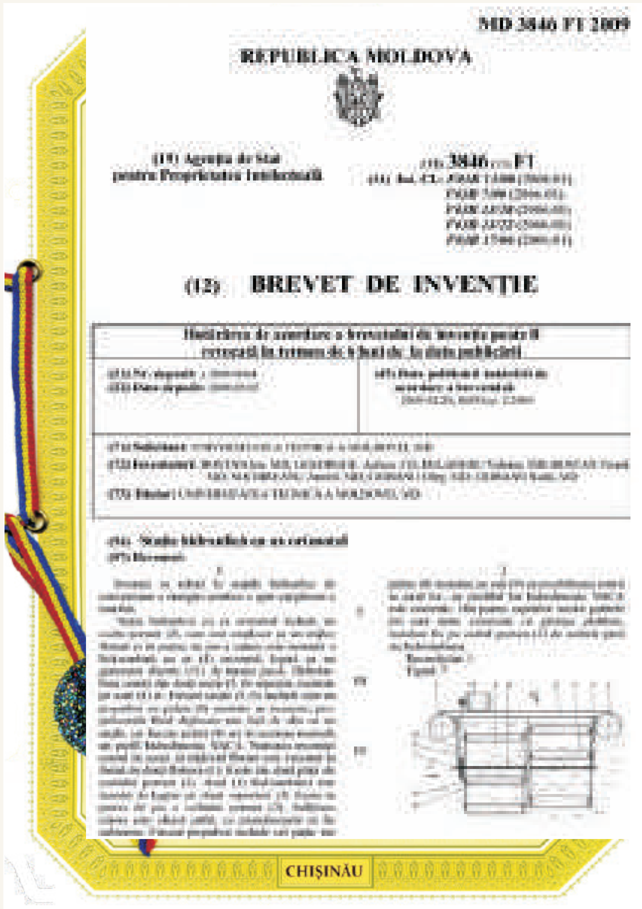
2

paletelor. Modulele (12) sunt asamblate prin intermediul unor elemente de fixare (16) pe o osie comună (10) şi fixate mobil de capătul barelor orizontale radiale (11) ale rotorului. Lungimea osiei (10) este selectată în funcţie de adâncimea râului. Capetele libere ale modulelor (12) sunt legate între ele cu o tijă comună (17).

Revendicări: 1

Figuri: 6

CHIŞINĂU



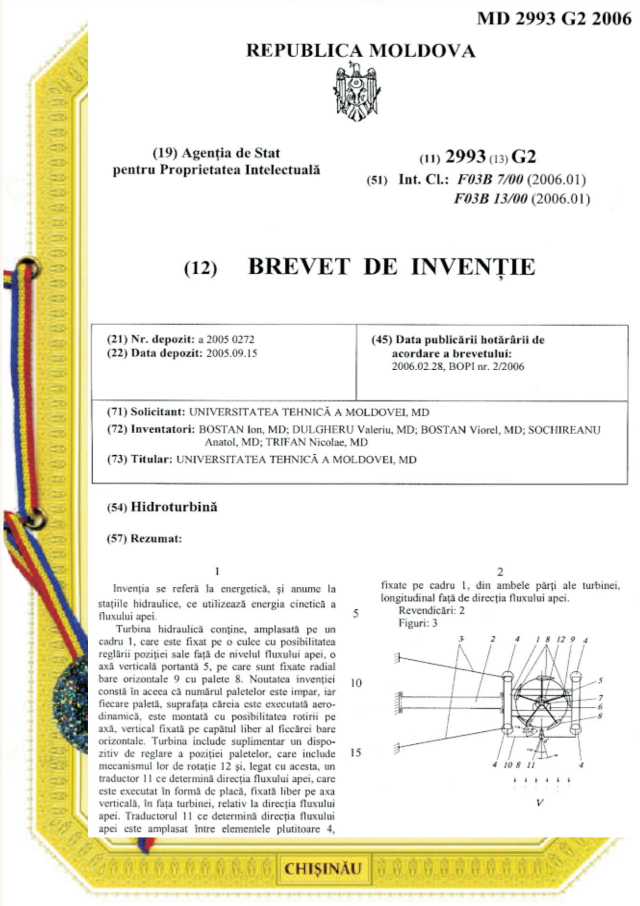
MD 3846 F1 2009

REPUBLICA MOLDOVA

(12) BREVET DE INVENŢIE

CHIŞINĂU

PATENTS


MD 2993 G2 2006

REPUBLICA MOLDOVA

(19) Agenția de Stat pentru Proprietatea Intelectuală

(11) 2993 (13) G2
(51) Int. Cl.: *F03B 7/00* (2006.01)
F03B 13/00 (2006.01)

(12) BREVET DE INVENȚIE

(21) Nr. depozit: a 2005 0272 (22) Data depozit: 2005.09.15	(45) Data publicării hotărârii de acordare a brevetului: 2006.02.28, BOPI nr. 2/2006

(71) Solicitant: UNIVERSITATEA TEHNICĂ A MOLDOVEI, MD
(72) Inventatori: BOSTAN Ion, MD; DULGHERU Valeriu, MD; BOSTAN Viorel, MD; SOCHIREANU Anatol, MD; TRIFAN Nicolae, MD
(73) Titular: UNIVERSITATEA TEHNICĂ A MOLDOVEI, MD

(54) Hidroturbină

(57) Rezumat:

