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MICRO-HES CALCULATION METHOD OF SMALL POWER

Abstract: The environmental situation, as well as the continuous growth of small capacity geographically dispersed and remote from electric grids located near water streams with pressures from 1 to 5 m and power from 1 to 100 kW, set the task of creating inexpensive and efficient autonomous automated micro-hydroelectric power stations. The main goal of these tasks is to satisfy household and industrial needs with electric energy.

In this paper, we present a methodology for calculating micro-hydroelectric power plants of small capacity to meet domestic and industrial needs of electric energy

Key words: Electric networks, water flow, power, generator, consumer, operating modes, calculation method.

Introduction The ecological situation, as well as the continuous development of low-power facilities that are geographically spaced and remote from public catering networks, from all up to 5 m and power from 1 to 100 kW, allows the creation of low-cost and efficient autonomous automated Micro-hydro power systems. The main goal of these tasks is to satisfy the needs of consumers.

The high energy density of water flows, the wide possibilities for regulating their energy and the relative temporal stability of the flow regime of most rivers and water channels make it possible to use simple and cheap systems for generating and stabilizing the parameters of the produced electricity.

An analysis of the known solutions for creating Micro-hydroelectric power stations in the field of small heads and water flow rates showed that the most promising in the above range are power plants with water filling wheels (VK) and self-excited asynchronous generators (ASG). VCs are simple in design, have a low cost, high coefficient of performance (EFFICIENCY), reliable and easy to operate, but their use as unregulated hydraulic motors in micro-hydroelectric power plants significantly increases the requirements for the system of stabilization of the magnitude and frequency of the generated voltage.

However, modern advances in the field of electrical engineering, semiconductor and converter technology make it possible to create reliable and inexpensive stand-alone automated Micro HPPs that provide high-quality electricity with minimal requirements for a hydraulic motor.

The development of low-pressure micro-hydroelectric power stations with VK and ASG is a complex task, therefore, to create electrical equipment for micro-hydroelectric power stations, a preliminary study of the ranges and dynamics of the generator shaft rotation frequency is required in relation to the capabilities of the VC at various flow rates and pressures.

In this regard, the study of operating modes, determining the characteristics of the LHG, building automatic control systems (ACS) for electric power parameters for micro-HPPs with effective VCs, and conducting in-depth studies of the operating modes of Micro-HPPs taking into account all its main elements are of paramount importance.

The methodology for calculating the power of flowing water is characterized by the flow rate and the flow rate. The channel of the stream is a cross-sectional area and a slope.

The amount of electricity received at a specific place in the free flow of a micro-hydroelectric turbine driving a turbine can be calculated using the following equations:

$$P=0{,}098\ Q*H,$$
$$n=Q*s*g*H \qquad (1)$$
$$Q=\pi*d^2*v/4$$
$$Ncmp=\pi*d^2*s*v^3/\eta*8$$

where: P - power (kW); Q - water consumption (l / s); H - total hydrostatic head (m); n is the speed of rotation of the working impeller - turbine (rpm.); N p - the power of the stream; S is the flow cross section (m2); g - = 9.8 m / s, gravity; d is the diameter of the impeller (m); vin, vout - the speed of the flow of the inlet and outlet in the impellers (m / s).

Given the head H flow power:

$$P_n=p*Q[gH+(v2_{вх}-v^2_{вых})/2]$$

And when taking into account the efficiency of a turbine with an engine, the power of a micro hydroelectric station is equal to:

$$P_{ГЭС} = 0{,}098\ \eta\ *Pn \qquad (2)$$

To begin with, suppose that the efficiency of the system is 50%, i.e. η = 0.5. Then, to determine the amount of electricity received, the formula is used:

$$P = 0{,}5Q*H \qquad (3)$$

Thus, the hydrostatic head required to obtain a given amount of energy is equal to:

$$H = P/0{,}5Q \qquad (4)$$

For example: at d = 0.2m, v = 5m / s and η = 0.8, the amount of electricity received is P = 2.0kW.

