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Technical and Economic Indicators of a Microhydroelectric Power Station in Agriculture

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Abstract *- This article analyzes technical specifications of micro hydroelectric power station, which are crucial for providing cheap electricity to agriculture.*

Keywords: water consumption, generator, water pressure, electricity.

Introduction

Hydroelectric power is a combination of kinetic and potential energies of a water flow. Any flow of water has potential and kinetic energy. A hydroelectric - power plant is an object that converts kinetic and potential mechanical energy intoelectrical energy.

The power of hydroelectric power stations is determined by the formula:

$$P = 9{,}81 * Q * H * \eta \quad \text{(kVt)} \quad \textbf{(1)}$$

Where $Q$is the water flow rate (m^3/s)
H-height of water pressure. (m)
η-HPP efficiency coefficient.

The efficiency of hydroelectric power plants is very high-2 times more than when looking at thermal power plants.(Efficiency up to 40% ATTHE TPP. At hydroelectric power stations up to 75-80%).
ЭффективEffective work of the GOEC depends on 2 important factors.
1. Stagnation of changes in water flow during the year, that is, stagnation of runoff, is regular throughout the year.
2. The river on which to build hydroelectric power station, has a maximum slope

Artificial hydraulic engineering measures are carried out when the capacity of a high-capacity hydroelectric power station is increased. For example, dams are built in the riverbed to increase water pressure. And in mountainous areas, special derivation channels are being built. In terms of power, a hydroelectric power station can have a capacity of several hundred watts to 10,000 MW. By capacity, they are classified into 2 groups. The remaining HPPs are called small and micro-HPPs, while more powerful HPPs than 10 mW are considered high-power HPPs.

High-capacity hydroelectric power plants require a very large infrastructure. In particular, very large funds, raw materials needed for construction, high voltage, high power against the electricity consumer. In addition, the construction technology of large-capacity hydroelectric power plants is quite complex. And the need to build a separate powerful hydrotubulefor each HPP makes this process even more difficult. The construction of high-capacity hydroelectric power plants is also harmful to the environment. The construction of such structures leads to a change in the landscape of this territory, turning a very large area into a swamp. Another territory causes huge damage to the flora and fauna.

The use of micro HPPsis more profitable mainly in areas far from power centers, in regions with a large number of failures in the power supply system and in regions with unplanned power lines. Such places can include economic facilities in mountainous areas, small villages, and a complex of cottages.The power of such micro-HPPs is selected depending on the power consumption of electric receivers. The power of micro-hydroelectric power plants can range from several tens of kilowatts to hundreds of kilowatts. At the same time, it is desirable to have an additional power source, so that the electricity consumption schedule is varied throughout the day. (For example, diesel generators). But on such diesel generators, the cost of 1 kWh чof energy falls by 25-30 cents. The energy load generated from micro HPPs depends on factors such as water consumption(1^{m^3}/h), the annual balance of water flow, and the slope of the riverbed.

Micro HPP hasthefollowing advantages:
* Simple and reliable design.
• High quality of generated electricity parameters in dynamic and static modes.
• Full compliance of the frequency and voltage of the generated electricity with the requirements of GOST.
• Full automation of work.
• Environmental friendliness of structural and technological solutions of HPP projects.
• Possibility to compensate for phase asymmetry.

Methods of building micro -hydroelectric power plants.

Micro-hydroelectric power plants are divided into several types, depending on the construction method.

Micro-hydroelectric power plants in a river basin are built by building dams on the rapid flow of a river slope or channel. The capacity of this type of micro-hydroelectric power station is much higher than that of other micro-hydroelectric power stations. They are mainly built to provide electricity to small residential complexes.

