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ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

SCIENTIFIC-TECHNICAL BASIS OF CLEANING CONCRETE-LINED IRRIGATION CHANNELS WITH A BUCKET EXCAVATOR

Speciality: 3305.08 –« Hydrotechnical construction»

Field of science: Technique

Applicant: **Gulnar Novruzova Vali**

Baku - 2025

The work was performed at dissertation work was carried out at the "Melioration and water management" department of the Azerbaijan University of Architecture and Construction .

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GENERAL CHARACTERISTICS OF THE WORK

Relevance of the topic and degree of development. In most agricultural countries of the world, including our republic, the main part of agricultural products is produced on irrigated lands.

Canals built in the lowland areas of the republic, including Mugan, Shirvan, lower Karabakh and Absheron, are weeded and silted due to the low slope of the bottom.

Natural phenomena such as floods, floods, and river floods intensify the process of siltation in canals. Currently, the cleaning of concrete-lined and earthen channels is mainly done with general-purpose backhoe excavators. In the direction of cleaning of irrigation canals, including concrete-lined canals, research works have been carried out in relevant Scientific Research Institutes of CIS countries, especially Russia, Turkmenistan, Uzbekistan and other countries. Of those mentionedIt seems that research works in the direction of the improvement and creation of existing mechanization tools and the development of new methods and technologies for cleaning canals from sediments and weeds is an urgent issue in accordance with the requirements of the modern era, and the dissertation under consideration is a partial solution to such an urgent problem. although it is dedicated to the research carried out in the direction of its solution.

The purpose of the study. The purpose of the work is to study the scientific and technical basis of cleaning the concrete-lined irrigation canals from sediment, silt and plant remains with a single bucket excavator .

Research methodology. Comparative analysis of options and visual observations were used in the implementation of the research, and mathematical statistical methods were used in the development of the research results.

The main provisions defended:

1. Study of siltation and cleaning methods of canals;
2. Channel cleaning technology with a wide-handled shovel excavator;
3. Assessment of the physical conditions of the sediments of the canals depending on the mode of operation ;

Depending on the condition of the sediments in the cleaning of the

earth channel and concrete-lined canals with a wide pick-up bucket, the interaction of the working body and the working environmentthe method of calculating energy indicators with the study of their relations;

5. Experimental study of sediment-sediment relationship;

Laws of the effect of the density of sediments on the damage of the machine and the quality of the work in the interaction between sediments and sediments ;

7. Comparison of sediment drilling and soil drilling;

8. Technical and economic indicators of the test of the improved working body in production .

Scientific novelty of the research. The scientific innovations of the study are as follows:

1. The nature and mode of operation of siltation in main, inter-farm and intra-farm canals were studied;

2. As a result of experimental studies carried out in the laboratory and in the field, the effect of sediment density on the productivity of the machine and the quality of work was studied, the interaction of the working body and the working environment was studied.the regularities of their relations have been determined.

3. A new technology for cleaning irrigation canals from sediments with a new working body has been developed.

4. The method of calculating the energy indicators of sediment drilling with a wide pick-up auger is given.

Accuracy of results. Theoretical and practical solution of scientific research work in the studied areaand it was performed according to the well-known methodology of the shearing theory of soils. The working body developed on the basis of the received results was checked in real conditions in the Absheron channel, and the theoretical and experimental research results were consistent.

Theoretical and practical significance of the study. The productivity and quality of work of the machine in cleaning the irrigation canals from sediments and plant residues with the proposed method and technology with the application of the improved working body was 50-60% higher than the same type of **base** excavator.

Approval and application. The main scientific results of the dissertation work are regularly presented at the scientific seminars of

the "Construction, Road and Reclamation Machines" (Currently "Machine and Mechanical Engineering") (2014-2022), Hydrotechnical Devices and Hydraulics" departments of Azerbaijan University of Architecture and Construction. (2006-2020); III International scientific and practical conference (Baku, 2006); At the Republican Scientific-Practical Conference (Baku, 2019, 2023); "Eurasia Science" LI International scientific-practical conference (Moscow, 2023), -The 19th International conference on "Technical and physical problems of engine-ering" International organization of IOTPE (October 31-2023), Doctoral students and young researchers XIV It was discussed and approved at the Republican scientific conference (Baku, 2009).

Publications. 15 scientific works have been published in national and foreign scientific and technical publications and one patent has been obtained on the results of studies reflecting the content of the dissertation work.

Personal attendance of the author: The leading role on the writing of articles and dissertations, the analysis of references, formulations of new ideas, planning and implementing of practical works, interpretation of results based on principals, which were formed by various research methods while completion of the dissertation belong to the author.

