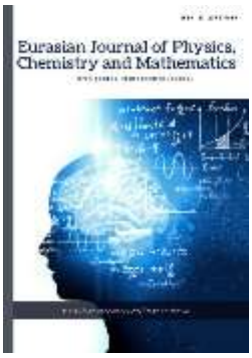

Physical and Mathematical Research of the Set Hydropower Tasks Under the Ferpi Microapp Project

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ABSTRACT

The article considers two physical and technical models using the appropriate mathematical apparatus to describe the design of a hydroelectric power station at FerPI on the Margilan Canal and one economic model to describe the same design. When creating each model, a specially developed earlier mathematical apparatus of the hydropower class was used, research on which was carried out by foreign colleagues of the authors of the device itself. The general solution of this class is presented as a conclusion.

Keywords: water flow, electrical energy, physical and mathematical model, mathematical apparatus, hydropower.

Introduction

1. Theoretical calculations. Before a detailed consideration of each of the tasks, there is an indication of some fundamental equalities in hydropower, the definition of which implies an algorithm for solving each of the specific tasks. Initially, it is necessary to note the expression for determining the point of maximum gross energy for a certain number of hydropower plants with an increase in active power (1) [1-9].

$$Э_{B1} = \widetilde{Э}_{Bi} = \int_{t_0}^{t_k} N_{B1}(t)dt \rightarrow \max\uparrow \quad (1)$$

In this case, the active power itself is determined by the regularity in (2), that is, it is directly dependent on the constant, energy consumption and pressure.

$$N_{B1}(t) = 9.81Q_{B1}(t)H_1(t) \quad (2)$$

The waste of the resource itself is determined by the first equation (3-4), which indicates a directly proportional dependence on the volume of the reservoir, through a differential ratio. When the pressure is on the second (3-4), depending on the high-altitude so-called "red lines" [10-21].

$$\begin{cases} Q_{B1}(t) = \dfrac{dV_{srab}(t)}{dt} \\ H_1(t) = Z_{vb1}(t) - Z_{nb1}(t) \end{cases} \quad (3-4)$$

The previously indicated "red lines" depend on time, as indicated above, on the function of changing the volume of the reservoir, which also appears depending on the head, for this case appearing in (5-6) through the first and second dependencies.

$$\begin{cases} Z_{nb1}(t) = Z_{vb1}(V_{vb1}(t)) \\ Z_{nb1}(t) = Z_{nb1}(V_{nb1}(t)) \end{cases} \quad (5-6)$$

These volume indicators themselves over time are presented as the difference between various time-dependent indicators and the zero “red line”, according to (7).

$$V_{vb1}(t) = V_{vb0}(Z_{vb0}) - V_{srab}^{vb}(t) \quad (7)$$

Where the indicated second difference element, represented by the volume of the reservoir with a certain parameter, has a certain integral time dependence on the consumption of the reservoir resource itself (8) [22-29].

$$V_{srab1}(t) = \int_{t_0}^{t_k} Q_{B_1}(t)dt \ (8)$$

The element used in (5-6) organizing the dependence to the second "red line" acts according to (9).

$$V_{nb1}(t) = V_{nb0}(Z_{nb0}) + V^{nb}_{nap1}(t) \ (9)$$

The first zero volume is already determined initially, as in (8) the second volume, as the first element of the difference, and the second element of the sum in (9) is also determined integrally through (10).

$$V^{nb}_{nap1}(t) = \int_{t_0}^{t_k} Q_{B_1}(t)dt \ (10)$$

Thus, using the example of a multistructural hydropower system (cartege), it is possible to express some basic energy formulas that appear in other energy solutions to problems. When the economic task requires its own explanation already at the stage of solution. Thus, you can go directly to the solution of problems.

2. First technical challenge

In this paper, two cases are considered from the technical point of view and one additional task from the economic point of view. At the same time, methods for solving them and general algorithms are described in detail, with all the necessary elements [30-37].

The first task is as follows. The channel itself is artificially created and without a concentrated level difference. In view of the absence of a concentrated level difference in the channel, it is possible to use only the velocity head or the kinetic energy of the flow. It is required for given passes into the channel for the entire series of past observations, the known cross section of the channel to determine the gross energy potential [38-47].

To solve this problem, the following steps are performed. Initially, it is necessary to divide the annual period into non-uniform time intervals according to expression (11).

$$\Delta t_i, i = 1,2, \dots, k \ (11)$$

Next, calculate the average interval power for a given channel cross section according to (12).

$$\overline{N_{kanı}} = 9.81 * \overline{Q_{kanı}} * \overline{H_{kanı}}, i = 1,2,3, \dots, k \ (12)$$

In this case, the concept of pressure (13) and gross power (14), dependent through active power (12), is introduced.

$$\text{where, } \overline{H_{kanı}} = \frac{\alpha V^2_{kan1}}{2g} = \frac{\alpha \overline{Q^2_{kan1}}}{\omega^2 2g} \ (13)$$

$$Э^{val}_{kan.} = \sum_{i=1}^{1} \overline{N_{kan1}} \Delta t \ (14)$$

Further, it remains only to indicate the necessary constants, more precisely, the condition of problem (15) itself.

$$\text{where, } \begin{cases} \omega = 5{,}5 \text{ м} \\ g = 9.81 \text{ м} \\ \overline{Q_{\text{кан}1}} = 4 \frac{\text{м}^3}{\text{с}} \\ \alpha = 1.3 * 10^3 \end{cases} (15)$$

After entering the constants, it is already possible to determine the pressure through (16), which can already be inserted into formula (12) according to (17) and get the result for the total power.

