ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 5, Issue 12, December 2018

Reactive Hydraulic Turbine with Power up to 100 KW on the Basis of LOVAL SNIP

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ABSTRACT: This paper proposes a new efficient design of micro-hydro and working on a jet turbine .Impellers of micro-hydro and hydro turbines can be propeller or blade, which has several drawbacks: the inability to provide continuous perpendicular water impact on the blade, also when water hits the blade because of the scattering of water on a large surface decreases the torque, which will lead to energy loss.

In addition, in this design, the cavitation effect almost does not work the impeller system. In the hydroturbine under consideration, the above disadvantages are minimized .The results of theoretical calculations and tables, graphic dependencies of experimental reactive micro-hydroelectric station a are given.

KEYWORDS: reactive, impeller, hydro turbine, circular cylindrical, reflector, torque. Efficiency factor.

I. INTRODUCTION

It is known that the efficiency of hydraulic turbines for mini and micro-hydro power plants is significantly influenced by their impellers. Therefore, the main element of the turbine is the impeller, which converts the potential and kinetic energy of the flow of water into mechanical energy. The type of turbine is determined by the shape of the impeller and is divided into active and jet turbine. In modern hydropower mainly used two types of jet turbines: axial and radial axial.

For pressures greater than 50 m, the Francis radial-axial (RA) turbine gives an excellent result, but at low water pressures the use of the above turbines due to the limited possibilities of installation installation conditions and cavitation effects, technical difficulties, large size will be ineffective.

II. RELATED WORK

The analysis of the deficiencies of the known structures [1-3] is the formulation of the actual problem of creating a reactive hydraulic turbine with an impeller with improved mechanical, hydraulic and reactive parameters and simplifying the design of the impeller.

At the suggestion of the authors of this work, the solution of this goal is achieved by the fact that in a reactive hydraulic turbine, containing an impeller with channels for water outflow and a stator with reflectors in order to increase efficiency by improving reactive recoil and simplifying the design, the impeller is made in the form of a cylinder, nozzle and the channels for the outflow of water are located on the same horizontal plane of the bottom of the working cylinder, the channels for the outflow of water are cone-shaped Loval type pipes, located perpendicular to the inner radius of the impeller, having an outlet nozzle, which perpendicularly directs the flow of water coming out of the nozzle to a tangential plane drawn at the center point of the arc of a concave and vertically installed circular cylindrical reflector. A new design of a reactive hydraulic turbine has been developed [8].

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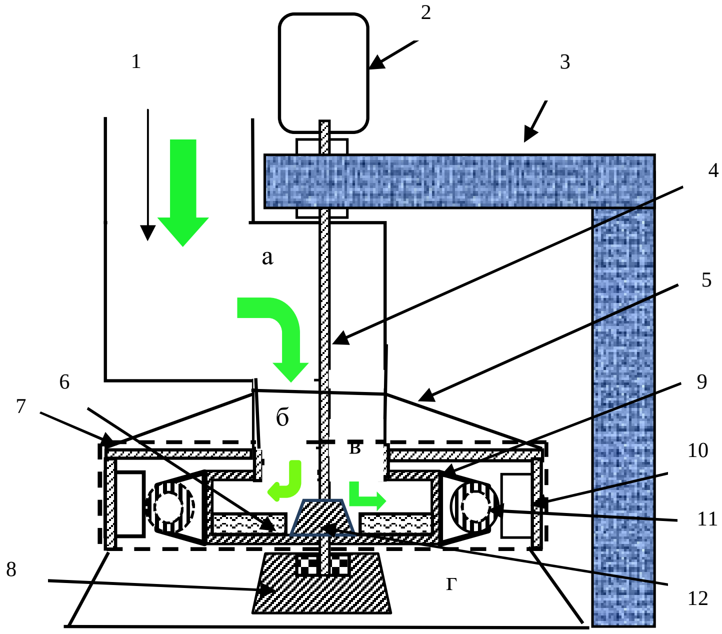

1-picture: Vertical section of the turbine.