The name of the organization where the dissertation was completed. The dissertation was completed at the Azerbaijan University of Architecture and Construction.

The total volume of the dissertation is indicated by noting the volume of the structural sections of the dissertation separately. Dissertation using introduction with 7 pages, first chapter with 37 pages, second chapter with 40 pages, third chapter with 45 pages, fourth chapter with 15 pages, conclusion with 4 pages, 102 names with 9 pages It consists of a list of literature. The total volume of the dissertation is 233779 characters (title 354 characters, table of contents 4891 characters, introduction 12644 characters, first chapter 47644 characters, second chapter 79117 characters, third chapter 55348 characters, fourth chapter 29444 characters, total the result is 4337 characters), 148 pages with 40 images, 15 graphs, 2 photo.

BRIEF CONTENT OF THE DISSERTATION

In the introduction, the relevance of the dissertation topic is justified, the purpose of the work, scientific innovations, practical significance, the reliability of the obtained results, the issues raised for defense, the approval of the work, the structure and scope of the work are given.

In the first chapter, the analysis of existing cleaning methods and technologies of canals was carried out [1].

As it is known, during the operation of irrigation canals, siltation occurs for various reasons, which causes a shortage of water in the irrigated areas due to the reduction of the subflow capacity of the system. This significantly hinders the implementation of the government's policy in the direction of the development of agriculture in the republic.

Since the leakage of water in the underground canals leads to water loss and salinization of the surrounding areas, the construction of intrafarm and interfarm canals with concrete lining is preferred recently. However, siltation and weeding occur in concrete-lined irrigation canals during operation.

The results obtained from the investigation of existing methods and technologies of channel cleaning show that general-purpose machines with working bodies are used in the cleaning of concrete-lined channels. This does not allow to obtain the necessary efficiency in cleaning. Therefore, it is important to create improved special working bodies for cleaning concrete-lined canals [2].

New drain cleanerthe working body consists of an arc-shaped guide (1), two sides (2) and a cutting blade (3).On the back of the bucketis equipped with a wide blade (3) on which two rollers (4) are symmetrically fixed. At the top of the ladder, the hydro-cylinder (5) that rotates the bucket, and at the bottom of the excavator's support,

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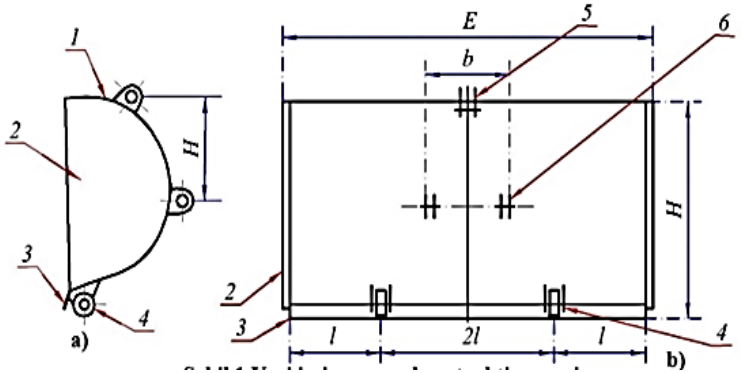
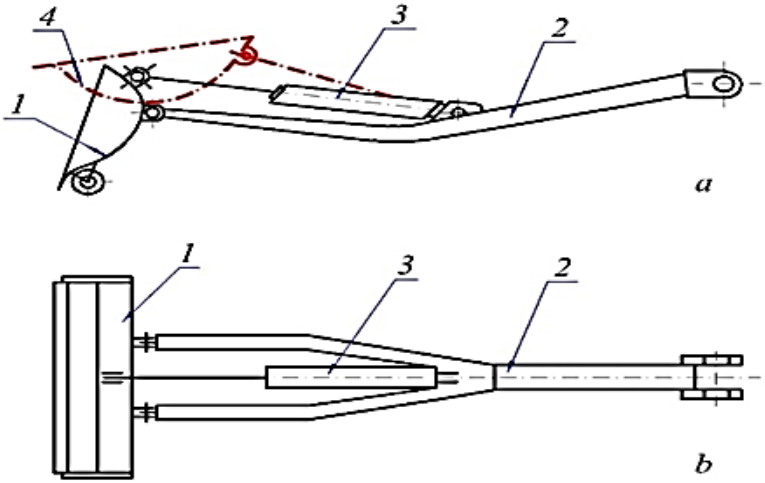
[1]Hajiyev, TM Study of the operation condition of Mughan irrigation canals. / GV Novruzova // Ecology and water management, Scientific-technical and industrial journal, Baku-2005. No. 6, pp. 19-21

[2]Novruova GV, Analysis of canal cleaning methods // - Baku: "Modern problems of the use of technological machines in construction industry", Republican Scientific and Practical Conference, - 2019, p. 79-83

earpieces are welded (photo 1) [3].



