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MODELING OF SUSTAINABILITY OF THE MICRO-HPS TURBINE CONSTRUCTION

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The topicality of this theme is explained by necessity to find stability of the micro-HPS. The stability of the turbine is guaranteed by the choice of optimal geometric and mass parameters. The model is needed for further research, optimization of geometry and raise the technical level of the micro-HPS as a whole. The model allows to estimate the parameters of the micro-HPS and to reveal the objective laws of its geometric and weight characteristics. Speaking aboutadvantages of the tools of optimization, it will be possible to calculate the optimum parameters of installation. This will reduce the cost of production. Besides, the model is applicable only to a certain topology of the micro-HPS, namely free flow of the micro-HPS with the power of 5 kW.The simulation object is the construction of the micro-HPS (figure 1)

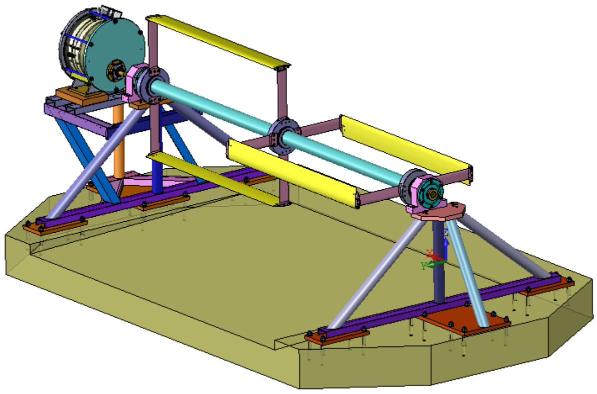

Figure 1 - Model of the micro-HPS

There are distinctive features of the model which are important for the compilation of model stability:

– The horizontal axis of rotation of the turbine;
– Set on the bottom of the pond.

The preparation stage is shown on figure 2. The system has the following three forces:

– The force of gravity, the vector of which is from the center of mass of the micro-HPS G, H;
– Reaction in the R, N;
– The power of the incident flow of water, acting on the turbine blades F,H.

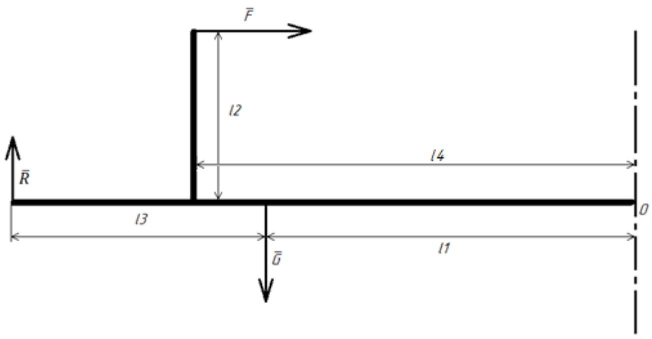

Figure 2 - schematic diagram of the micro-HPS and operating at its design load

All of these forces create torques, with respect to the point.It’s shown in the figure above (fig. 2). In addition, we note that created model may be taken into account only those powers which have a significant impact on the sustainability of the micro-HPS. The following forcesare not included:

- The power of the incident flow, operating on the surface of the beams, the generator, the Foundation;
- Angle of flow.

Let’s consider the equations of equilibrium:

$$R \cdot (l_1 + l_3) + F \cdot l_2 - G \cdot l_1 = 0 \quad (1)$$

After equation of the static equilibrium state of installation was compiled,we compose the equations of rotational motion of the micro-HPS, describing the angular position relative to the polar coordinate system, with its center at the point (figure 3):

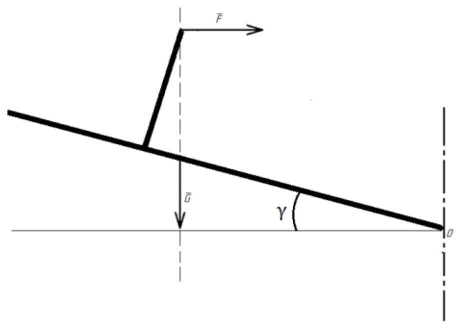

Figure 3 - Scheme of capsizing of installation of micro-HPS

$$\gamma_i = \gamma_{i-1} + \omega_i \cdot \Delta t \quad (2)$$

whereγ_{i-1} −the angle of rotation of the micro-HPP on the previous timethe segment Δt;

ω_i −the angular velocity in this period of time.

Here there is one condition, about the angular velocity: it will be zero, if the angle of the shift to the previous period Δt will be less than or equal to zero ($\gamma_{i-1} \leq 0$). Physically, this will look like the plate, which is fixed installation will stick to the bottom of the pond, under its own weight. And so, it should be noted that at that point in time, when the base will deviate to some angle ($\gamma_{i-1} \leq 0$) the reaction R in support will be equal to zero (R=0).

