Cleaning of irrigation systems from muddy sediments by hydromechanization method

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Abstract

The article mentions the use of a new technology for cleaning irrigation systems from muddy sediments. This technology was modeled and tested using Ansys Mechanical Finite Element Analysis (FEA) Software for Structural Engineering. Analytical analyzes were carried out to maintain the design parameters of irrigation system coatings. As a result of the analysis, a deformable tooth device using a wedge with a thickness k (N/m) is applied to the coating with an impact force F (N) $\boldsymbol{\alpha}$ =10 ^{0} -30 ^{0} It is determined that it is affected under the corners, so that it is compressed in the range of Δl =5-15 (mm) and does not damage the coating of the irrigation system.

Keywords. Irrigation systems, hydraulic excavator, spring, mud, coating, twinkling.

Introduction.

In recent years, there has been a demand for work aimed at creating a new technology for cleaning irrigation systems from muddy sediments. Today, maintaining the design parameters of irrigation systems is one of the most difficult issues. In this regard, the world's leading scientists are putting forward their scientific proposals.

In Hydrodynamics, sediment transport, and morphodynamics in the Vietnamese Mekong Delta: Field study and numerical modeling by Binh Doan Vana, Binh Kantoush Sameh, Ata Riadhc et al.

Flow, sediment transport and associated morphological changes in the Vietnam Mekong Delta (VMD) were studied using field survey data and a two-dimensional (2D) depth-averaged hydromorphodynamic numerical model [1].

The works published by mature scientists in the world on the technologies of cleaning irrigation systems from silt and sediments in the Scopus database in the first quarter of 2022 and

2023 were analyzed using the VOSviewer program and their correlation was studied (Fig. 1).

of the Republic of Uzbekistan , 547.5 billion will be spent on the construction and reconstruction of irrigation facilities in the water management system during the 6 months of 2022. soums or 77% of the annual limit (102% compared to the 9-month plan) was used, 224.8 km of canals, 88.7 km of channel networks, 7.3 km of pressure pipelines, 9 hydrotechnical facilities, 2 pumping stations, 48 irrigation wells construction and reconstruction works have been carried out.

209.3 billion for the construction and reconstruction of reclamation facilities. soums or 81% of the annual limit (104% compared to the 9-month plan) were used, 589.0 km of collector-drainage networks, 31 hydrotechnical facilities and 9 bridges, 15 melioration vertical drainage wells were built and reconstructed.

In addition, 291.0 bln. soums or 80% of the annual allocated limit (111% compared to the 9-month plan) was used, and 14,016.0 km long collector-drainage networks were repaired and restored [1].

Materials and methods.

2 main technologies are used in the cleaning of drainage systems by hydromechanization method.

1. Using hydraulic excavators.
2. With the help of mudslide projectiles.

When cleaning with the first technology (using hydraulic excavators), the parameters of the channel and the hydraulic excavator serve as an important factor.

Channel parameters:

Width of the channel-B (m), depth-h (m), width of the bottom of the channel -b (m), slope coefficient of the side walls of the channel-m, slope -i, thickness of the coating in case of covered channels-t (m).

Parameters of hydraulic excavators:

The length of the boom - l (m) , the volume of the pit - V (m^3) , the power of the excavator - N (kw) (Figure 1)

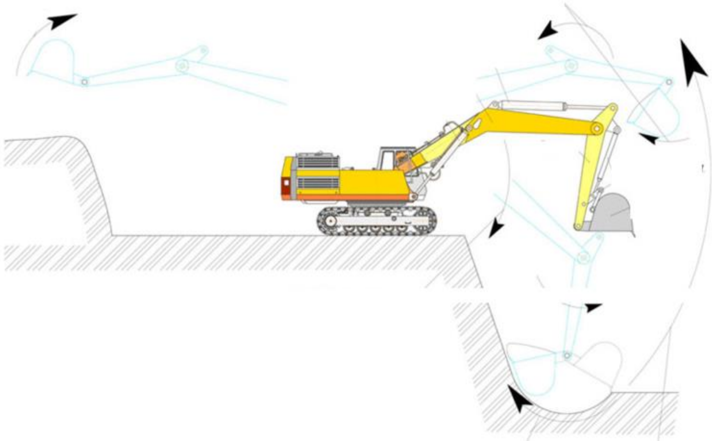


Figure 1. Canal cleaning maneuvers of a hydraulic excavator

Today, concrete linings are seriously damaged during the cleaning process of concrete-lined channels (Fig. 2).