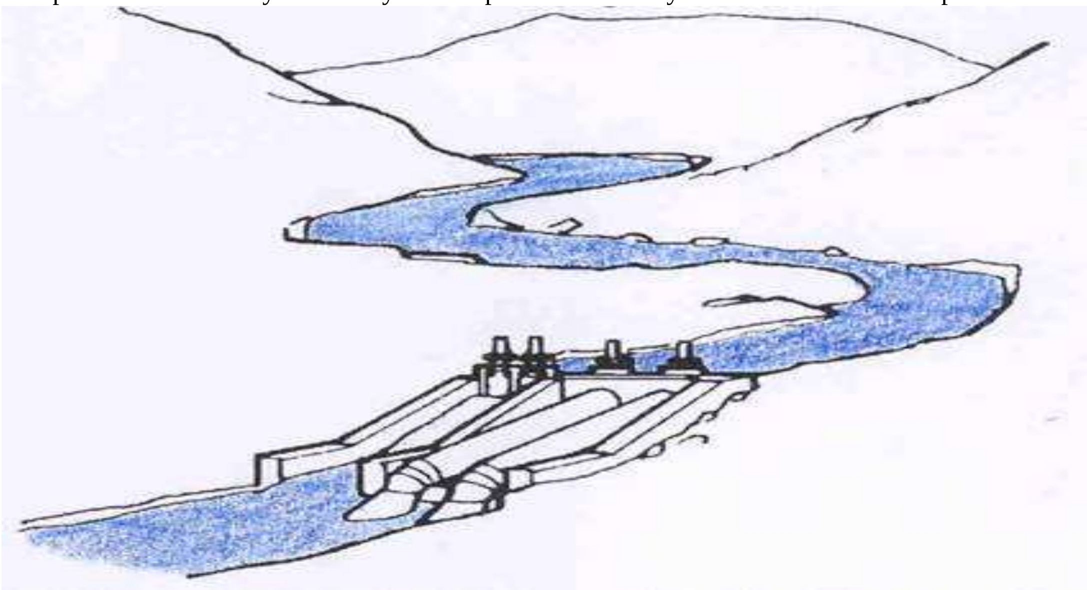

Figure 1. View of micro hydroelectric power station in the river basin

Micro hydroelectric power plants of a derivative type. At the same time, a smaller channel or ditch, depending on the fact that it is lower than the upper part of the bed, stretches part of the watercourse. A hydro turbine is installed at the end of the pipe or channel ..

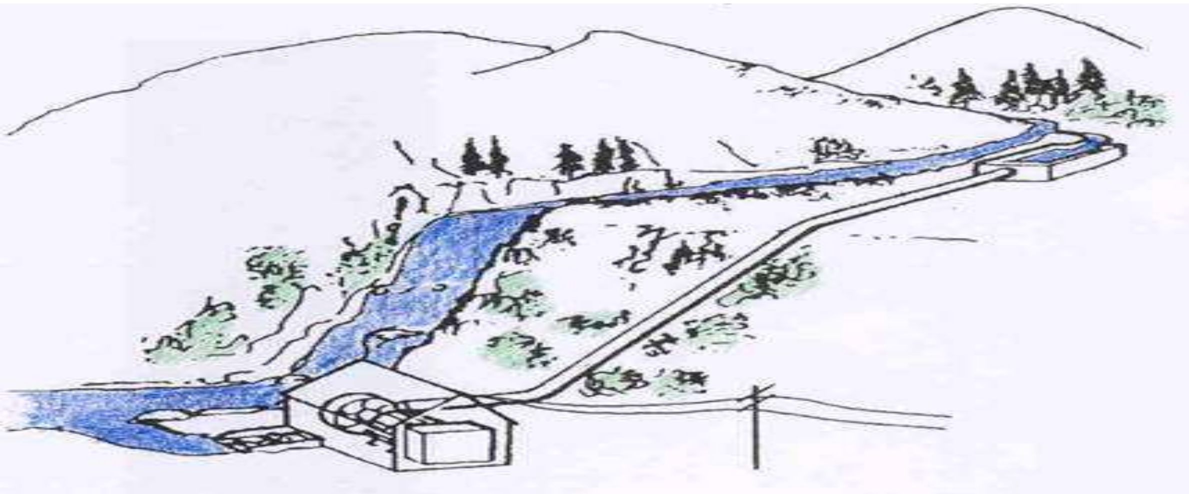

Fig. 2. A type of micro -hydroelectric power station of a derivational type.