Concerning the force F(t) flow, which acts on the blade, that is to say to us that we are interested in the projection of the normal and tangential component of this force on the horizontal axis. Then, using formula (3) we’re aimed to find the total of active power flow. Figure 4 shows the force in time with a different number of the blades of the turbine.

$$F_{\text{х.сум}}(\varphi, k) = \sum_{i=0}^{k-1} F_{\text{х}}\left(\varphi + i \cdot \frac{2\pi}{k}\right) \quad (3)$$

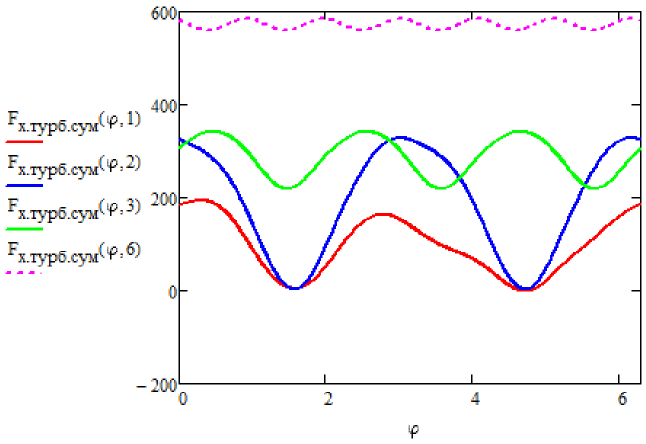

Figure 4 - the Dependence of the total force, with 1, 2, 3, 6 blades of the turbine, from the angle of rotation of the blade

Note that condition (γ_(i-1)>0) should also be observed:

$$R(\gamma, t) = \frac{F(t) \cdot \cos\left(90 - \left(\gamma + \arccos \frac{\sqrt{l_2{}^2 + l_4{}^2}^{\,2} + l_4{}^2 - l_2{}^2}{2 \cdot \sqrt{l_2{}^2 + l_4{}^2} \cdot l_4}\right)\right) \cdot \sqrt{l_2{}^2 + l_4{}^2} - G \cdot l_1 \cdot \cos(\gamma)}{(l_1 + l_3)} \quad (7)$$

where F(t) –the force acting on the blades of the turbine[1].
$M_{\text{опр}}(\gamma, t)$ –the moment of arising under the influence of the flow of water to the turbine:

$$M_{\text{опр}}(\gamma, t) = F(t) \cdot \cos\left(90 - \left(\gamma + \arccos \frac{\sqrt{l_2{}^2 + l_4{}^2}^{\,2} + l_4{}^2 - l_2{}^2}{2 \cdot \sqrt{l_2{}^2 + l_4{}^2} \cdot l_4}\right)\right) \cdot \sqrt{l_2{}^2 + l_4{}^2} \quad (8)$$

$M_{\text{уст}}(\gamma)$ –the moment of arising under the weight of the micro-HPP:

$$M_{\text{уст}}(\gamma) = G \cdot l_1 \cdot \cos(\gamma) \quad (9)$$

At the given initial parameters (table 1) the calculation with the subsequent optimizationhas been implemented. The result of the optimization will be a list of graphs with the dependence of the values of the reaction of support from each of the input parameters.

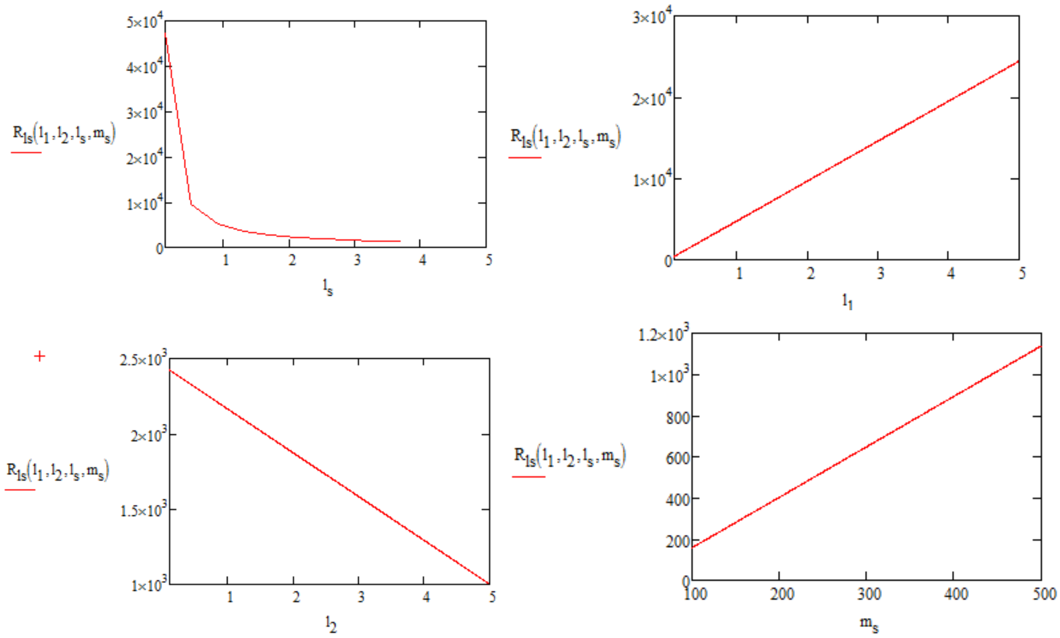

Figure 4 - Graphic dependences of the reaction in the R input parameters

In conclusion I'd like to say that the algorithm described above will allow obtaining the mass and geometric parameters of the systemmore efficient.

Using the equation of balance, we can select a specific set the above parameters, which will reduce the production costs of installation and retain its position under loads. As practice shows, it is reasonable to strive to reduce the mass of installation (decrease volume of concrete, filling basis), an increase in the dimensions (length shoulders l_2 and $l_s = l_1 + l_3$). This is explained by the fact that there is a great number of problems with the installation and transportation of micro-HPS.