The magnitude of the hydrostatic pressure can be significant (as in a waterfall) or small. Actually, it turns out that the energy will depend on how efficiently the water is delivered from the top of the structure to its base (it depends on the length, size and type of pipe used). Then how efficiently energy is converted into electricity.

Further, electricity is transferred from the generator to the place of use - residential buildings, equipment, etc. Part of the energy is also lost in this area. Typically, a highly efficient power system requires higher costs.

Provided that the system has sufficient hydrostatic pressure and flow (flow rate) of water, other aspects are considered - labor costs, materials, etc. In each case, these components vary widely.

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An example with the initial data: Q = 3.0 m^3 / s; H- = 1.5 m; vin = 6m / s; vout = 2m / s, η = 0.8, and fluid density ρ = 10^3.

The amount of electricity generated will be as follows:

$$P_{турб.} = \eta*\rho*Q[g*H + (v^2_{вх} - v^2_{вых})/2] = 0{,}8*10^3 * 3[9{,}8*1{,}5+ (6^2-2^2)/2] = 73{,}7кВт. \quad (5)$$

Usually heuristic calculations are performed taking into account the similarity coefficient, connecting the geometric, kinematic and dynamic similarity of model and real turbines according to the Reynolds and Froude numbers (the ratio of inertial forces to weight forces).

The main parameters are: H, Q, P, n and D1 - the main maximum impeller diameter.

1. The relationship of the speed of rotation of the turbine with the diameter of the impeller.

$$\frac{n_a}{n_b} = \frac{D_{1b*}\sqrt{H_a}}{D_{1a*}\sqrt{H_b}} \qquad (6)$$

where a and b are constant values of the regime of the speed of passage of water through the turbine.

2. The costs of two such turbines:

$$\frac{Q_a}{Q_b} = \frac{D_{1a*}^2\sqrt{H_a}}{D_{1b*}^2\sqrt{H_b}} \qquad (7)$$

where: Qa and Qb are the flow rates of water through the turbine

3. Efficiency of two similar turbines

The power of two such turbines, one of which have: D1 = 1m., N = 1m. and the given values of revolutions, flow rate and power according to well-known formulas:

number of revolutions $n=\frac{60_u}{\pi D_1}$; where u is the peripheral speed and flow rate $V=\varphi\sqrt{2gH}$; where φ is the viscosity of the stream.

A turbine using the potential and kinetic energy of a fluid stream receives:

$$E\ раб = \frac{P}{\gamma} + \sqrt{\frac{aV^2}{2g}}$$

$$n_1^1 = \frac{nD_1}{\sqrt{H}};$$

$$Q_1^1 = \frac{Q}{D_1^2\sqrt{H}}$$

$$N_1^1 = \frac{N}{D_1^2 H\sqrt{H}} \qquad (8)$$

where: Erab is the jet energy, n_1 is the turbine speed, Q_1 is the flow through the turbines, and N1 is the power in the first approximation.

Taking into account the efficiency obtained in the second approximation:

$$N=n_1^1 * \frac{\sqrt{H}}{D_1} * \sqrt{\frac{\eta_T}{\eta_M}};$$

$$Q=Q_1^1 * D_1^2 * \sqrt{H *} \sqrt{\frac{\eta_T}{\eta_M}};$$

$$N=N_1^1 * D_1^2 * H * \sqrt{H} * \frac{\eta_T}{\eta_M} \sqrt{\frac{\eta_T}{\eta_M}} \qquad (9)$$

Based on the above calculations, the speed coefficient of the turbine, i.e. the speed of a turbine developing a power of 1 horsepower (730 W) at a pressure of 1 meter is determined by a simple formula:

$$n_s = \frac{n\sqrt{N_{лош.сил}}}{H\sqrt[4]{H}}; \qquad (10)$$

Conclusion Using the energy of small rivers promises significant benefits for the supply of electric energy to individual consumers. Therefore, the creation of a new technical tool for generating small amounts of electric energy in water flows with low consumption but high energy will improve the life of rural residents, summer cottages, farms, mills, and bakeries. As well as small manufacturing and industrial enterprises where there is no nearby power line, for individual consumers.

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