A simple micro-hydro power, which can be seen on the river itself, without any changes. Their capacity will be minimal. Microchips usually consist of a hydro tubule (generator), a device that regulates the output voltage, a number of elements, ballast resistances and protective circuits, depending on the type of station. With the main thing of the device in micro hydroelectric Ah is its generator. Theёgenerator, in addition to converting mechanical energy into electrical energy, is also involved in the process of adjusting its parameters. Therefore, it also serves as a controller on such devices. In place of such generators, synchronous machines are often used. The complexity of excitation in asynchronous generators, insufficient ability to adjust the output electrical parameter lead to their low use.

Frequency and voltage regulation in such equipment is carried out in various ways.

- Frequency control by changing the angle of inclination of the working blades or reducing water consumption. The disadvantage of this method is the length of adjustment.(1.5-3 sec.)
- With the help of ballast resistances. In this case, a ballast resistance is connected to the output of the generator, the voltage and its frequency are regulated by consumers.
- Through the device that regulates the frequency of the generator. It is mounted on the blades and the generator on the evaporator shaft and helps the generator keep the frequency at the output evenly, giving the shaft a constant speed.

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- Through a machine-valve source . This equipment replaces the generator. It differs from other methods in that it produces a high-precision voltage and frequency. But the cost of such equipment is much more expensive, so in practice they are rarely used.

The most common method of regulating the voltage of the auto ballast system today is a method auto ballast that is cost-effective.

Generators (hydro turbines.) used in micro HPPs are also divided into 2 types.

1. Active hydro turbines. At the same time, it generates energy due to the kinetic energy of the water flow transmitted to the nozzle of the pipe. They tend to flow quickly and are freely used in channels. They mostly produce little power.

2. Jet turbines. Such hydro turbines, they work at the expense of the potential energy of the water flow. They are used in wood and plant microbes.

We can cite as an example the generators embedded in conventional generators of the assets that are built into the drums. Due to the large overall dimensions and low FIC i, cruciform type hydro turbines are almost not used. Depending on the amount of water flow and the height of water pressure, hydro turbines are divided into such types as Pelton, Togro, Bank, Kaplan, Francis. Their average efficiency is 75-80%.

The primary carrier of energy in microcircuits is the flow of water. Factors such as flow capacity, water consumption, water pressure strength, seasonal turbulence of the watercourse are important in the operation of HPPs. But water consumption and pressure in numerous canals and rivers will fluctuate seasonally. This happens depending on the climate and terrain of the area where the river is located. In addition, the design of a micro-hydroelectric power station takes into account the slope of the river, the annual maximum and minimum water consumption.

Correct implementation of these calculations will lead to a reduction in capital expenditures that will go to it, and reduce energy consumption.

When choosing the location of a micro HPP , the flow capacity of the same river and the fact that the energy received from the same HPP fully corresponds to the energy consumed are taken into account. In mountainous areas, micro-hydroelectric power plants of the derivational type are most often used. Through a small dam on the upper side of the Buda riverbed, some of the water is directed to the bottom of the river through a ditch or specially dug channel. A jet turbine is installed at the end of the pipe or channel .гидротурбина. We can increase the energy of the water flow through this pipe. When selecting a generator, the diameter of the pipe and the height between the lower and upper parts of the pipe are taken into account. Micro HPP pipes can be made of steel, rubber, concrete or other hard materials. What material to choose and the price depends on the shape of the terrain on which micro HPPs are located.

The location of the earth's surface in mountainous areas increases the possibility of using micro - hydroelectricовpower plants , since local rivers have a higher slope or have steeper slopes in a certain part of the plain rivers. If local conditions show that the height of water pressure is less than 1 m, then the construction of micro HPP in such areas is inefficient.

Water consumption in rivers varies seasonally. Therefore, when studying the characteristics of local water consumption of micro-HPPs, the minimum water consumption in dry times is also taken into account. Another important factor is the freezing of rivers. That is, the duration of this soaking period also affects the capacity of micro-hydroelectric power stations.

Even a minor change in river flow can cause water quality to change the way of life of the surrounding wildlife. For this reason, it is advisable not to use more than 10% of the total water consumption of the river during the construction of micro HPPs, as much as possible.

