

NOZZLE TURBINE AND EXPERIMENTAL RESULTS

Bozarov Oybek Odilovich,

Tashkent State Technical University, PhD, doctoral student (DSc), Uzbekistan,

Phone: (94) 278 81 70. E-mail: obozarov7@inbox.ru

Kiryigitov Bakhridin Abdusattarovich

Andijan Institute of Agriculture and Agrotechnologies

Phone: (90) 141 28 54. E-mail: baxriddin.kiryigitov@mail.ru

Abstract

Today, the most important problem for all countries of the world is the provision of electricity to the needs of the population and the industrial sector. Due to low water, the volume of electricity production at hydroelectric power plants in Uzbekistan has decreased by 23% this year, as in the countries of Central Asia [1]. According to statistics, in the Republic of Uzbekistan, when generating electricity in 2021, the RES capacity was 2,147 MW. The share of hydropower was 2043 MW (95%) [2].

Table 1. Speed of hydraulic turbines, ns.

Types of hydro turbines	<i>n_s, об/мин</i>
Bucket	10-50
Radial-axial:	
Low-speed hydro turbine	70-150
Medium turbine	150-250
High Speed Hydro Turbine	250-400
Propeller turbines:	
Average working	550-750
Fast turbines	750-950

The hydraulic turbines listed in Table 1 mainly operate with a water head of $N \geq 5$ m and require a large water flow. Hydro turbines of the type operate with very low efficiency, since the water pressure in most sources in Uzbekistan reaches 5 meters. On the basis of Pelton, Turgo, Kaplan hydro turbines, Hydro Induction Power produces 3 types of hydro generators HV 1200, HV 1800, HV 3600, and their cost is \$3600, \$4200, \$6000. They can operate at a water pressure of 18.29-152.4 m, a water flow of 0.63-37.85 l / s, a maximum power of 0.6-3.6 kW. Their efficiency ranges from 6% to 30% [5], equipment from Nautilus Water Turbine (Francis) with 46 rpm and efficiency up to 75% (at high water pressures) and 10,600 US dollars [6].



Table 2. The main technical characteristics of microhydroelectric power plants with blades.

Options	Type of micro hydroelectric power station					
	Micro HPP 10Pr		Micro HPP 15Pr	Micro HPP 50Pr		Micro HPP 100Pr
power, kWt	0,6-4,0	2,2-10,0	3,5-15,0	10,0-30,0	10,0-50,0	40,0-100,0
Water pressure, m	2,0-4,5	4,5-10,0	4,5-12,0	2,0-6,0	4,0-10,0	6,0-18,0
Water consumption, m ³ /s	0,07-0,14	0,10-0,21	0,10-0,30	0,3-0,8	0,4-0,9	0,5-1,2
Speed, мин ⁻¹	1000	1500	1500	600	750	1000
Rated voltage, V	230		400	230, 400		230, 400
Rated current frequency, Hz	50		50	50		50

It is easy to calculate that the efficiency of microGP 10Pr with a water pressure of 2-4.5 m is 47% -64.7%. Diagonal and concave micro HPPs operate effectively at a water head of $N \geq 8$ m. Their disadvantage is that the efficiency is very low at a water head of up to 8 m (Table 2).

In order to eliminate the existing shortcomings of the above hydroturbines, a jet hydroturbine with a nozzle was developed in [7] (Fig. 1).

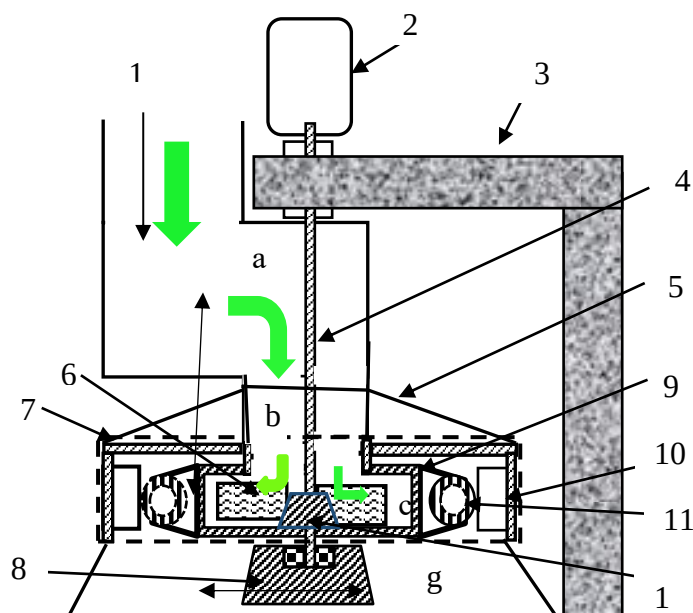


Figure 1. General scheme of a reactive micro hydroelectric power station.

The developed design of the microTP consists of the following parts: inlet (inlet of water into the hydroturbine); hydraulic turbine impeller; the outer casing where the stator is located; frame platform (for installation of micro hydroelectric power



station); intermediate devices for transmitting the rotational motion of the hydraulic turbine shaft to the generator; a cabinet with a control system.