1

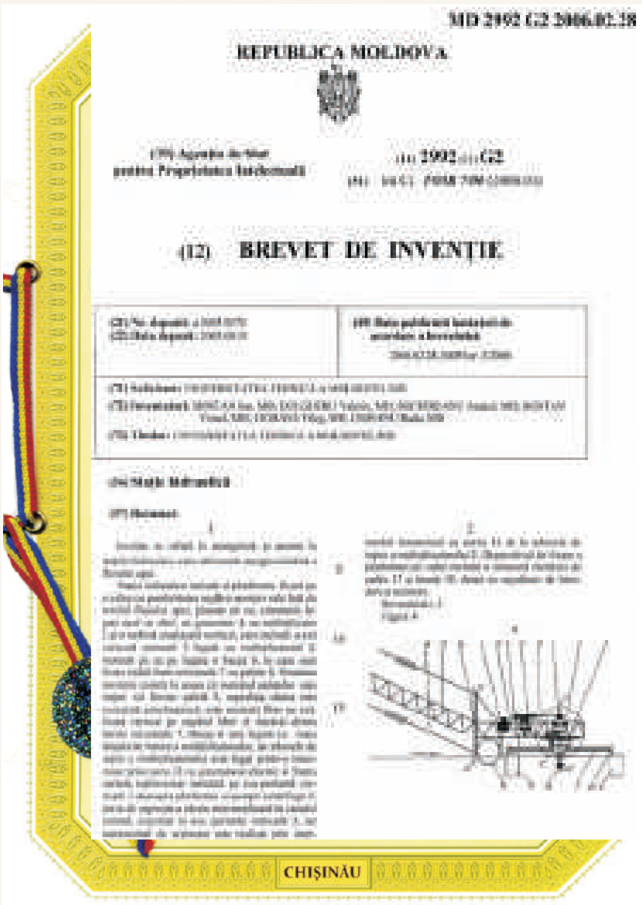
Invenția se referă la energetică, şi anume la stațiile hidraulice, ce utilizează energia cinetică a fluxului apei.

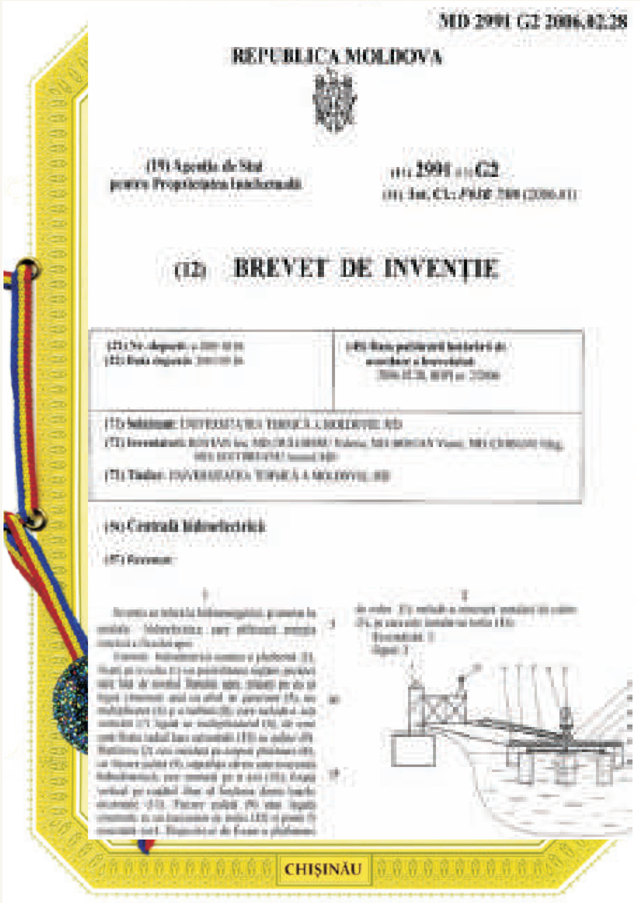
Turbina hidraulică conține, amplasată pe un cadru 1, care este fixat pe o culee cu posibilitatea reglării poziției sale față de nivelul fluxului apei, o axă verticală portantă 5, pe care sunt fixate radial bare orizontale 9 cu palete 8. Noutatea invenției constă în aceea că numărul paletelor este impar, iar fiecare paletă, suprafața căreia este executată aerodinamică, este montată cu posibilitatea rotirii pe axă, vertical fixată pe capătul liber al fiecărei bare orizontale. Turbina include suplimentar un dispozitiv de reglare a poziției paletelor, care include mecanismul lor de rotație 12 şi, legat cu acesta, un traductor 11 ce determină direcția fluxului apei, care este executat în formă de placă, fixată liber pe axa verticală, în fața turbinei, relativ la direcția fluxului apei. Traductorul 11 ce determină direcția fluxului apei este amplasat între elementele plutitoare 4,

2

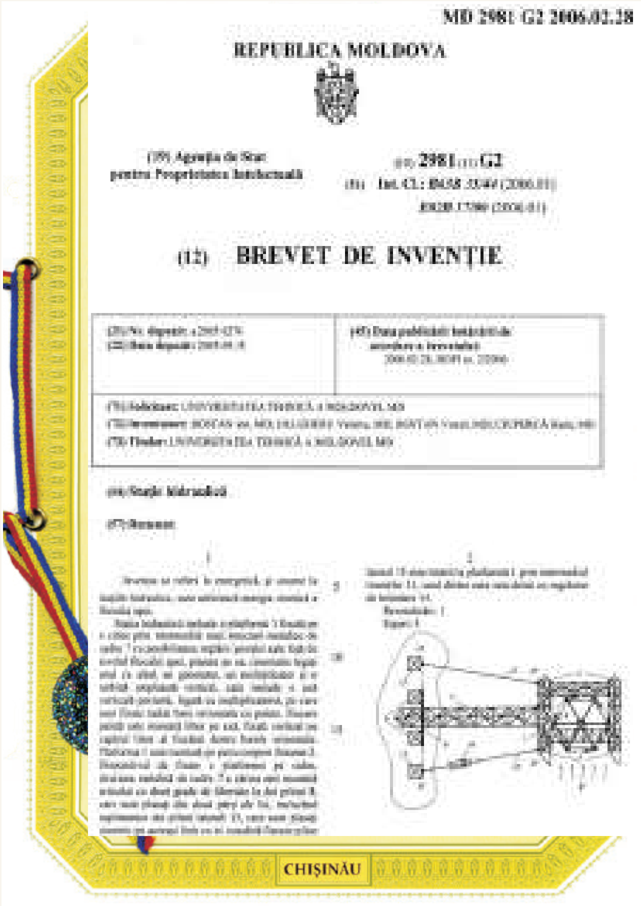
fixate pe cadru 1, din ambele părți ale turbinei, longitudinal față de direcția fluxului apei.