Figure 2. Image of damage to concrete lining from silting of canals.

It was carried out by many scientists in the world as a result of scientific research.

In the patent received by Russian scientists A. Elagin, M. Mirov and others [6] in 2013, the side walls and the bottom part of the bucket are connected at an angle of 45 ^{0} , and the thickness of the bottom part decreases towards the cutting surface of the soil. This, in turn, reduces the friction on the metal when cutting the sludge.

But this device is more suitable for cleaning channels with concrete lining, where small sediments and various algae have not grown. The cutting edge of the knife is not sharp. In the patent obtained by A.Muravsky and others [7], special friction and erosion-resistant blades are installed on three parts of the teeth fixed to the buckets of the excavator [8].

In this patent, the blade of the teeth is more used for digging in frozen and hard ground. But digging concrete channels with these sharp-edged teeth is relatively difficult and inconvenient. Although it has a high cutting ability, our main goal is to clean the bottom of the channel from mud and weeds, while maintaining the integrity of the concrete [9].

In order to scientifically study such situations, a model of the cleaning process of concrete-lined channels with hydraulic excavators was created using the Ansys Mechanical Finite Element Analysis (FEA) Software for Structural Engineering [8] modeling program (Fig. 3).

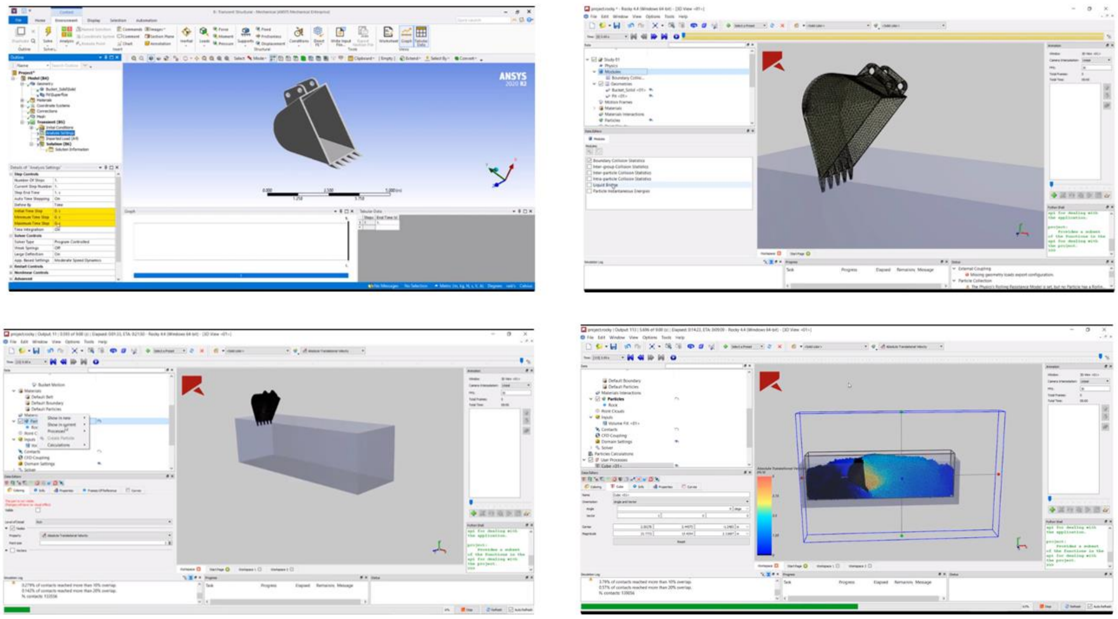


Figure 3. Ansys Mechanical Finite Element Analysis (FEA) Software for Structural Engineering models the cleaning process of concrete-lined canals with hydraulic excavators.

Through this model, the analysis of the technology of cleaning irrigation systems by hydromechanization method was carried out.

In this program, the forces acting on the material of the hydraulic excavator bucket, the thickness of the concrete lining of the channel were studied [10].