When using the Neve-Stokes and Bernoulli equations to calculate the flow rate of water leaving the turbine nozzle between the surface of the inlet pipeline S2 and the surface of the water outlet from the nozzle, the following inequality arises:

$$\frac{S_2}{S_c} \geq \sqrt{\zeta_{90^\circ} - \zeta_2}; \quad (1)$$

From the analysis for the dependence of the diameter of the inlet pipeline of the hydraulic turbine on the diameter of the water inlet to the nozzle, we obtain:

$$\frac{d_1}{d_3} \geq \sqrt{\frac{3}{2N}}. \quad (2)$$

The fact that the radius of the impeller cylinder R2 is larger than d2 leads to an increase in torque. For the number of impellers mounted on the inner wall of the stator, the following can be written:

$$k = \frac{\pi(R_c + h_{cm})}{d_c}; \quad (3)$$

where, $R_c + h_{cm}$ is the inner radius of the stator.

For the impeller radius Rpk, the stator radius Rst, the radial nozzle height hsp, the radial height hotr of the impeller and the distance b from the highest point of the nozzle on a radius from the center of the impeller to the inner edge of the impeller, the following equation is suitable:

$$R_{cm} - R_{pr} = h_{cn} + h_{otr} + b \quad (4)$$

At a value of b equal to $b = 0.7 d_c$, the reactive force in the nozzle reaches its maximum value.

For $b > 0.7 d_c$, the resulting reactive power decreases, and for $b < 0.7 d_c$, the hydraulic resistance increases.

To create the maximum moment of reactive force, the radial height of the reflector h_{otr} , the radial height of the nozzle d_c , the distance l between the stator reflectors along the circumference and the angle β should take optimal values.

Through experiments and calculations on a hydroturbine model, it was found that the efficiency of reflectors is maximum at an angle β in the range of $20^\circ \div 30^\circ$.

According to the results of a theoretical calculation of the geometric dimensions and energy parameters of the hydroturbine, a micro hydroelectric power station with a



jet hydro turbine with a nozzle was manufactured: at a pressure of 2 meters and a water flow rate of 0.2 m³/s [8].

The theoretical value of the coefficient of speed is found by the formula:

$$n_s = f \left(\frac{Q}{Q_e} \right)^{\frac{1}{2}} \left(\frac{H_e}{H} \right)^{\frac{3}{4}} = \frac{3,65 n Q^{\frac{1}{2}}}{H^{\frac{3}{4}}} = \frac{3,65 \cdot 160 \cdot \sqrt{0,2}}{2^{\frac{3}{4}}} = 155,8 \text{ rpm} \quad (7)$$

The prepared microhydroelectric power station was tested in a stream in the village of Siza, Balykchy district. The average efficiency of micro HPPs was 56%. If the efficiency of the generator is $\eta_{\text{gen}}=0.95$, and of the additional devices $\eta_{\text{dop}}=0.95$.

In this case, the efficiency of the hydro turbine is found by the following formula

$$\eta_{\text{gidr}} = \frac{\eta_{\text{MGES}}}{\eta_{\text{gen}} \cdot \eta_{\text{peredacha}}} = \frac{0,56}{0,95 \cdot 0,95} \cdot 100\% = 62,5\% \quad (8)$$

The hydraulic turbine efficiency was 62.05%.

According to the results of theoretical calculations (Table 1.), the efficiency of a hydro turbine of a micro HPP is 67.54%. Its difference from the test results was 5.5%.

ЛИТЕРАТУРА

1. <https://www.gazeta.uz/ru/2021/11/09/energy/>
2. https://irena.org/-/media/Files/IRENA/Agency/Publication/2022/Apr/IRENA_RE_Capacity_Statistics_2022.
3. Zakhidov R.A., Arifzhanov A.Sh. Management of the connection of distributed generators based on renewable energy sources to the general energy system, Geliotekhnika, 2017 (2), pp. 60-66.
4. Bozarov O.O., Ozbekov M.O., Egamberdiev Kh.A., Begmatov E.M. Microelectric stationlar tarmog'ini yaratish uchun foto va hydropower potential foydalanish imkoniyatlarini tahlil qilish (1-qism) // FarPI ITZh, 2022 spec. issue No. (5), pp. 82-85.
5. F. Montomoli, M. Massini, H. Yang, J.C. Han. The benefit of high-conductivity materials in film cooled turbine nozzles. // International Journal of Heat and Fluid Flow, 2012, Volume 34, April, Pages 107 -116.
6. https://manbw.ru/analytics/mini-GES_hydro-turbine_hydroelectric-power-plant.html
7. Abhijit Date, Aliakbar Akbarzadeh. Design and analysis of a split reaction water turbine //Renewable Energy, 2010, Volume 35, Issue 9, September, Pages 1947-1955.
8. Bozarov O.O., Aliev R.U., Zakhidov R.A., Kodirov D.B., Reactive hydraulic turbine // Patent No. UZ FAR No. 01287.public bulletin, Tashkent, 2018. No. 3(201), (20.02.2018), P.24-25.