Fiqure 1. Constructive scheme of the new working body
a) side view ; b) back view



Fiqure 2. Technological conditions of the working body
a) side vie; b) plan view

[3]Novruzova, GV Cleaning of concrete – lined channels with a large capacity bucket //- Ukraine : Problems of computational mechanics and strength of structures, -2022 - p. 91-104.

Since the width of the bucket is large, the support designed in the form of a hook is connected to the ladder at two points to reduce the torque generated in the work process and ensure the stability of the working body . During the working process, the bucket rotate 120°can times with a hydraulic cylinder in the vertical plane.

Since various factors affect the productivity and quality of work in the cleaning of canals with a working body with a wide blade, the following studies were carried out in order to improve the working body and the technological process:

1. The distribution of forces generated in the interaction between the bed and the sediment and the study of the impact of the bed profile on the drilling resistance;

2. Investigating blade-cover connection in concrete-lined channels and adjustment of blade-cover window with under-knife rollers;

3. Development of the technology of effective cleaning of the channel from sediments with a special excavator ;

4. Improving the quality of cleaning by studying the effect of sediment density on the productivity of the machine and the quality of work.

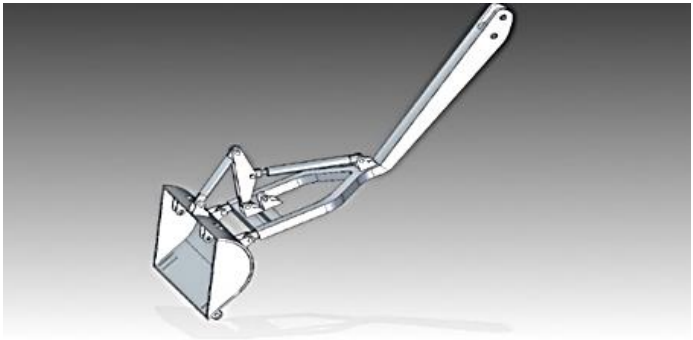
The dependence of the interaction between the blade and the sediment and the quality of work on the trajectory of the blade blade, the nature of the interaction between the blade and the sediment, the optimal shape of the blade, the adjustment of the distance between the blade and the surface were investigated in experimental studies, taking into account the productivity of the machine and the quality of cleaning.

The proposed working body for cleaning concrete-lined canals can be installed on the excavator in two versions, such as a straight bucket and a reverse bucket.

In the version of the flat-back excavator, the new working body is assembled at the base of the excavator. In this version, the excavator digs below the level where it stands.

The results of the conducted experimental studies bucket that 50-55% of the duration of one working cycle of the ЭО-3322К excavator is spent on digging the sediment, 20-25% on moving the bucket loaded and unloaded, and 20-30% on unloading the sediments from the bucket.

is being In order to reduce the time spent on turning operations (loading-unloading movement of the sluice), the arm is extended and the sediment is discharged from the turn to the opposite dam of the channel. With the application of this technology, it is possible to increase the quality of canal cleaning up to 90-95% and the productivity of the machine by 30-35%, due to the fact that canal cleaning is carried out according to the "loop" drilling scheme and the drilling traces fall side by side.



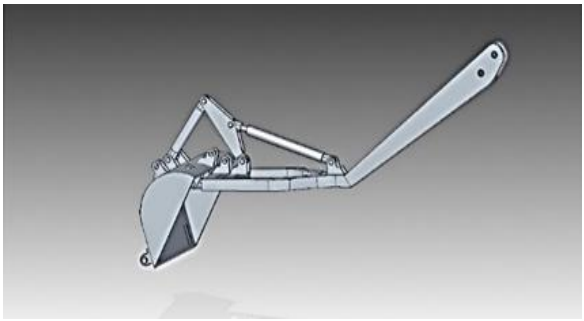
Fiqure 3. A straight-back excavator version of the new working body

In the reverse position of the bucket, the support is connected to the upper part of the bucket with a bracket. During the working process, the bucket allows the movement of the knife and the saw along the entire perimeter of the channel.

Large drains are cleaned in two passes with a reverse bucket drain cleaner. First, the machine moves on one side of the canal, and when it returns, it moves on the other side.