Revendicări: 2
Figuri: 3





PATENTS


MD 2981 G2 2006.02.28

REPUBLICA MOLDOVA

(19) Agenţia de Stat pentru Proprietatea Intelectuală

(11) 2981 (13) G2

(12) BREVET DE INVENŢIE

(71) Solicitant: UNIVERSITATEA TEHNICĂ A MOLDOVEI, MD

(73) Titular: UNIVERSITATEA TEHNICĂ A MOLDOVEI, MD

(54) Staţie hidraulică

(57) Rezumat:

CHIŞINĂU


MD 2916 G2 2005.11.30

REPUBLICA MOLDOVA

(19) Agenţia de Stat pentru Proprietatea Intelectuală

(11) 2916 (13) G2

(12) BREVET DE INVENŢIE

(71) Solicitant: UNIVERSITATEA TEHNICĂ A MOLDOVEI, MD

(73) Titular: UNIVERSITATEA TEHNICĂ A MOLDOVEI, MD

(54) Centrală hidroelectrică flotantă

(57) Rezumat:

CHIŞINĂU


MD 2888 G2 2005.10.

REPUBLICA MOLDOVA

(19) Agenţia de Stat pentru Proprietatea Intelectuală

(11) 2888 (13) G2

(12) BREVET DE INVENŢIE

(71) Solicitant: UNIVERSITATEA TEHNICĂ A MOLDOVEI, MD

(73) Titular: UNIVERSITATEA TEHNICĂ A MOLDOVEI, MD

(54) Staţie hidraulică

(57) Rezumat:

CHIŞINĂU


MD 2288 C2 2003

REPUBLICA MOLDOVA

(19) Agenţia de Stat pentru Protecţia Proprietăţii Industriale

(11) 2288 (13) C2

(12) BREVET DE INVENŢIE

(71) Solicitant: UNIVERSITATEA TEHNICĂ A MOLDOVEI, MD

(73) Titular: UNIVERSITATEA TEHNICĂ A MOLDOVEI, MD

(54) Staţie hidraulică

(57) Rezumat:

CHIŞINĂU

Appreciation of the research results at the International Exhibitions of Invention, Research and Technology Transfer


THE IFIA GLORY MEDAL

IS PRESENTED BY

THE PRESIDENT OF THE INTERNATIONAL FEDERATION OF INVENTORS' ASSOCIATIONS TO:

Hydrodynamic rotors with modified profile NACA for flow SHP

FOR THE EXHIBITED EXCELLENT INVENTION:

I.Bostan Academician, V.Dulgheru, V.Bostan, A.Graur, A.Sochireanu, O.Ciobanu, R.Ciobanu

ON THE INTERNATIONAL WARSAW INVENTION SHOW

OCTOBER 19, 2012 WARSAW

1968 - 2008

DR. ANDRAS VEDRES THE IFIA PRESIDENT

GLORY

"Gloria medal" for excellence in innovation, International Exhibition IWIS 2012, Warsaw, Poland.


EURO INVENT

EUROPEAN EXHIBITION OF CREATIVITY AND INNOVATION

EXPOZIȚIA INTERNAȚIONALĂ A CREATIVITĂȚII ȘI INOVĂRII

DIPLOMA

Awarded to

Bostan I., Dulgheru V., Bostan V.,
Sochireanu A., Ciobanu O., Ciobanu R., Trifan N.

for

Floatable microhydropower station

PRIZE

Environment Protection

President of International Jury
Kane Kramer

President of Exhibition
Prof. Ion SANDU

reativity
nd Innovation
ropean Year 2009

9 May 2009

„Environment Protection Prise”, EuroInvent 2009, Iassy, Romania.

Appreciation of the research results at the International Exhibitions of Invention, Research and Technology Transfer

Gold Medal, Eureka, Brussels, 2011.

Gold Medal, Geneve, 2013.

Silver Medal, Eureka, Brussels, 2012.

Silver Medal, Eureka, Brussels, 2008.

Appreciation of the research results at the International Exhibitions of Invention, Research and Technology Transfer

Gold Medal, SIR, 2007, Iassy, Romania.

Gold Medal, Eureka, Brussels, 2006.

Silver Medal, Geneve, 2010.

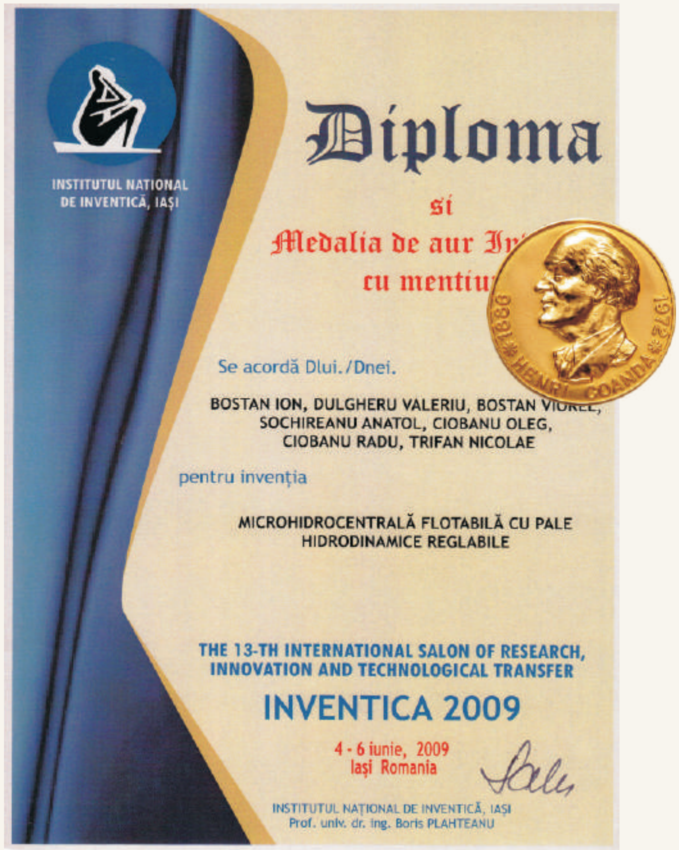
Gold Medal, Geneve, 2008.