III.OBJECT AND METHODS OF RESEARCH

The design is illustrated by drawings, where in fig. 1 shows a cross section along a vertical plane of a hydro turbine; Fig. 2 shows the dependence of the efficiency of the turbine on the water pressure; in fig. 3 shows the dependence of water consumption on the pressure of a specific example of performance of a reactive hydraulic turbine for a “micro-hydroelectric station”.

Reactive hydraulic turbine (Pic. 1) contains an impeller in the form of a cylinder 12 mounted on shaft 4 with a trapezoidal base 6 and installed in the central part on the lower base with effectively reducing mechanical friction during rotation by the tip shape - thrust bearing 8. The foot of 8, having a common with a stator, a cross-shaped base mounted on a housing 13 that expands as it moves away from it. The impeller in the form of a cylinder, branch ducts in the form of a pipe 9 with a nozzle-shaped tip 11, a stationary stator 10 with an effectively chosen height and internal metal reflectors 7, which serve as barriers to the impact of water flow coming out of the tubular snot 11, thereby increasing the reactive force .To improve the outflow of water from the impeller through the channels 9, radial vanes 6 are installed on the bottom of the cylinder. The channel for outflow of water is a cone-shaped tube 9 and the tip of the tube is made in the form of a concave nozzle 5, directing the output flow is perpendicular to the plane of the reflectors 7. Moreover, the number of tubes nozzle may be 4 or more. The stator 7 with internal reflectors 10 is installed on the base 13 expanding as it is distanced from it in the form of a truncated cone along a vertical section, which facilitates fast flowing down of free falling water after an emphasis on the reflectors 10 of the stator 7.

Provided condition of minimum hydraulic resistance. In this design, mainly three places there is a local resistance with a smooth transition, when the water enters the hydro turbine, a smooth rotation of 90^0 vertically downwards occurs, the resistance ξ_2 can be obtained from the directory $\xi_2 = 1.25$ [4], here due to the small distance of water flow by hydraulic resistances can be neglected.

When water enters the rotating cylinder, a sudden expansion occurs, which is calculated using the Borda-Carno formula [6]. In addition, the water in the cylinder forks at the nozzles, and also before exiting the nozzle, there is a smooth compression in a place with a turn of 90^0, where it can be calculated using the formula proposed by I.D. Semikin [6]:

$$\xi_2 = \xi_{90^0}(1 - cos\varphi) \qquad (1)$$

When the angle of rotation φ decreases, the volume of the separation zone decreases and along with it the energy loss decreases.

Before the water leaves the nozzle, a smooth compression occurs along with a smooth rotation in the form of a cone-shaped confuser, which minimizes local resistance. In this case, the vortex formation of water will be minimal. Loss of energy and pressure can be neglected. The walls of the nozzle are designed so that the hit water is reflected in the direction perpendicular to the radius of the rotating cylinder of the impeller. Bearing in mind the above, we can use for the local resistance when the water leaves the nozzle, the smooth rotation formula for 90^0.

The carried out theoretical calculations for the construction under consideration gave the following results: the expressions for the speed of outgoing water from the nozzle and the torque of the impeller shaft are as follows:

$$V_c=\sqrt{V_2^2\left[1+\frac{2S_2}{\alpha NS_3}\left(1-\frac{S_2}{NS_3}\right)-\frac{1}{\alpha}\left(\frac{S_2}{NS_3}\right)^2\left(1-\frac{S_2}{NS_3}\right)^2\right]+\frac{2gH_2}{\alpha}}\left\{\frac{S_3}{S_6}-\sqrt{\left(\frac{S_3}{S_6}-1\right)^2-\xi_{90^0}}\right\};\quad(2)$$

where, $V_2=\sqrt{\frac{2g\varphi^2(H_1-H_2)+\alpha V_1^2}{\xi_2+\alpha}}$; $V_1=\varphi\sqrt{2g(H_0-H_1)}$; (3)

