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Determination of MicroHPS in LABVIEW on a VIRTUAL BENCH

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ABSTRACT: This article discusses the use of LabVIEW to study the operation of microhydroelectric power plants.

KEYWORDS: generator, micro hydroelectric power station, program LabVIEW, power, virtual stand, design hydroelectric power station.

I.INTRODUCTION

The development of technical means for supplying electric energy to low-powered individual consumers is an urgent task. We are considering how to calculate a hydroelectric system with low hydrostatic pressure for alternative power supply in computer simulation.
MicroHPS contains in its design elements such as a hydraulic turbine, an electric machine generator, an output voltage, stabilization system and a number of elements, the presence and design of which depends on the type and characteristics of the station: certain hydraulic structures, shutoff valves, ballast loads, etc.
As a rule, microHPSs do not require the construction of complex hydraulic structures - dams. Therefore, their turbines are installed either in a free flow of water, or in a special pressure pipe.

II. SIGNIFICANCE OF THE SYSTEM

The energy crisis associated with a reduction in fossil fuels and the rapidly growing environmental problems determine the growing interest around the world in the use of natural renewable energy resources. Among them, the energy of water flows occupies a very significant place in terms of reserves and scale of use. This is explained by the high energy density of the water flow and the relative temporal stability of the flow regime of most rivers. The stability of the water flow and the wide possibilities for regulating its energy make it possible to use simpler and cheaper systems for generating and stabilizing the parameters of the generated electricity. As a result, hydroelectric power plants produce cheaper electricity compared to wind power plants, as well as power plants using other types of renewable energy resources.
It should be noted that hydropower plants can be installed on virtually any watercourse: from small streams to the largest rivers. The power of their hydraulic units changes accordingly. At present, the following classification has been adopted: stations with power up to 100 kW - micro hydroelectric power stations, from 100 to 1000 kW - mini hydroelectric power stations, from 1000 to 10000 kW - small hydroelectric power stations and more than 10000 kW - large hydroelectric power stations. The design and construction principles of these classes of power plants can vary significantly.
Historically, the first hydroelectric power plants belonged to the class of micro hydroelectric power stations, and the time of their appearance coincides with the successes in the industrial development of electric machine generators.

III. LITERATURE SURVEY

The calculation of the current water capacity is based on the flow rate and the speed of the current. The amount of electricity generated on which – the specific local flux of the micro-hydrogen turbine can be calculated using the following equations:

$$P = 0{,}098 \cdot Q \cdot H$$

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$$n = Q \cdot s \cdot g \cdot H$$

$$Q = \frac{\pi \cdot d^2 \cdot v}{4}$$

$$N = \frac{\pi \cdot d^2 \cdot s \cdot v^3}{\eta}$$

where:P – power (kW); Q – discharge water (l/sec); H – full hydrostatic pressure (m); n – speed of rotation of the working working wheel –turbines (min^{-1});
N_{str}– power of a flow;
F – section of the flow (m^2);
g = 9,8 m/s, velocity of free falling;
d – working wheel diameter (m);
v_{in}, v_{out}– input and output speed of the stream of the working wheels (m/sec).

Taking into account the pressure H, the flow rate:

$$P_n = \rho \cdot Q \cdot \left(gH + \frac{\left(v_{in}^2 - v_{out}^2\right)}{2} \right)$$

And when the engine turbine efficiency factor is taken into account:

$$P = 0{,}098 * \eta * P_n$$

The power control of the ballast of a hydraulic unit can be carried out by current, voltage, frequency and other parameters. In the general case, when not only the payload of the station, but the energy of the working water flow changes, a frequency-controlled autoballast is required, acting primarily on the speed of the hydraulic unit. Correction of the output voltage, it is advisable to carry out the excitation circuit of the generator.
One of the most promising circuit solutions for microHPS ballast controllers is a digital frequency controller.
The block diagram of a micro HPP with a digital frequency controller is shown in Fig. 1, where the HT hydraulic turbine drives a synchronous generator SG, the stator winding of which is connected with a payload $Z_н$, $Z_{нв}$, $Z_{нс}$and a set of ballast resistances $R_{б1}$ - $R_{бN}$ connected through bipolar thyristor cells, controlled by a digital frequency controller DFC. In the general case, the DFC can control N ballast resistances of a metered value. The number of stages of the ballast load determines the error of regulation of the resulting equivalent station load in steady-state conditions. The equivalent load of synchronous generator is understood as the total load at the terminals of an electric machine, defined as a parallel connection of useful and ballast loads.

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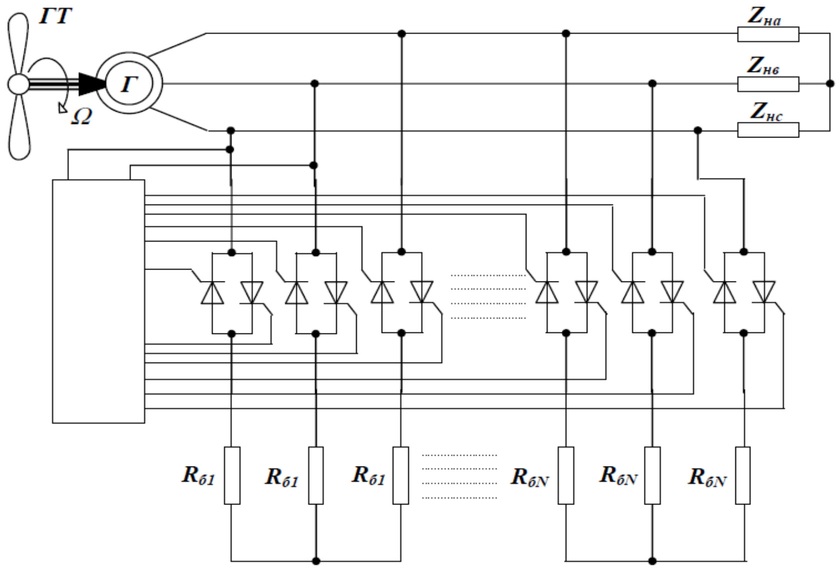