Appreciation of the research results at the International Exhibitions of Invention, Research and Technology Transfer

Gold Medal, Inventica, 2013, Iassy, Romania.

Medal "INVENTICA", Inventica, 2012, Iassy, Romania.

Gold Medal, Inventica, 2010, Iassy, Romania.

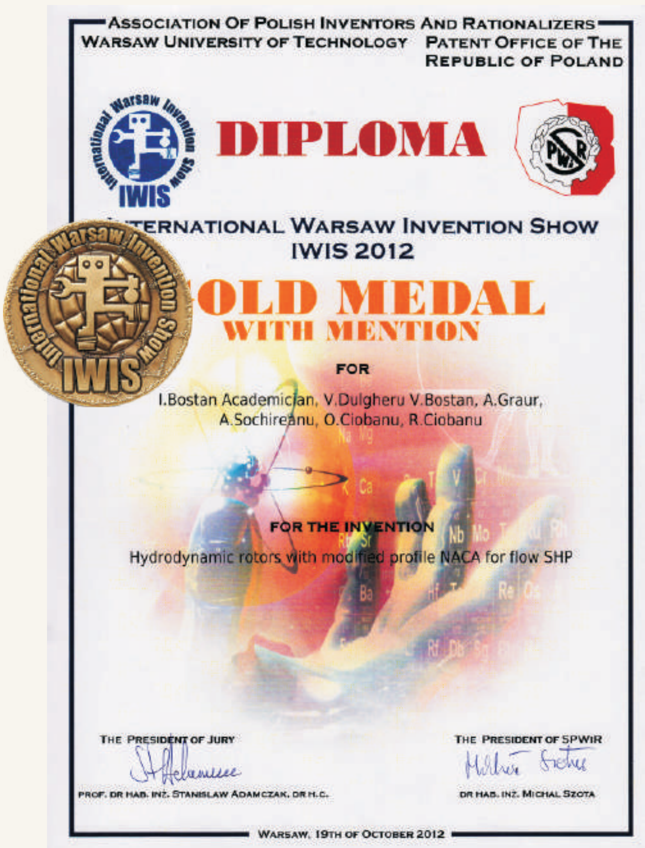


Gold Medal with mention, Inventica, 2009, Iassy, Romania.

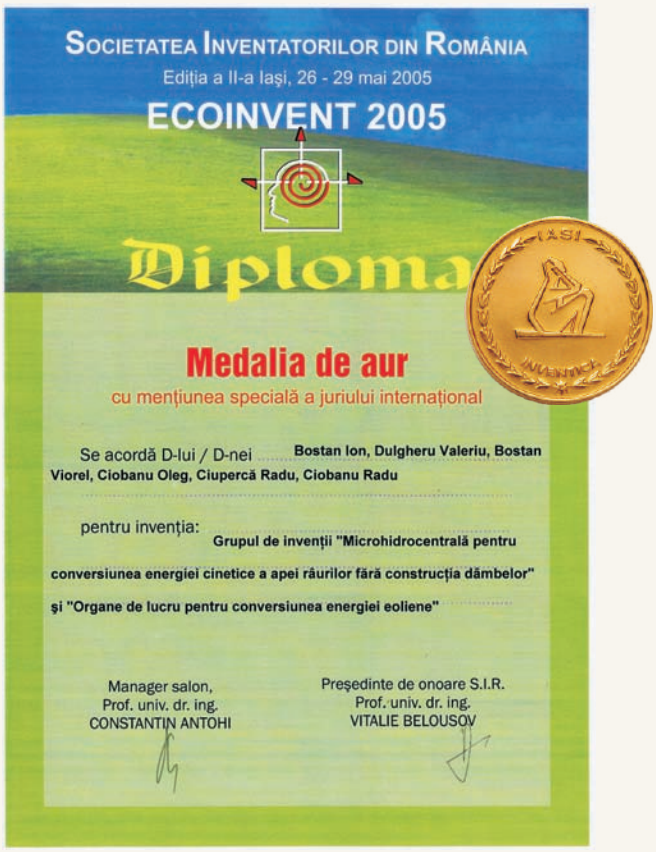
Appreciation of the research results at the International Exhibitions of Invention, Research and Technology Transfer

Gold Medal, IIIC, 2012, SuZhou, China.

Gold Medal, SuZhou, 2008, China.



Gold Medal with mention, IWIS, 2012, Warsaw, Poland.



Gold Medal with special mention of International Jury, Ecoinvent, 2005, Iassy, Romania.