Studies have shown that maintaining the strength of the concrete lining during the cleaning of concrete-lined canals is determined to be an important parameter depending on the impact force of the hydraulic excavator bucket on the concrete lining (Fig. 4).

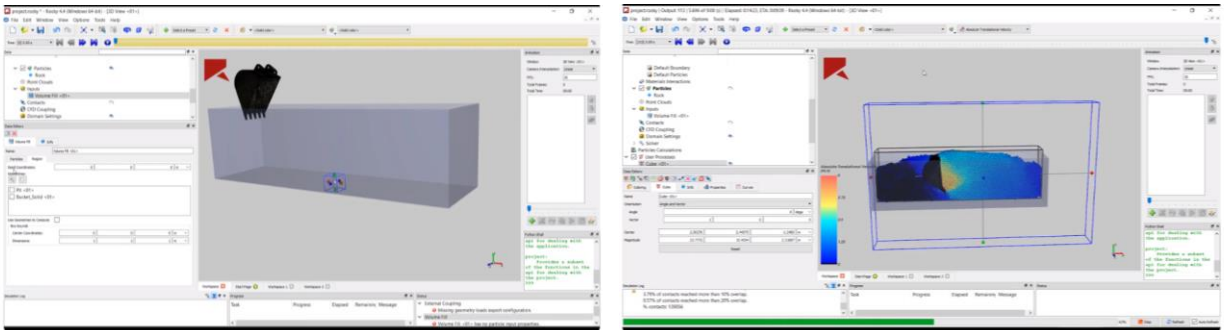


Figure 4. A color histogram representation of the forces acting on the coating during channel desilting.

According to the color histogram in Figure 4, the analysis of impact forces was carried out in the following amounts.

Results.

In order to maintain the quality of the coating during the cleaning of channels from muddy sediments, a movable tooth device was developed (Fig. 5).

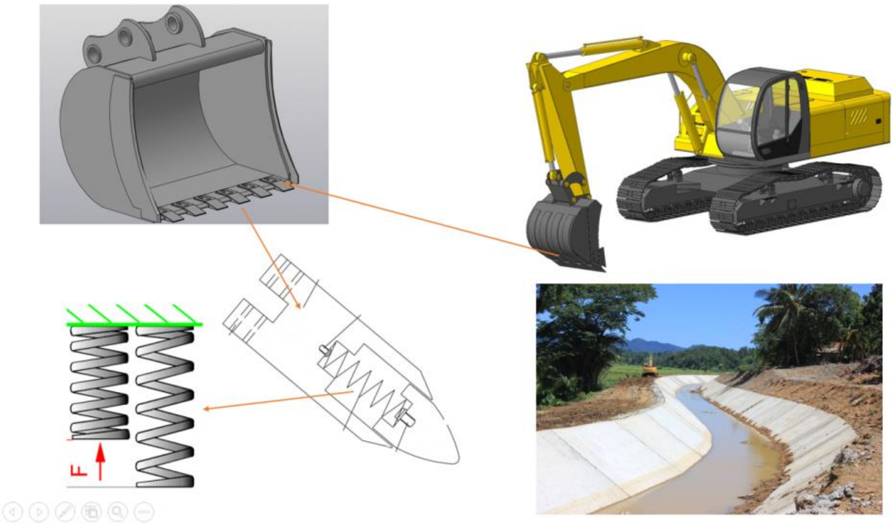


Figure 5. Deformable tooth device mounted on the hydraulic excavator

The device consists of a support part, a spring, a tooth (cutting part), a bolt seat for fastening to the tub, and a set of bolts.