When the turning angle is 60-120˚ in the opposite bucket version, 25-30% of the duration of the excavator's work cycle (15-20 seconds) is spent on digging the sediment, 50-60% on lifting and spreading the bucket, and 15-18%- is spent on emptying the sediments from the furnace and turning operations of the working body.

It has been determined that currently it is appropriate to use a wide bucket excavator with a ladder in the cleaning of irrigation canals with earthen channels and concrete lining.



Fiqure 4. Reverse version the new working body

In the second chapter theoretical studies performed in the direction of determining the structural-technological parameters of a single-shaft excavator that cleans channels from sediment are given.

The effect of the physical and mechanical properties of soil and sediments on the working body was investigated, and the causes of siltation and the composition of the sediment were investigated. Sludge depends on flow velocity, particle diameters, depth and width of flow. In the studies of many scientists, the influence of plants growing in the channel on sedimentation has not been taken into account. However, the observations made show that the plants growing in the canal significantly affect siltation of the canal [4].

Sediment generated in channels in the study of the resistance of the sediment mass to digging with a wide-scale augerwere compared with the physical and mechanical properties of clayey cast soils with low density.

In the conducted studies, the energy indicators of the excavation of the sediments in the canals with an excavator were analyzed by the analytical method according to the "Soil Mechanics" technique, and V.V.Sokolovsky's "Statistics of spilled soils" was taken as a basis. With the application of this theory, A.N.Zelenin, I.Y. Ayzenstok, Y.P. Peters, K.A. Artemyev, V. I. Balovnev and others conducted research.

The study of the resistance forces acting on the working body of a bucket excavator in channel cleaning is based on the theories of

[4]Novruzova, GV Effect of technological parameters of excavation on the quality of channel cleaning // Hajiyev TM - Baku: Ecology and water management, Scientific-technical and production journal, - 2007, No. 1, p. 22-24

V.V.Sokolovsky and Otto Mor.

Due to the compatibility between the studied working body and the technological processes of excavation of sediment and dry soil by examining the forces affecting the working body in the work process, the possibility of using the terms of the statics of the poured soils of "Soil Mechanics" in determining the energy capacity of sediment excavation with a layer is justified.

Determination of drilling resistance: **The resistance forces** acting on the working body of the single-handled excavator during canal cleaning were determined in semi-solid and solid sediments in the states of the working body with and without rollers [5].

It was determined that the sediments can be divided into solid-semi-solid, semi-solid and solid groups according to their excavation characteristics. There are many physical similarities between the excavation properties of sediments and some soils :

a) the excavation process of sediments from the third and partly the second group is close to light-loose clay soils physically and in terms of energy capacity;

b) the sediments included in the first and second groups are excavated by the excavation method, and the processes of the distribution of stresses, generation of active and passive forces can be considered physically as in the soil-wall relationship in the statics of sandy soils.

According to the research, there is a correspondence between the physical parameters of semi-solid and solidified sediments of cast (less hardened) sandy and light loam soil.

Study of drilling resistance based on sediment-soil physical similarity: It is possible to apply some regularities of the widely studied soil drilling processes to the sediment drilling process.

The process of separating a certain part of the soil (sediment ash) from the main mass with the working body can be carried out by "cutting", "sprouting" and other methods.

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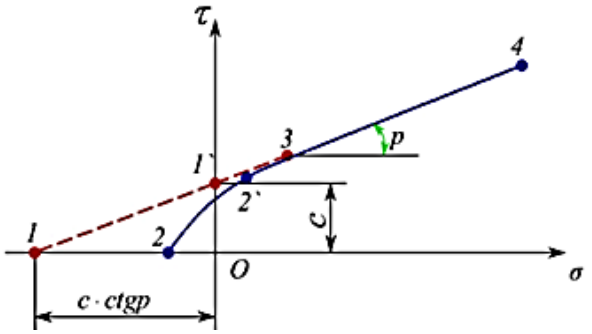
[5]Novruzova, GV Energy capacity determination of sediment cleaning from concrete-lined channels based on real indicators // - International Journal on technical and physical problems of engineering," (IJTPE) (SCOPUS)-2023. - p. 352-356.

In the "cutting" process, if the resistance index is greater than $K_q > 0.3$, but compared to the case where $K_q \approx 0.2...0.25$,
the density of the sediments decreases by about 2-3 times and the sediment accumulation is harvested.