Appreciation of the research results at the International Exhibitions of Invention, Research and Technology Transfer

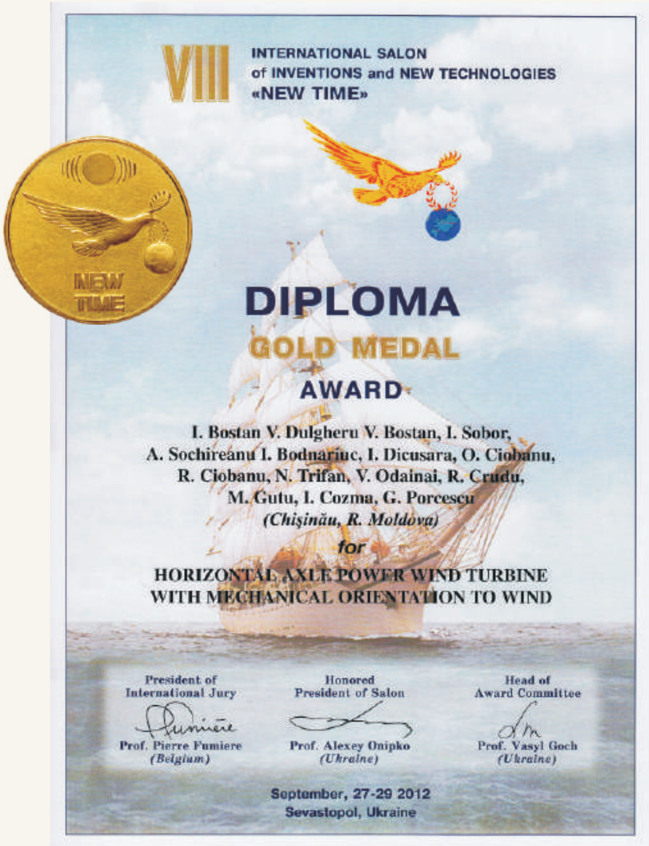
Prise with Gold Medal, Archimedes, 2013, Moscow.

Gold Medal, Novy`j Chas, 2009, Sevastopol, Ucraine.

Gold Medal, Novy`j Chas, 2007, Sevastopol, Ucraine.

Gold Medal, Novy`j Chas, 2006, Sevastopol, Ucraine.

Appreciation of the research results at the International Exhibitions of Invention, Research and Technology Transfer



Prise and Gold Medal, New Time, 2012, Sevastopol, Ucraine.

Gold Medal, Archimedes, 2010, Moscow, Russia.

Bronze Medal, Archimedes, 2013, Moscow, Russia.

Silver Medal, Archimedes, 2007, Moscow, Russia.

Appreciation of the research results at the International Exhibitions of Invention, Research and Technology Transfer

Gold Medal, Pro Invent, 2012, Cluj Napoca, Romania.

Silver Medal, Pro Invent, 2009, Cluj Napoca, Romania.

Gold Medal, Pro Invent, 2011, Cluj Napoca, Romania.

Gold Medal, Pro Invent, 2013, Cluj Napoca, Romania.

Gold Medal, Euroinvent, 2012, Iassy, Romania.

Silver Medal, Euroinvent, 2013, Iassy, Romania.

Gold Medal, Euroinvent, 2010, Iassy, Romania.

Gold Medal, Euroinvent, 2009, Iassy, Romania.

Appreciation of the research results at the International Exhibitions of Invention, Research and Technology Transfer

National Institute of Inventics Prize, Inventica, 2006, Iassy, Romania.

Gold Medal, Inventika, 2009, Bucharest, Romania.

Prise, New Times, 2007, Sevastopol, Ucraine.

Gold Medal, Inventika, 2006, Bucharest, Romania.

Appreciation of the research results at the International Exhibitions of Invention, Research and Technology Transfer


SPECIAL AWARD

This is awarded to

Bostan I., Dulgheru V., Bostan V., Sokireanu A., Vaculenco M., Ciobanu O., Ciobanu R., Gladiş V.

for

Mini-hydropower station with hydrodynamic rotor for flow water kinetic energy conversion

in 16th Moscow International Salon of Inventions and Innovation Technologies (Archimedes)

April 02 - April 05, 2013

Chinese Innovation & Invention Society (TAIWAN)

CIIS

Mr.Wu,Kou-Chen ,President of CIIS

April 5, 2013

Special Prise, Acrhimedes, 2013, Moscow, Russia.


Preşedintele Camerei de Comerţ şi Industrie Maramureş

acordă

Diplomă şi Trofeul Salonului Inventatorilor

Ion BOSTAN, Valeriu DULGHERU, Viorel BOSTAN, Ion SOBOR, Anatol SOCHIREANU, Ion BODNARIUC, Nicolae TRIFAN, Ion DICUSARĂ, Oleg CIOBANU, Radu CIOBANU, Valeriu ODAINÂI, Iulian MALCOCI, Radu CRUDU, Marin GUŢU, Vitalie GLADÎŞ

participanţi la ediţia a III-a a SALONULUI INVENTATORILOR

pentru

„INSTALAŢII PENTRU ENERGII REGENERABILE"

Gheorghe MARCAŞ

Baia Mare, 25 mai 2012

Diploma and Trophy of the Inventors Fair for developing renewable energy conversion systems, *Baia Mare, 2012.*


ВСЕРОССИЙСКОЕ ОБЩЕСТВО ИЗОБРЕТАТЕЛЕЙ И РАЦИОНАЛИЗАТОРОВ

Почетная Грамота

награждается

Бостан И., Дулгеру В., Бостан В., Сокиряну А., Вакуленко М., Чобану О., Чобану Р., Гладыш В.

Микрогидроцентраль с гидродинамическим ротором для конверсии кинетической энергии воды в механическую или электрическую.

Медалью

Санкт-Петербургского Совета ВОИР

За высокий уровень инновационных разработок, представленных на международном салоне «АРХИМЕД – 2013» (г. Москва)

Председатель СПб и ЛОС ВОИР

В. Курносов

Постановление Совета № 14

12 - 04 - 2013 г.

Санкт-Петербургский и Ленинградский областной Совет

Diploma of Honour, Acrhimedes, 2013, Moscow, Russia.


HRVATSKI SAVEZ INOVATORA

ХОРВАТСКИЙ СОЮЗ ИЗОБРЕТАТЕЛЕЙ

ДИПЛОМ

Лучшее изобретение молодых

Бостан В., Сокиряну А., Вакуленко М., Чобану О., Чобану Р., Гладыш В.

Микрогидроцентраль с гидродинамическим ротором для конверсии кинетической энергии воды в механическую или электрическую.