$$\overline{H_{kanı}} = \frac{\alpha V^2_{kan1}}{2g} = \frac{\alpha \overline{Q^2_{kan1}}}{\omega^2 2g} = \frac{1.3 * 10^3 * 4^2}{2 * 9.81 * 5.5^2} = 35{,}04604 \ m \ (16)$$

$$\overline{N_{kan1}} = 9.81 * \overline{Q_{kan1}} * \overline{H_{kan1}} = 9.81 * 4 * 35{,}04604 = 1\,375{,}207 \ kW * h (17)$$

Now it remains to determine the gross potential. And since there is only one installation and the time of its action according to (17) is equal to an hour, then it will not be difficult to determine the gross power using (18).

$$Э^{val}_{kan.} = \sum_{i=1}^{1} \overline{N_{kan1}} \Delta t => \Delta t = \frac{1}{36} => Э^{val}_{kan.} = \frac{1\,375{,}2066}{36} = 38{,}2 \ kW \ (18)$$

Thus, the nominal gross potential of this installation is determined.

3. Second technical challenge

Another technical problem is based on the fact that there is a concentrated level difference in a given alignment, measured in meters. This value is expressed through (19) and symbolizes the difference in water levels in different situations [48-52].

$$H_{perep} = Z_{kan}^{verx} - Z_{kan}^{nij} = const = 0.3 \text{ м} \ (19)$$

The presence of this circumstance only leads to an increase in the permeability of water through the channel, or more precisely, the cross section of the channel, defined as 5.5 m in (15). And since the cavity of the channel itself is a parabola, the presence of the indicated difference in the height of the water level will lead to the presence of a double difference in width in the same (15) and will lead to the equality of the section as 5.8 m, in which case the constants will be (20), head through (21), and potentials through (22-23).

$$\begin{cases} \omega = 5{,}8 \text{ м} \\ g = 9.81 \frac{\text{м}}{c^2} \\ \overline{Q_{\text{кан}1}} = 4 \frac{\text{м}^3}{\text{с}} \\ \alpha = 1.3 * 10^3 \end{cases} \ (20)$$

$$\overline{H_{kan}} = \frac{\alpha V_{kan1}^2}{2g} = \frac{\alpha Q_{kan1}^2}{\omega^2 2g} = \frac{1{,}3 * 10^3 * 4^2}{2 * 9{,}81 * 5.8^2} = 31{,}5 \text{ м} \ (21)$$

$$\overline{N_{kan1}} = 9.81 * \overline{Q_{kan1}} * \overline{H_{kan1}} = 9.81 * 4 * 31{,}5 = 1\,236{,}06\ kW * h \ (22)$$

The gross potential (23), as you might guess, decreased after the increase in the water level, due to a decrease in pressure and giving a larger cross-sectional area, due to the parabolic (cylindrical) shape of the channel section.

$$Э_{kan.}^{val} = \sum_{i=1}^{1} \overline{N_{kan1}} \Delta t => \Delta t = \frac{1}{36} => Э_{kan.}^{val} = \frac{1\,236{,}06}{36} = 34{,}335\ kW \ (23)$$

Thus, the second technical problem is also solved, having determined the energy of 34.35 kW with an increase in the water level and as 38.2 kW with an increase in the water level from the previous problem, setting the gross potential drop to 3.8496 kW. 0.003113

4. Economic task

After determining the technical tasks on this topic, calculations on the economic part of this issue are of great importance. The main indicator in this case is the economic radius of the HPP itself, determined by (24) and calculated by (25).

$$r_{EK}^{LEP} = \frac{C * q_{DEU} * Э_{DEU} - N_{DEU}(K_{GES} * P_{GES} - K_{DEU} * P_{DEU} * \alpha)}{K_{LEP} * P_{LEP} + U_{LEP}} \ (24)$$

Where, C (sum/(kg of fuel equivalent)) is the cost of 1 kg of standard fuel (TL) of a DEU;

q_DEU ((kg of reference fuel)/(kW*h)) - specific consumption of reference fuel per 1 kW*h=0.1164 t;

E_DEU (kWh) - annual output of DEU = 1,204,675,200 kWh;

N_DEU (kW) - installed power of DEU = 38.2 kW;

K_HPP, K_DEU-specific capital costs per 1 kW installed capacity of SHPPs and DEUs (sum/kW);

P_HES, P_DEU, P_TL (relative unit: 0.08-0.12) - coefficients

total regulatory deductions from SHPP, DEU, and power lines = 0.11-0-0.1;

α=N_HES/N_DEU (p.u.)-displacement coefficients of SHPP in relation to DEU=1;

K_LEP,U_LEP-specific capital costs and costs for power lines for

1 km of power line length (sum/km).

$$r_{EK}^{LEP} = \frac{C * 0{,}1164 * 1\,204\,675\,200 - 38{,}2 * (K_{GES} * 0{,}11 - K_{DEU} * 0 * 1)}{K_{LEP} * 0{,}1 + U_{LEP}} = \frac{140\,224\,193{,}28 * C - 4.202 * K_{GES}}{K_{LEP} * 0{,}1 + U_{LEP}} = \ (25)$$

Speaking about the dependence on gross energy, formula (24) can be transformed into the following form (26).

$$r_{\text{эк}}^{\text{ЛЭП}} = \frac{C * \frac{Э_{kan.}^{val}}{Q_{kan1}} * \left(Э_{kan.}^{val} * 3{,}6 * 24 * 3 * 365 * 10^4\right)}{K_{LEP} * P_{LEP} + U_{LEP}} - \frac{Э_{kan.}^{val}(K_{LEP} * P_{LEP} - K_{DEU} * P_{DEU} * \alpha)}{K_{LEP} * P_{LEP} + U_{LEP}} \ (26)$$

Thus, the overall results of the Micro-HPP device, created by the team of the Ferghana Polytechnic Institute, were obtained: two technical calculations and one economic general indicator that provides all the necessary data.

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