Graphic 1.Dependense of the limited contact stress of the concrete on the normal stress

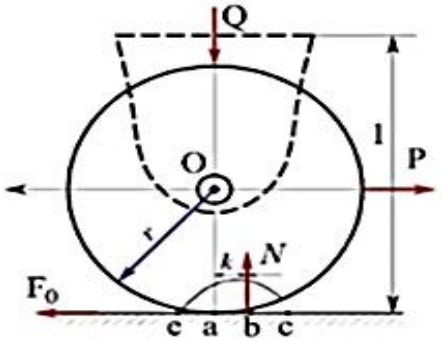
In the "Soil mechanics" theory, for experimental calcula-tions, the creep resistance of the soil is considered as a linear function of the normal stress on the creep surface. Compliance with this law in sediment drillingof the limited contact stress (τ) of the soil from the normal stress (σ) is justified in the part between points 3-4 of the graph of dependence .$\tau = f(\sigma)$

In the graph (Graphic 1), the tangent of the angle of the sediment (soil), which is approximately equal to the slope angle, ρis called the coefficient of internal friction. The "1-2" part of the graph shows the sticking indicator *(c)*, the "3-4" part shows the limited contact stress and $c \cdot ctg\rho$ and characterizes the mass density. The difference is that while in dry soil excavation, high wear occurs, which significantly affects the cutting force of the blade, in sediments, especially when $Kq > 0.3$, this is a minority.

Determination of the forces acting on the roller. The purpose of building on the rollers is to prevent damage to the concrete cover of the slab. Rolling and sometimes slipping may also occur in the loaded and unloaded states of the vehicle. Since it was used for the first time

in the cleaning of concrete-lined canals, the auger placed on rollers was studied for its construction and geometric dimensions of its main indicators.

Rolling and sliding occur in the movement of the rollers. A hydraulic cylinder mounted on the support of the excavator that moves the bucket changes the position of the bucket and ensures that it is filled with soiled sediment. At this time, the resistance and driving forces acting on the roller create a rolling friction moment. The rolling resistance depends on the material of the roller and the driving force in contact with the surface (Figure 9).



Fiqure 9. Forces acting on the roller

The following forces act on the roller. At point O, the external force $P(N)$ from the support, the sliding friction force $F_0(N)$, and the resistance force act $W(N)$.

According to the condition $P > W + F_0$, it must be so.

where $N -$ is the reaction force of the surface N,

According to the condition, the static friction force is

$F_0 \le Q \cdot b$.

Where $Q -$ the force acting on the roller (the weight of the scoop and the sediment) is the gravitational force (N)

$f_0 -$ the coefficient of static friction, in this case, is the coefficient of adhesion.

When the roller begins to move, increasing deformation occurs

at point ac, while decreasing deformation occurs at point ae. Therefore, the reaction force N shifts by the arm k of the rolling friction. During rolling, it is necessary to overcome the moment of friction, which is determined by the following formula.

$$M_{s.d} = Q \cdot k, \tag{1}$$

where $k -$ the arm of the force is also the coefficient of rolling friction. When rolling begins on a concrete surface, the torque is determined by this formula.

$$M_d = P r, \tag{2}$$

where $P -$ the driving force generated at the support, N, $r -$ is the radius of the roller, m.

When the rolling moment M of the roller is equal to the rolling resistance, we obtain:

$$P \cdot r = M_{s.d} = Q \cdot k, \tag{3}$$

where

$$P = \frac{k}{r} Q, \tag{4}$$

From equation (4), it is evident that the force P is directly proportional to the coefficient of rolling friction and inversely proportional to the rolling radius.

$P -$ under the action of the force, the roller either rolls or, in some cases, slips.

This situation has been examined to determine under which conditions rolling friction or sliding friction occurs. It is assumed that the scoop is filled with sediment, and in this case, the sliding friction resistance is:

$$F_0 = f_0 Q, \tag{5}$$

Therefore, the sliding of the roller over the concrete surface is:

$$P = f_0 \cdot Q, \tag{6}$$

The condition of rolling without slipping is defined by equation (3).

$$P \cdot r = Q \cdot k. \tag{7}$$

If the roller only slips, the following condition must be satisfied..

$$P = f_0 \cdot Q; \quad (8)$$

An additional condition $\Pr < kQ$ must be satisfied. Here

$$Qf_0 \cdot r < kQ \;; \qquad f_0 < \frac{k}{r} \text{ accepted .} \quad (9)$$

It has been determined that for the roller to roll solely on the surface, the condition $P > f_0 \cdot Q -$ must be met such that the coefficient of sliding friction f_0 is greater than the ratio $\frac{k}{r}$.