16-й Московский международный Салон изобретений и инновационных технологий «Архимед»

2-5 апреля 2013 г.

Москва, Россия.

ХОРВАТСКИЙ СОЮЗ ИЗОБРЕТАТЕЛЕЙ

Президент

Лиляна Педишич

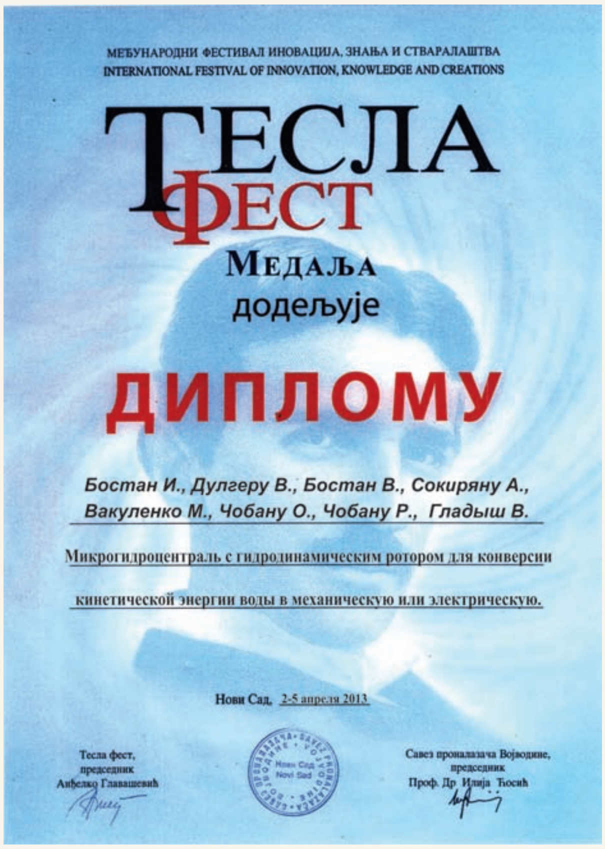
Gold Medal, Acrhimedes, 2013, Moscow, Croatian Society of Inventors.

Appreciation of the research results at the International Exhibitions of Invention, Research and Technology Transfer

Special Prise, Acrhimedes, 2013, Koreea Invention Promotion Association.

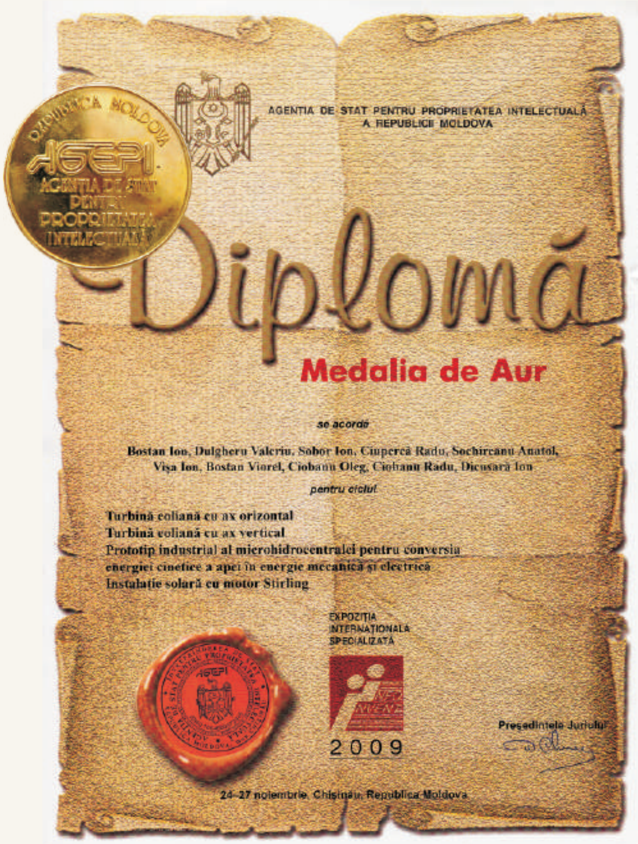
Diploma, Ministry of Defence of the Russian Federation, 2009.

Gold Medal, Acrhimedes, 2013, Horvatian Society of Inventors.

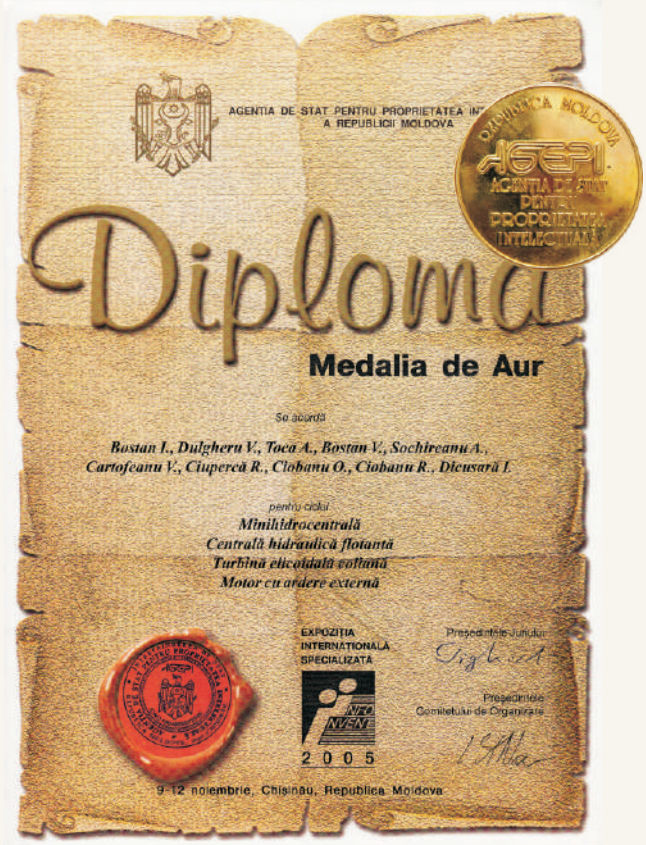


Medal Tesla, Acrhimedes, 2013, International Festival of Innovation, Knowledge and Creation.