The moment equation [6] for the construction in question has the following form:

$$\sum(\vec{R}_2\times\vec{F}_e)=\frac{d\vec{H}_{tb}}{dt}+\int\vec{R}_2\times(2\vec{\Omega}\times\vec{V})\delta m-\frac{d\vec{H}_l}{dt}+\frac{dH_e}{dt};\quad(4)$$

Using the continuity equation, as well as the initial and boundary conditions for the construction under consideration for the torque of hydro turbines

$$\Omega_z=\frac{v_2}{(R_{p\kappa}+h_n)}cos\beta;\quad v_x=v_a cos\beta;\quad v_y=0;\quad \beta=arccos\frac{R_{p\kappa}}{R_{st}}$$

$$dm_w=N\rho\pi(R_{p\kappa}+h_{sp})^2 v_c dt;$$

$$M_z=-R_2\frac{dm_c}{dt}\left(v_n-\Omega_z(R_{p\kappa}+h_{sp})\right);\qquad R_2=R_{p\kappa}+h_{sp};$$

We obtain the solution of equation (4) for the torque, the following expression:

$$M_z=-N\rho\pi R_2^3 v_n(v_n-\Omega_z R_2)=-N\rho\pi R_2^3 v_n^2(1-cos\beta);\quad(5)$$

where, *N*–nozzle number,

$$R_2=R_{p\kappa}+h_n;$$

IV. RESULTS OF THE RESEARCH

The results of computer calculations based on the obtained formulas showed that with a constant size of the structure, with small water pressures, the PDP reaches 78%, with a further increase in pressure, the efficiency increases to 90%. The dependencies of torque, power, water flow and other parameters are shown in the following table [1].

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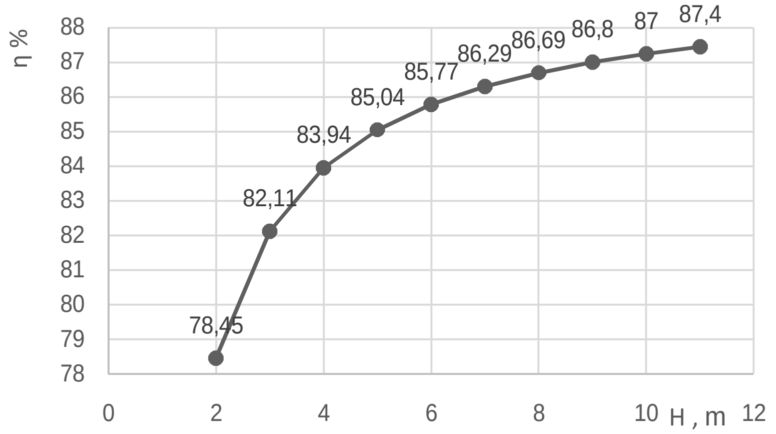

2-picture: Dependence of the efficiency of a reagent turbine with water pressure.

1-table. The dependence of the parameters of reactive micro-HES

H (m)	N	R_n (m)	V_n (m/s)	Q (dm^3/s)	P (Wt)	η (%)	M $(N \cdot m)$
2	12	0,045	5,548522	423,3633	6516,852	78,4559	3360,383
3	12	0,045	6,952242	530,47	12819,78	82,11633	6345,746
4	12	0,045	8,116726	619,3225	20400,87	83,94654	9750,638
5	12	0,045	9,133938	696,9377	29072,35	85,04467	13485,75
6	12	0,045	10,0487	766,736	38711,12	85,77676	17496,65
7	12	0,045	10,88687	830,6901	49228,34	86,29967	21746,17
8	12	0,045	11,66497	890,0606	60555,96	86,69186	26207,11
9	12	0,045	12,39432	945,7113	72639,67	86,9969	30858,55
10	12	0,045	13,08307	998,2643	85434,8	87,24093	35683,85
11	12	0,045	13,73733	1048,186	98903,81	87,44059	40669,43

V.CONCLUSION

The tables show that, unlike the analogue of [4], when implementing the indicated features, the proposed design of a reactive hydraulic turbine:

