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Mathematical Model of Available Control of Dredger Movement

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Abstract: The article highlights the scientific and technical issue related to the optimal placement of dredgers on the damless section of the Amudarya and in the channel for supplying water to the I-PS in order to optimize their operation on the river and canal sections. In turn, the question of the optimal location of dredgers gives rise to the need to study the dynamics of the relief of the riverbed or canal.

Keywords: Dredger, hydraulic parameters of water flow, bottom morphology, dynamics of suspended and bottom muddy sediments.

The average annual volume of treatment works of the damless part of the Amudarya River and sections of the canal that supply water to the I-PS from muddy discharges is 8,117 million m3. Muddy drains are mainly cleaned by dredgers. These works, of course, require a large amount of labor and financial resources. This situation requires a study of the characteristics of the river runoff, the section of the river on which the damless water intake is located, the morphometric characteristics of the channel supplying water to the I-PS, as well as the ability of the water flow to carry turbidity. Here, the turbidity regime of the river and the aquifer changes mainly due to the large accumulation of turbidity along the channel and unstable channel processes associated with their movement. Considering the foregoing, we are striving to solve a scientific and technical problem related to the optimal control of dredgers in the specified section of the river and the canal that supplies water to the I-PS.

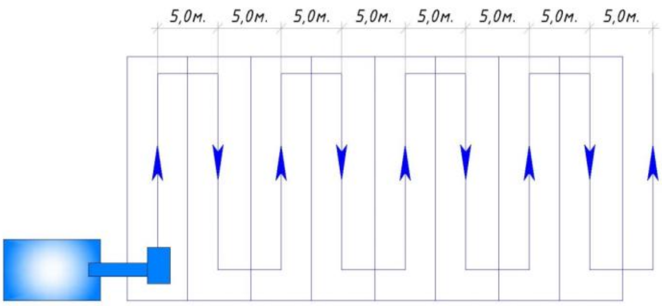
In our opinion, the problem of optimal control of the operating mode of the dredger led to the inverse problem of kinematics. The solution to this problem, in turn, requires modeling the processes associated with the placement of flutes in the places where the dredger is collected, minimizing the time it takes to move the dredger.

With the help of dredgers working at this facility, the channel is cleared of silt with an average length of 4-10 meters and a width of 10-20 meters in 6-15 hours a day (Fig.1).

In order to maximally clean the turbid deposits formed in the water supply channel to the pumping station, it is necessary to choose the length of the slurry pipeline (slurry pipeline) depending on the distance and height of the hydraulic mixture transportation. In this case, the maximum distance should be 300-350 meters, depending on the length of the slurry pipeline.

1- fig. Photos of the river and the canal supplying water to the 1st pumping station.

According to the number of dredgers in the channel, the sections of the channel to be cleaned from dirt are divided into dredger blocks. Each block is divided into cards. The dimensions of the maps are determined depending on the distance between the connection points of the pulp pipes with the main ones. Figure 2 shows the shape of the optimal technology for placing dredgers.



2- fig. Technological form of work of the dredger

We will assume that the movement of the dredger is uniformly accelerated. We study the cyclogram of the movement of the dredger. Let's study the work of a dredger of a similar type of equipment, shown in Figure 2.

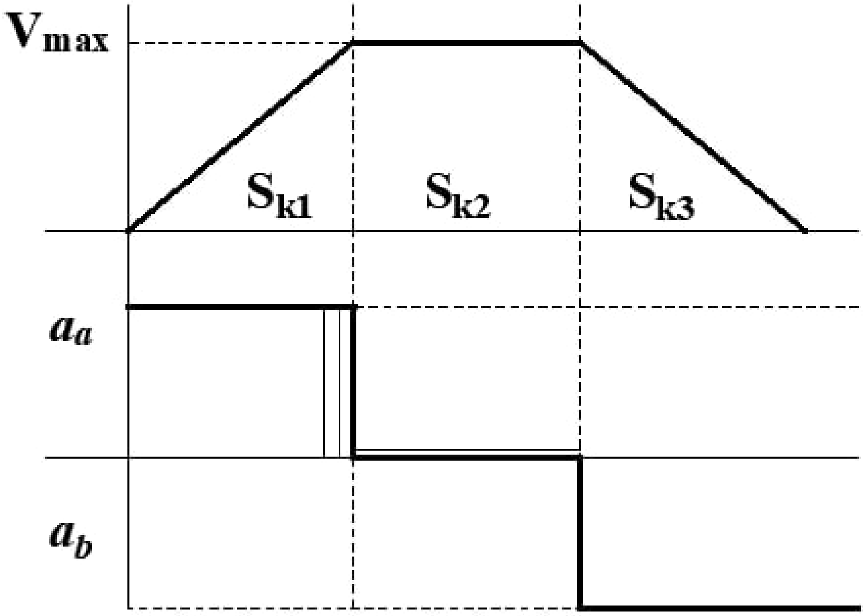
Based on this, the necessary process of crossing the desired section can be represented as the sum of 3 successive modes [1].