For the roller to slip on the concrete surface, the condition $\Pr < kQ$ must be satisfied, and the coefficient of sliding friction must be less than the ratio $\frac{k}{r}$.

The conducted studies on the use of a layer-type scoop equipped with two wide-gauge rollers have yielded the following results:

The rubber-coated rollers installed at the bottom of the scoop protecting it from damage.

The rollers prevent the cutting blade of the scoop from contacting the concrete, reducing drilling time and thereby increasing productivity.

The rollers prevent the scoop from tilting sideways, maintaining its level during drilling.

A force analysis of the working mechanism was carried out to determine the types and sizes of hydraulic system units, select the hydraulic system scheme, establish the nominal pressure of the working fluid, and verify the strength of the parts and components of the working mechanism.

In the third chapter, the objective, methodology and analysis of the obtained results are presented.

Experimental studies are carried out in laboratory and field conditions in order to study the influence of the physical state of the sediment on the drilling process, the close relationship between the working body and the environment, the study of the cleaning quality of the bottom of the channel, the determination of the resistance forces in sediment drilling, and the adequacy of the results of theoretical and

experimental studies in production conditions. has been given.

Modeling of the working body and its close relationship with the working environment in laboratory conditions was carried out by the method of Professor V.I. Balovnev according to the criterion of similarity.

In experimental studies, the physical parameters of semi-solid, solid and hardened sediments were taken in kind and in the model. In the first phase of the experimental research, the forces and stresses on the working body were determined depending on the state of the sediment in the semi-natural channel under water and when the channel was dry (Figure 10).

Figure 10. General view of the experimental model

Regardless of the condition of the sediments, the characteristics of the deformations caused by the forces acting on the scoop's arm and stiffening element have been investigated.

The main part of the research was conducted in a semi-natural channel, both underwater and in a dry state. The sediments were sourced from the Absheron canal, specifically from the area around the Goradil settlement.

In the second phase, studies were carried out on a model test stand equipped with a scoop whose side surface was glazed, allowing precise observation of the processes. Depending on the sediment's

cohesion, the filling of the sediment layer into the scoop, the sediment layer taking the profile shape of the scoop's wall, or its detachment from it were fully observed. Research was conducted on the test stand under dry, semi-dry, low-water, and underwater conditions to study the sediment excavation and the impact of working conditions on machine productivity, both in the laboratory and in natural settings (see Figure 11).

On the semi-natural test stand, rollers of three different sizes were fixed under the scoop blade, and the thickness of the sediment layer remaining on the surface after excavation was measured for each roller size. The energy indicators of excavation were also studied on this stand under various sediment cohesions and different excavation parameter values.

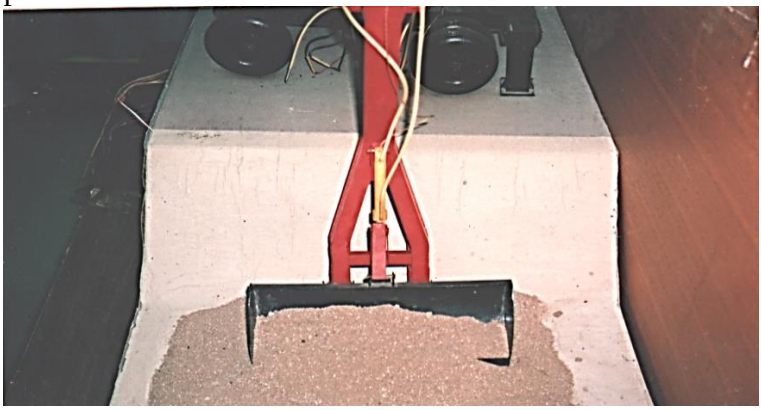


Figure 11. General view of the experimental model

Findings from experimental studies $\left|P - \overline{P}\right| \le \Delta P$ fulfilled by verifying the fulfillment of the condition.

Study of the technological process in practice: In the study of the technological processes, the following issues were investigated in the connection system between the wide-scale slag and the sediment [6]:

1. Study of the kinematics of physical processes and the

[6] Novruzova, G.V. Influence of physical properties of pumps on energy-technological indicators of an excavator when cleaning a channel // - Baku: "Theoretical and applied mechaniks", - 2010, No. 1, 93-97 c.

characteristics of the influence of various factors in the cleaning of the canal with a wide-handled bucket.

2. Improving the quality of channel cleaning by adjusting the movement trajectory of the wide-removable blade in sediment drilling to the cross-sectional perimeter of the channel in both roller-less and roller versions.