In the technical and economic situation of the construction of micro HPPs, the location of the station plays a great role. They are as follows:

* Average slope of the river. X (m).
* Average water consumption. K(m^3/ s).
* Average water flow rate . in(m / s).
* Duration of the course during the year.(hours)

From these factors, you can determine the approximate capacity of the plant and the amount of electricity generated during the year. For example, the power of microchips depends on the total pressure of the water flow. Total pressure-the distance between the upper and lower parts of a pipe or channel. There is also the concept of working pressure, which is equal to the fact that the hydraulic pressure is separated from the total pressure. We can only use the full pressure to determine the approximate power of the HPP. But to determine its exact power, we need to determine the operating pressure.

$$H = H_{пол} - h_{тр} - h_{доп} \quad \textbf{(2)}$$

Here h_{Tr} is aloss in friction, $h_{DOP}$is a loss in additives or valves, buffering, again in the bend of the pipe. Friction losses can be found by the following formula.

$$h = J * L \quad \text{m.} \ \textbf{(3)}$$

Here J is the hydraulic gradient. L-pipe length.

This formula is used to determine the hydraulic gradient. $J = a \cdot V^m \cdot D^n$ **(4)**
Where Vis the flow rate (m/ s), D is the pipe diameter. (m). *a, m, n* are coefficients that depend on the pipe material. For example, for steel

Table 1.

Table of pipe material coefficients

Material name	a	n	m
Steel pipe	0.885	1.8	1.17

For determination of friction loss in pipeline systems Micro hydroelectricAh , it is recommended to use the equation Darcy Weisbach's law .

$$h_{tr} = f \cdot \frac{L}{4R} \cdot \frac{V^2}{2g}$$, m **(5)**

Where r is the radius of the pipe. V- average flow rate. *f* is the dimensionless coefficient (this depends on the smoothness of the pipe surface).
Additional losses can be found as follows.

$$h_{add} = \varepsilon_x \cdot \frac{V^2}{2g}$$ **(6)**

Here ε_x is the coefficient associated with the pipe bend. It is usually taken from reference books. We have seen above the calculation of micro-hydroelectric power plants of the derivational type.

Now we are getting acquainted with the calculations for freely installed hydroelectric power plants without any other hydraulic engineering measures on the stream(micro HPP in the river basin).The capacity of a water flow is characterized by the water flow rate of a given flow and its speed. The cross-section of the riverbed and the slope of the riverbed are also taken into account. The amount of energy received from the micro-HPP pipe under construction into the free flow of water depends on the following equations.

$$P = 0{,}098 \cdot Q \cdot H$$ **(7)**

$$n = Q \cdot S \cdot g \cdot H$$ **(8)**

$$Q = \pi d^2 v / 4$$ **(9)**

$$N_{flow} = \pi d^2 S \cdot v^3 / \eta \cdot 8$$ **(10)**

Where P is the power (kW), Q -water flow rate (^{m3}/ s), H – total hydrostatic pressure (m), n-rotation frequency of the working pipe wheel. (OBR/min), N-the total power of the water flow, S-the surface of the cross-section of the water flow (m^2) , g-9,8 the acceleration due to gravity, d is the diameter of the wheel. (m)
v_{input} , v_{output} - the speed of water when hitting the wheel and exiting it.(m / sec)
Taking into account the full power of the flow N

$$P_{полн} = \rho \cdot Q\left[gH + \left(v_{вход} - v^2_{выход}\right)/2\right]$$ **(11)**

The power of micro HPPs, taking into account the power of the pipe.

$$P = 0{,}098 \cdot P_{пол} \cdot \eta$$ **(12)**

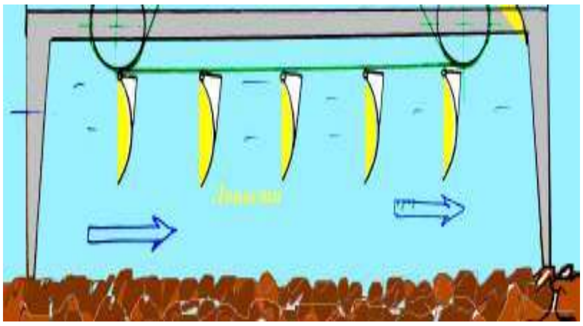
For example, from a micro-hydroelectric power station built on a water flow of d=2 m, v= 5 m/s, = 0.8, it will be possible to get 2 kW of energy. It should also be taken into account that a certain amount of energy is also lost in the linear section from the generator to the consumer.