It is not taken into account due to the fact that the mass of the spring is very small compared to the mass of the hydraulic excavator. When the spring is loaded, i.e., its initial length is equal to 0 , it is compressed by Dl when the load is applied to it, and this is called static compression of the spring. During the impact period, when the weight of the load is equal to the elastic force of the spring, it is in a state of equilibrium.

$$mg = k\Delta \mathrm{l} \tag{1}$$

The load is moved a distance (x) below the equilibrium position. At this point, the spring is compressed by Dl+x, obeying Hooke's law due to its small value, and the resultant force acting on the load at this point is

$$F = mg - k(\Delta \mathrm{l} - \mathrm{x}) \tag{2}$$

is equal to. (1) taking into account .

$$F = k\Delta \mathrm{l} \tag{3}$$

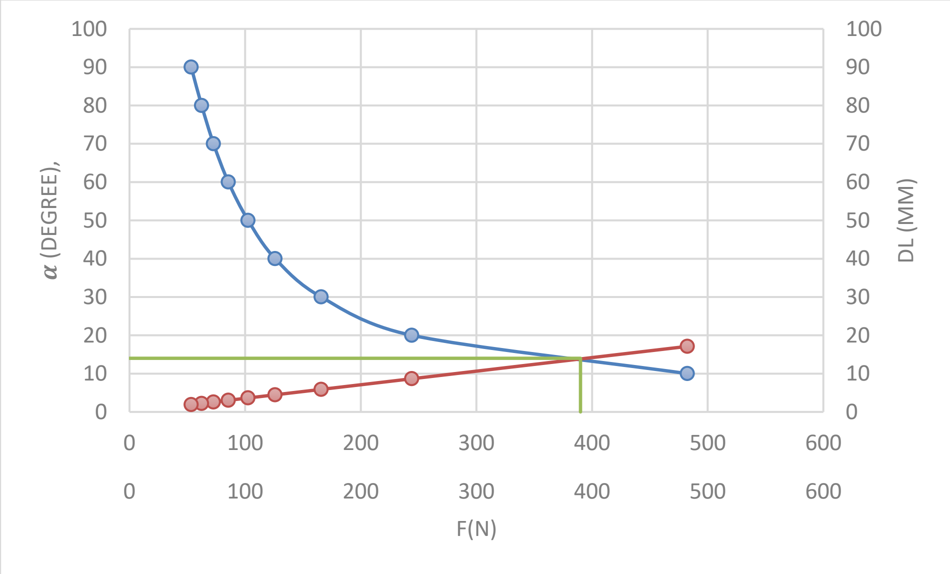
we get an expression.

When cleaning irrigation systems, we determine the coating resistance force acting on the channel coating as follows:

$$F = bh\tau_0 \frac{\cos\alpha + 1}{\sin\alpha} + \frac{2}{9} b\mu\vartheta_0 \left(\sqrt{9h\tau_0\mu^{-1}\vartheta_0^{-1} + 1} + 1\right) \frac{3\cos\alpha + 1}{\sin\alpha} + b(\rho - \rho_w) g \frac{h^2}{2} \tag{4}$$

Here: $\boldsymbol{\mu}$ - dynamic viscosity (Pa · s); $\boldsymbol{\tau}_0$ - coating tension (Pa); h-tooth depth (m); ϑ_0 - the initial speed of the tooth (m/s); b and L are the width and length of the tooth (m), respectively; $\boldsymbol{\alpha}$ - cutting angle (rad); ρ and ρ_w are densities of soil and water, respectively (kg/m^3); g-acceleration of free fall (m/s^2).

We get the relationship between the shear angle $\boldsymbol{\alpha}$ (degrees), the impact force F (N) and the compression length of the spring Δl (mm) below (Graph 1).



Graph 1. α (degree), F (N), Δl (mm) bond graph.

From graph 1, it can be seen that a deformable tooth device with a wedge of unit k (N/m) is applied to the coating with an impact force F (N) α =10 ^{0} -30 ^{0} impact under the corners, so that it is compressed in the range of Δl =5-15 (mm) without damaging the coating of the irrigation system.

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Conclusion.

Patents in the field on materials and methods were studied, and an Ansys Mechanical Finite Element Analysis (FEA) Software for Structural Engineering model of the cleaning process of concrete-lined channels with hydraulic excavators was developed.

Based on the analysis of this model, a deformable tooth device was created that maintains its coating and design parameters during the cleaning of channels from mud and sediments.

Deformable tooth device with a deformation k=28200 (N/m) is applied to the coating with an impact force F=53.4-482.4 (N) α =10 ^{0} -30 ^{0} It was found that it affects under the corners, so that it is compressed in the range of Δl =5-15 (mm) and does not damage the coating of the irrigation system.

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