3. Study of the energy capacity of sediment drilling and the factors affecting it.

In addition to these, the effect of digging sediment in dry, semi-dry, low-water conditions and under water and working conditions on the productivity of the machine was studied in the laboratory and in nature.

In order to determine the nature of the physical processes in sediment drilling and their effect on the energy capacity of production, the process of the sediment layer being filled into the auger depending on the thickness of the sediment, the process of the excavated layer taking the profile shape of the auger wall or moving away from it. were observed. Correlation analysis of the relationship between the energy capacities of drilling processes and the analysis of the factors affecting it was carried out.

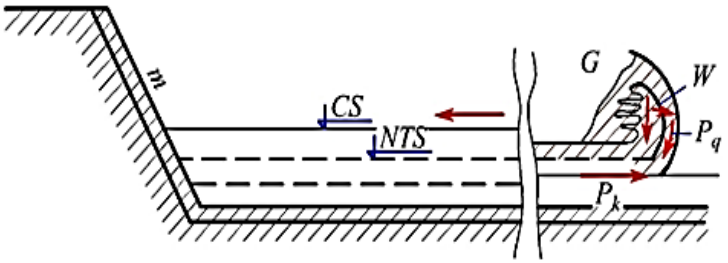
In the experiments carried out in a channel with a concrete lining in a semi-natural stand, rollers (rollers of three sizes) were fixed under the blade of the bucket, and the thickness of the sediment remaining on the lining was measured with each size of the roller. The power indicators of the drill are also determined at that stand. A part of the wall (90 cm) on the visible side of the channel itself was made of transparent plastic glass to increase the possibilities of observation while conducting the experiments in the second model stendin.

The experiments were carried out at different values of sediment thickness and drilling parameters (Figure 12).

The degree of repetition of experiments was determined by B.V.Onedenkov's method and the obtained results were checked by A.N.Zele's method.

The number of experimental indicators is considered satisfactory if the errors that can be omitted in the conducted experiments are 5...9%. The error in the conducted experiments is 7%.

The quality of channel cleaning was checked by experimental studies.



Fiqure 12. The course of physical procsesses in the channel

The quality of sediment removal was checked in the characteristic places of the channel by repeating the experiments and measurements in field conditions 5-8 times in the channels with flow at the beginning, middle and end of the strip, and 3-5 times in semi-arid conditions .

Electrotensometric measuring devices were used to determine the energy capacity of sediment drilling and the factors affecting it. The accuracy of the oscilloscopes was controlled by microdynamometric measurements.

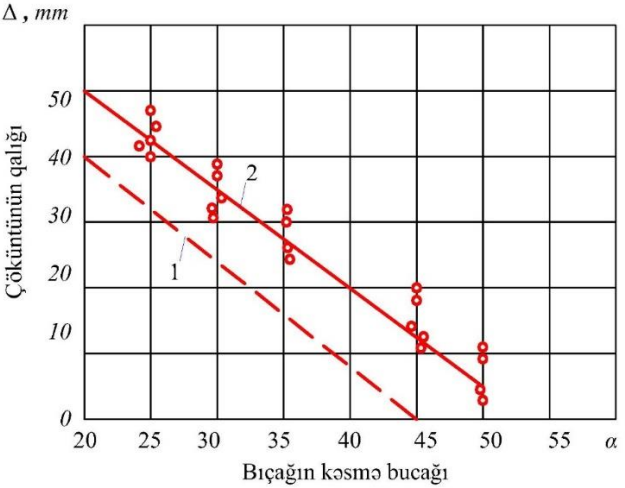
Tensometric measurements were carried out in laboratory conditions at different values of sediment density (moisture) and drilling (cutting) depth.

Study of the influence of the movement of the blade on the quality of cleaning in the work process: When cleaning channels with a straight-backed excavator, the value of the cutting angle of the blade ($\alpha = 20...25^{\circ}$) is minimal in relation to the plane of movement of the roller on the slopes of the canal, and between 40-50˚ inside the canal. Sediment in the strips has a negative effect on the quality of cleaning. According to theoretical studies, since $\Delta = 1...2$ mm when $\alpha = 50^{\circ}$, the sediment residue should not remain at the bottom of the channel, and when the value of the α angle decreases to 20˚ in the later stages, the height of the sediment residue should be 15...20 mm. However, the results of experiments carried out in laboratory and field conditions showed that the actual height and volume of the residue is 10...20% higher than the values obtained from theoretical studies, and it is 3-4

times higher in the corners of the channel [7].

Experiments (Graphic 3), it was obser ved that the residue of previous sediments passing under the knife and remaining under the roller, raising them to a certain extent depending on the thickness, affects the level of the knife.