Fig. 1. Structural scheme of micro hydroelectric power station with digital frequency regulator

IV. METHODOLOGY

To automate the calculations, various computer programs are used. We have developed a virtual bench for calculating and studying a damless free-flow micro-hydroelectric power station in the LabVIEW environment.

LabVIEW is an application development environment that uses the graphical programming language G and does not require writing program texts. The LabVIEW environment provides tremendous opportunities for both computational work and, mainly, for the construction of instruments that make it possible to measure physical quantities in real installations, laboratory or industrial, and to manage these installations.

A program written in LabVIEW is called a virtual appliance (VI). The external graphical representation and functions of the VI simulate the operation of real physical devices. LabVIEW contains a complete set of instruments for collecting, analyzing, presenting and storing data. The source code of the virtual instrument is a block diagram of a programmable task.

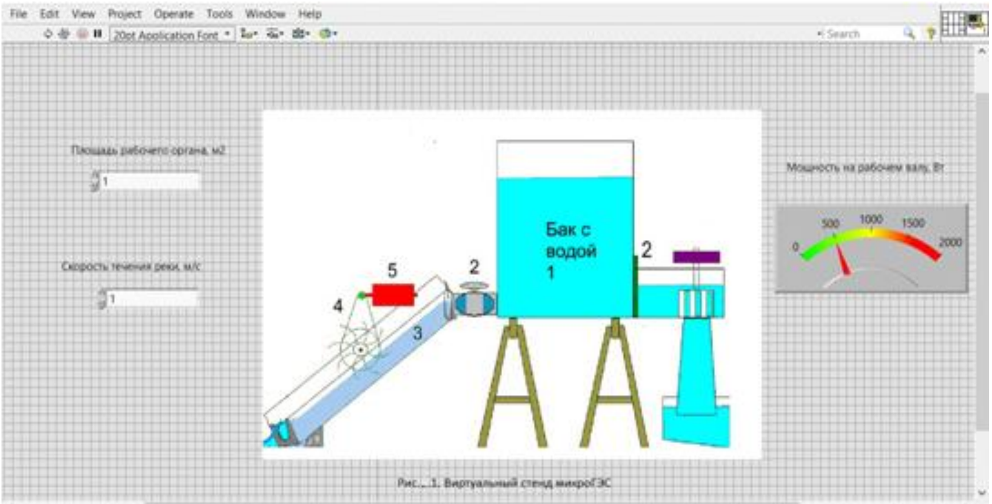

Fig.2. Virtual stand of micro-hydro power station:
1 – water tank; 2 – gate valve; 3 –duct; 4 – working wheel;
5 – generator.

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At the developed virtual stand, it is possible to carry out calculation and research for the optimal design of micro hydroelectric power stations. To determine the power on the shaft of the working body of the micro hydroelectric power station on the left side of the virtual stand, you need to enter the value of the area of the working body F and the flow rate of water V. Then click on the button with the arrow on the top of the virtual stand. The power values will be visible on the device on the right side of the virtual stand. For example, with $F = 1m^2$ and $V = 1m/s$, the power is 500W. If you need to determine the area of the working body at the required power, then change the F values until we obtain the required power on the device. Based on the calculation results, a graph of the micro-hydroelectric power is plotted depending on the water velocity and the area of the hydraulic impeller (Fig. 3).
The developed virtual stand greatly facilitates the calculation and research of students and researchers about the work of micro hydroelectric power stations.

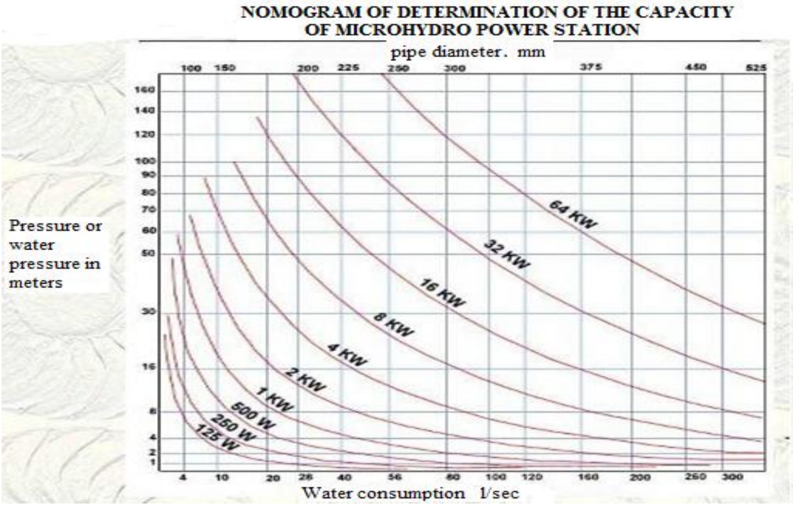

Fig.3. Nomogram of determination of the capacity of micro-hydro power station.

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