$S_k = S_{k1} + S_{k2} + S_{k3}$

Here: S_k - Distance to be traveled by the dredger; S_{k_1}- section of the traveled path in acceleration mode; S_{k_2}- straight motion mode; S_{k_3}- braking mode.

For each distance S_k, it is required to calculate the section length based on the expression (λ). We introduce the following constraint on dredgen motion:

Acceleration aa and deceleration ab of movement from the place of the dredger, as well as the maximum speed Vmax in the exact and precise technological process. Then, in each of the sections S_{k_1}, S_{k_2} and S_{k_3}, the characteristic features of the speed function V(t) and the acceleration function a(t) are seen according to the rule of change of the speed of the material point (Fig. 3).



3- fig. A graph of changes in speed and acceleration of the dredger.

In order to model the optimal movement of the dredger, we assume that it moves as a material point. This process can be characterized at each traversed road section.

For this purpose, the dredger is set to move according to the technological form shown in Fig. 2, moving along a broken line from A_0 to A_1. If the dredger moves from point A_0 to point A_1 along broken line sections, then the parameter equation of broken lines connecting points A_0 and A_1 can be expressed as follows.

$$R_1(t)=\binom{x(\tau)}{y(\tau)}=\binom{x_0+\tau(x_1-x_0)}{y_0++\tau(y_1-y_0)} \qquad (1)$$

(1) To solve the equation, we introduce the following initial conditions:

$$\left.\begin{aligned} R_1(0) &= A_0 \\ R_1(1) &= A_1 \\ \tau_1^0 &= 0 \\ \tau_1^1 &= 1 \end{aligned}\right\} \qquad (2)$$

We formulate the following problem of optimal control. Trajectories (1) and (2) are given on the **XOY** plane, and the movement of the dredger along this trajectory should have a minimum deviation.

$$R_1(t)=\binom{x_0+\tau(x_1-x_0)}{y_0++\tau(y_1-y_0)} \to min \qquad (3)$$

That is, we put the optimality condition into equation (3) as follows:

$$|R_1(t)| \leq \varepsilon \qquad (4)$$

That is, the meaning of the condition (4) is that the dredger should not leave the strip of width ε.

If we assume that the parameter of equation (3) changes in the interval t, [0,1], then t_0=0, t_1=1. As a result, based on the equation presented in [2], we have the following parametric equation:

$$R_1(t) = R_1(\tau_1^0) + [R_1(\tau_1^0 + (\tau_1^1 - \tau_1^0)P(t_0 t_1, t_1 - t_0)) - R_1(\tau_1^0)] =$$

$$\binom{x_0 + P(t,0.1)(x_1 - x_0)}{y_0 + P(t,0.1)(y_1 - y_0)} = \binom{x_0}{y_0} + \binom{x_1 - x_0}{y_1 - y_0} P(t,0.1) = A_0 + (A_1 -$$

$$A_0)\frac{1}{2}(1 + |t| - |t - 1|)$$

or

$$R_1(t) = A_0 + (A_1 - A_0)\frac{1}{2}(1 + |t| - |t-1|) \qquad (5)$$

As a result, we got the equation of broken lines to points A_0 and A_1. According to the condition of the matter, it must be so

$$J[R_1(t)] = \int_0^1 \left[A_0 + (A_1 - A_0)\frac{1}{2}[1 + |t| - |t-1|\right]^2 dt < \varepsilon^2 \ (5)$$

Condition (5) refers to the optimal control condition of the dredger movement.

Summary. Based on the methods of control theory, a mathematical model of optimal control of the dredger movement has been developed.

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