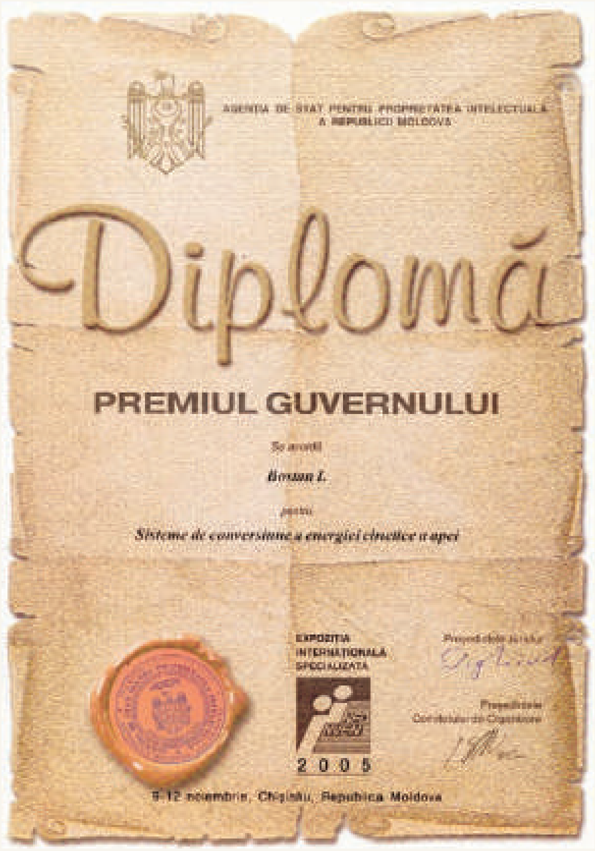
Appreciation of the research results at the International Exhibitions of Invention, Research and Technology Transfer



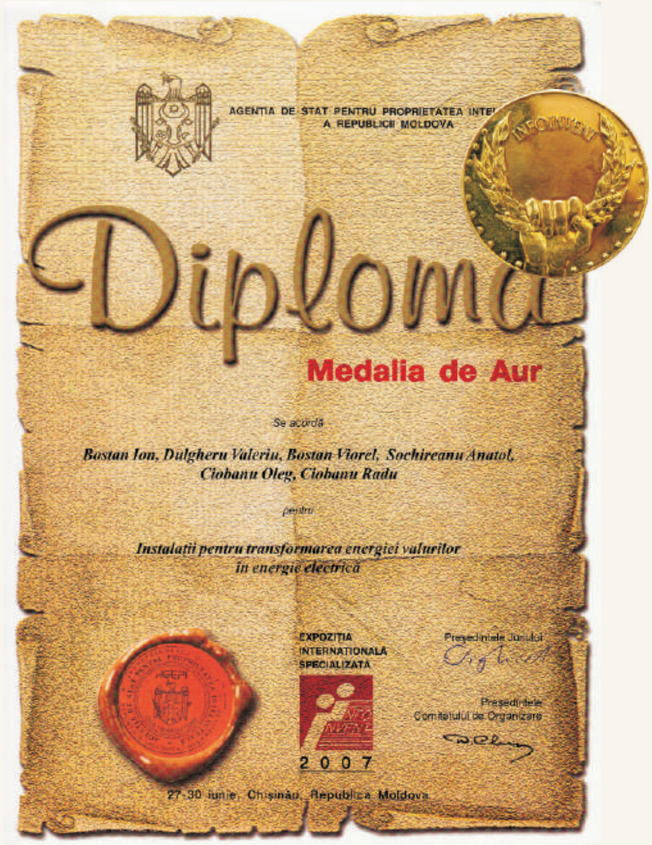
Gold Medal, Infoinvent, 2009, Chishinau, Republic of Moldova.



Gold Medal, Infoinvent, 2005, Chishinau, Republic of Moldova.



Government Award, Infoinvent, 2005, Chishinau, Republic of Moldova.



Gold Medal, Infoinvent, 2007, Chishinau, Republic of Moldova.

SELECTED SCIENTIFIC PUBLICATIONS

EDITED BOOKS ON RENEWABLE ENERGY CONVERSION SYSTEMS

Monographs:

1. Bostan, I., Gheorghe, A., Dulgheru, V., Sobor, I., Bostan, V., Sochirean, A. Resilient Energy Systems. Renewables: Wind, Solar, Hydro. Springer, VIII, 507 p. 2012. ISBN 978-94-007-4188-1
2. Bostan I., Gheorghe A., Dulgheru V., Bostan V., Sochireanu A., Dicusară I. Conversion of Renewable Kinetic Energy of Water: synthesis, Theoretical Modeling, and Experimental Evaluation. Energy Security: International and Local Issues, Theoretical Perspectives, and Critical Energy Infrastructures (NATO Science for Peace and Security Series C: Environmental Security). Published by Springer. 2011, Pp. 125-177. ISBN 978-94-007-0718-4.
3. Bostan I., Dulgheru V., Bostan V., Ciupercă R. Antologia invențiilor. Sisteme de conversie a energiilor regenerabile: fundamente teoretice, concepte constructive, aspecte tehnologice, descrieri de invenții. Ch.: Ed. BONS Offices. 2009, 458p. ISBN 978-9975-63-078-4.
4. Bostan I., Dulgheru V., Sobor I., Bostan V., Sochirean A. Sisteme de conversie a energiilor regenerabile. Univ.Tehn. a Moldovei.- Ch.: Ed. „Tehnica-Info” SRL, (Tipografia BONS Offices). 2007.- 592 p. ISBN 978-9975-63-076-4.