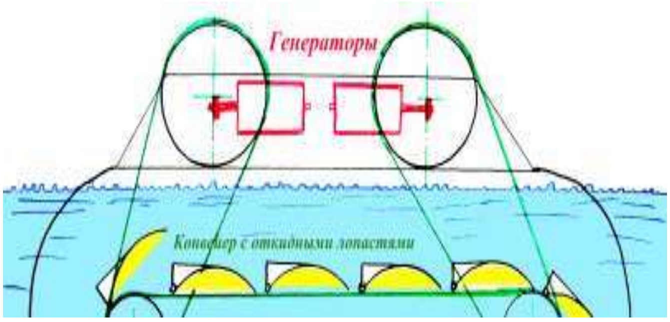
At a normal flow rate of waterы(, the pressure (h) is sufficient, we also pay attention to the material from which the hydroelectric power stations are made, and to its strength. In each case, different components give different power levels. For example , if the channel or the river , where we want to build a micro-hydro power, will be Q= 3m^3/s, H= 1.5 m , $v_{,input}$= 6 m/s, v_{output}= 2 m/s, η = 0.8, we find the electrical power received from the built generator micro hydro.

$P = \eta \cdot \rho \cdot Q\left[H \cdot g + \left(v^2_{вход} - v^2_{выход}\right)/2\right]$ = 0,8*1000*3(1,5*9,8+ +(6 ^{2}-2^2)/2)= 73,7 kW.

This means that in such conditions we could provide electricity to an average of 7 apartments.

In real pipes, the main parameters H ,C, P, H are known. D1-the maximum diameter of the tubular wheel. Micro HPPcan also have 2 tubes.





and the connection between them will look like this.

$$\frac{n_a}{n_b} = \frac{D_{1b} \cdot \sqrt{H_a}}{D_{1a} \cdot \sqrt{H_b}} \quad (13)$$

Here bare the values that depend on the velocity of water passing through the pipe.
And the proportions of water consumption for two pipes are written as follows.

$$\frac{Q_a}{Q_b} = \frac{D_{1a}^2 \cdot \sqrt{H_a}}{D_{1b}^2 \cdot \sqrt{H_b}} \quad (14)$$

The efficiency of two pipes

$$\hat{E}_\eta = \sqrt{\frac{\eta_{tru}}{\eta_{full}}} \quad (15)$$

For example, the power of two pipes, one of which X= 1 m, the number of revolutions at D= 1 m will be equal $n = \frac{60u}{\pi D_1}$. And the speed of the current will be $v = \varphi\sqrt{2gH}$. φ - the viscosity of the flow.

The potential and kinetic energy of a liquid are the formulas for the relationship between pipe parameters

$$E_{ish} = \frac{P}{\gamma} + \frac{\alpha V^2}{2g} \quad (16)$$

$$n_1^1 = \frac{nD_1}{\sqrt{H}} \quad (17)$$

$$Q_1^1 = \frac{Q}{D_1^2\sqrt{H}} \quad (18)$$

$$N_1^1 = \frac{N}{D_1^2 H\sqrt{H}} \quad (19)$$

Here E_{slave}-energy flow n_1^1 - frequency pipe, Q_1^1 the flow of water passing through to Turbine, N_1^1 power tubes first approximation. Many pipes can also relate the speed of rotation to the horsepower of the generator's power.

$$n_s = \frac{n_1 \sqrt{N_{ot.k}}}{H \sqrt[4]{H}} \quad (20)$$

The approximate calculation work shows that for individual consumers it is enough to build a micro HPP with a capacity of 5.5-7.5 kW. To obtain this energy, the flow rate must be at least 2.0 - 2.5 m/s.

It is advisable to use the energy of small rivers and channels, large ditches separately for consumers, small settlements, on farm operations, as well as in mountainous areas remote from power lines. This increases the ability to get a lot of energy at the expense of lower costs.

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