- has the following advantages [8]: Inside the cylindrical impeller, the water trajectory will be a complex curve, due to the rotation of the impeller centrifugal and Coriolis forces appear, which give their positive results for the rotational force of hydroturbines
- With rotational dynamic equilibrium of the impeller, water flow is stable, which ensures the stability of the generated current.
- the channel for the outflow of water from the impeller cylinder is a concave cone-shaped section of a pipe with a tip in the form of a Laval nozzle, which ensures the mutual perpendicularity of the radius of curvature of the impeller and the channel for outflow of water, as well as the mutual perpendicularity of the direction of the outgoing water flow and the tangent plane, conducted to the point of the center of the arc of a concave and vertically installed circular cylindrical reflector, which gives maximum efficiency of using the torque p active force;
- autonomy of the installation;
- long service life;
- no need for land areas;
- rotation is caused mainly by the reactive force of the impeller emerging from the nozzle;

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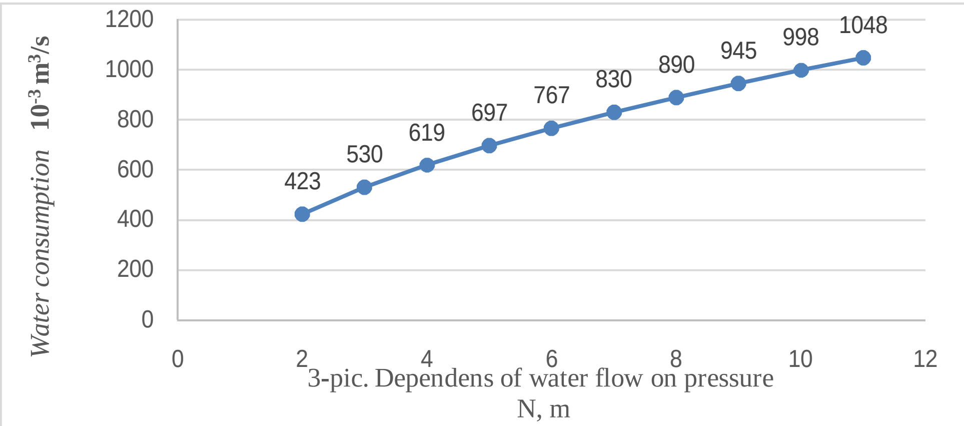
- from a hydrotechnical point of view, there is no concept of regulating the flow of a reservoir (in the sense used for dam and derivational hydroelectric power plants) due to a change in pressure depending on the instantaneous power of the consumer;
- the principle of partial overlapping of the channel performs in a wide range of regulatory functions without additional design and construction costs due to the flow around the unit can be considered as a lot nozzle.

A specific example of performance of a reactive hydraulic turbine has the following dimensions:
- impeller diameter 600 mm,
- impeller height 100 mm,
- number of drainage channels 12 pcs,
- outer diameter of the stator 700 mm,
- number of reflectors on the inner wall of the stator 36,
- diameter vertically mounted shaft 40 mm,
- shaft height 1300 mm.

The water flow through a pipe with a diameter of 274 mm is fed to a hydro turbine, the shaft of which is equipped with a pulley.The rotation of the shaft at a speed of 180 ÷ 200 rpm through the pulley and the connecting belt is transmitted with an acceleration factor of ≈ 5.2 to the shaft of the electric generator. The created “micro-hydroelectric power station” with a reactive hydraulic turbine had the following technical characteristics:



3-pic. Dependens of water flow on pressure

- water pressure ≈ 230 mm,
- power 4 kW, voltage 220 ÷ 230 V,
-current frequency 50 Hz,
-dimensions 700 × 700 × 1300 mm,
- all ≈120 kg.

Thus, the proposed design of a reactive hydraulic turbine is efficient, simple in its implementation and can be used as the basis for the creation of new highly efficient vertical hydraulic turbines for micro and mini hydroelectric power stations, as well as for modernization of existing ones.

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