Articles in international journals:

5. Bostan I., Dulgheru V., Bostan V., Sochireanu A., Ciobanu O., Ciobanu R. Micro-hydropower station for kinetic energy conversion of flowing water. Hidraulica. Magazine *of Hydraulics, Pneumatics, Tribology, Ecology, Sensorics, Mechatronics.*(No. 3-4/2012. Pp. 15-21. ISSN 1453 – 7303.
6. Bostan I., Dulgheru V., Bostan V., Sochireanu A., Ciobanu O., Ciobanu R. Micro-hidropower station for kinetic energy conversion of flowing water. Annals of the University of Craiova, Electrical Engineering series, no 35, 2011, Craiova, Romania, p. 77-82, ISSN 1842-4805.
7. Ion BOSTAN, Valeriu DULGHERU, Ion SOBOR, Viorel BOSTAN, Anatol SOCHIREANU. Micro-hydropower station for kinetic energy conversion of flowing water / Annals of the University of Craiova, Electrical Engineering series, No. 35, 2011; P. 77-82. ISSN 1842-4805.
8. Ion BOSTAN, Valeriu DULGHERU, Ion SOBOR, Viorel BOSTAN, Anatol SOCHIREANU. Wind microturbines with power of 10 kW / Annals of the University of Craiova, Electrical Engineering series, No. 35, 2011; P. 71-76. ISSN 1842-4805.
9. Bostan I., Dulgheru V., Bostan V., Sochireanu A., Ciobanu O., Ciobanu R. Micro-hidropower station for kinetic energy conversion of flowing whater. Annals of the University of Craiova, Electrical Engineering series, no 35, 2011, Craiova, Romania, p. 77-82, ISSN 1842-4805.
10. Bostan I., Dulgheru V., Bostan V., Sochireanu A., Trifan N., Dicusara I., Ciobanu O., Ciobanu R. (2011). A micro/hydropower station for the conversion of flowing water kinetic energy in Environmental Engineering and Management Journal, Universitatea Transilvania din Braşov, România, 10-12 Noiembrie, 2011, (pag 1033-1040). IF 1,435.
11. I. Bostan, V. Dulgheru, A. Toca, R. Ciupercă *Implementation of the experimental prototype of the wind turbine with vertical axis and helical blades* // Buletinul Inst. Politehnic din Iaşi. Tom. LIV (LVIII). Fasc. 3. Secția Construcții de Maşini. - Iaşi: Univ. Tehn. “Gh. Asachi”, 2008. – P. 111-118. (rom. ; rez. în engl.): fig. - Bibliogr. : 6 tit.
12. Bostan I., V. Bostan, Dulgheru V., O. Ciobanu, I. Dicusară. Cercetarea interacțiunii palei hidrodinamice a microhidrocentralei cu fluxul de apă. Scientific Bulletin, Serie C, Volume XXII. Fascicle: Mechanics, Tribology, Machine Manufacturing Technology, Part 2. Ed. Universității de Nord din Baia Mare, 2008. Pp. 47-52. ISSN

1224-3264.
13. Bostan I., Sobor I., Dulgheru V. Studiu de prefezabilitate a microhidrocentralei flotabile pentru producerea energiei mecanice / Revista „Convorbiri economice. Publicație lunară. ISSN1582 – 3555, nr. 5, 2008, p. 39-42.
14. Bostan I., Dulgheru V., Bostan V., Ciobanu O. Aspects concerning the constructional and functional optimisation of the multi-blade rotor with hydrodynamic profile of blades of the micro-hydropower stations for energy conversion // Acta Technica Napocensis. Series: Applied Mathematics and Mechanics. - Cluj-Napoca, 2007. - 50. - Vol. II. - P. 255-258.
15. Bostan, I. ; Dulgheru, V. *Some aspects concerning the study of market for renewable energy obtained from river water flowing kinetic energy* // Convorbiri Economice. Braşov,- 2006. - Nr. 8. - P. 32 – 34.
16. Bostan, I. ; Dulgheru, V. ; Ciobanu, O. *Technological constructive aspects concerning the development of the multiblade rotor of the micro-hydropower station* // Buletinul Institutului Politehnic din Iaşi. Tomul LII (LVI). Fascicula 5 D. Secția: Construcții de Maşini, - Iaşi: Univ. Tehn. "Gh. Asachi", 2006. - P. 1275 – 1279. : fig. - Bibliogr. : 8 tit.
17. Bostan I., Dulgheru V., Bostan V., Ciobanu O. Aspecte privind optimizarea constructivă şi funcțională a rotoarelor cu palete multiple cu profil hidrodinamic ale paletelor din stațiile de putere mare pentru conversia energiei //Acta Technica Napocensis. Series: Applied Mathematics and Mechanics 50, vol.II, 2006. ISSN 1221-5872. P. 255…258.
18. Bostan, I. ; Bostan, V. ; Dulgheru,V. *Numerical Modelling and Simulation of the Fluid Flow action on Rotor Blades of the Micro-hydropower Station* // Ovidius University Annual Scientific Journal. Mechanical Engineering Series - Constanța, 2006. - Vol. VIII. - Nr. 1. - P. 70-78: fif. - Bibliogr. : 5 tit.
19. Bostan, I. ; Bostan, V. ; Dulgheru, V. *Conceptual design of the electrical micro-hydropower station for the conversion of running water kinetic energy into mechanical and electrical energy* // The annals of "Dunărea de Jos" University of Galați. Fascicle XIV Mechanical engineering - Galați, 2006. - P. 34 – 38: fig. , tab. - Bibliogr. : 6 tit.

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20. Ion Bostan, Valeriu Dulgheru, Ion Sobor, Viorel Bostan, Anatol Sochirean. Utilizarea surselor regenerabile de energie - eoliană, hidraulică şi solară în condițiile Republicii Moldova. În rev. Akademos, nr. 4(23), 2011. P.54-59.
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