A theoretical and experimental study of the influence of the roller knife knot on the quality of sediment removal shows that, taking into account the condition of the channel and sediment , the roller with a minimum diameter should be close to the razor blade.



Graphic 3. Graph of the dependence of the quality of channel cleaning (Δ, mm) on the cutting angle of the blade (α).

$q = 0{,}27 - 0{,}32$;

1- theoretical; 2- actual indicators.

When the sediment is solid, the rollers sink into the pile of sediment due to the weight of the pile and the height of the residue decreases.

Due to the fact that consumption decreases when there is comb-like residue at the bottom of the canal, it is not possible to fully assess

[7]Novruzova, GV Influence of bucket movement on quality of cleaning processes. // The 19th International conference on " Technical and physical problems of engineering" International organization of IOTPE 31 October- 2023,- p.152-156.

the quality of cleaning the canal with the balance of drilling and residue.

In comb cleaning, depending on the height of the residue, the volume of unexcavated sediment and the productivity of the machine changes.

Mainly designed for cleaning concrete-lined canals from sediments with a new machine (working body), in order to avoid damage to the blade and boards, since the scraping of the knife blade on the concrete, sticking to the concrete slabs at the seams causes the breakage of the working body and the concrete lining, and a sharp increase in the resistance force. it should be raised 5-8 sm above the board. This reduces the quality of sediment cleaning in the channel.

The quality of channel cleaning can be evaluated by the coefficient of restoration of the sub-digging capacity of the channel and the volume coefficient of sediment excavation:

$$K_s = \frac{Q_f \cdot 100\%}{Q_\ell}; K_n = \frac{W_f \cdot 100\%}{W_c}$$

The quality of channel cleaning is the specific volume of the residue and the productivity of the machine
$M_i > 50\% M_{max}$ is characterized by the norm.

When the channel is cleaned with a backhoe excavator, residual sediment remains at the junction of the slope and the bottom.

When cleaning with a flat-back excavator, the main technological processes take place at the bottom of the canal and on the opposite slope. Since the height of the sediments on the slope is low and the blade cannot move along the trajectory exactly corresponding to the profile of the slope, the residual layer slips and falls into the corner (slope-bottom junction) and remains there. When the residues spread to the bottom of the channel, the average height is 3-5 mm, the cleaning quality decreases.

Since the quality of channel cleaning depends not only on the height and volume of the residue brought to a single area, but also on the effect of the generated wave on the subflow capacity of the channel, these indicators were also determined by visual observation and measurement in laboratory conditions.

Determination of resistance forces in sediment drilling:

Regardless of the condition of the sediments, the forces acting on the drill are concentrated in the arm and the stiffening element connected to the drill joint. Under the influence of resistance forces, the stock of the hydraulic cylinder is first subjected to tensile and then compression deformation, and the sleeve of the cylinder is subjected to compression deformation when the cylinder is filled.

In the experiments, it was determined that in the work process, 0-10% of the load of the driver falls on the rollers from the adjustable shaft. 2 rollers (katok) are fixed behind the 750 mm wide bucket blade. When α =45˚, the rollers sit on the concrete slab. The edge of the knife remains 5-6 mm above. Sizes of Di worms: length – 60 mm, diameter – 40 mm (2 times smaller than natural size). In order to determine the load on the rollers and the pressure exerted by them on the ground, measurements were made with buried membrane tensors placed in predrilled holes at the same level in the roller strips in the channel. Transmitters are attached to measure the forces acting on the arm and hydraulic cylinder. The resistance forces corresponding to all states of the valve from empty to full are recorded in the oscillogram (Figure 13).

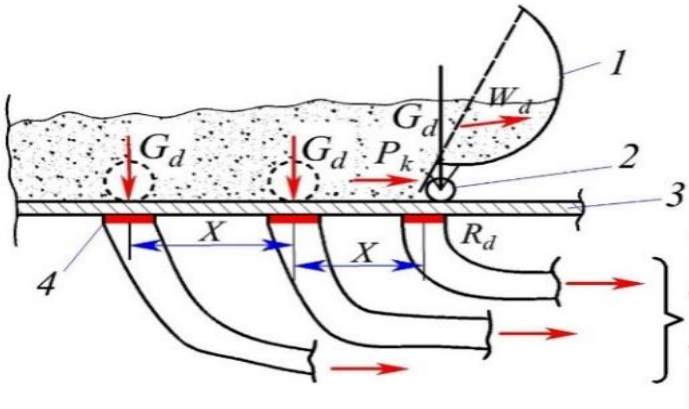
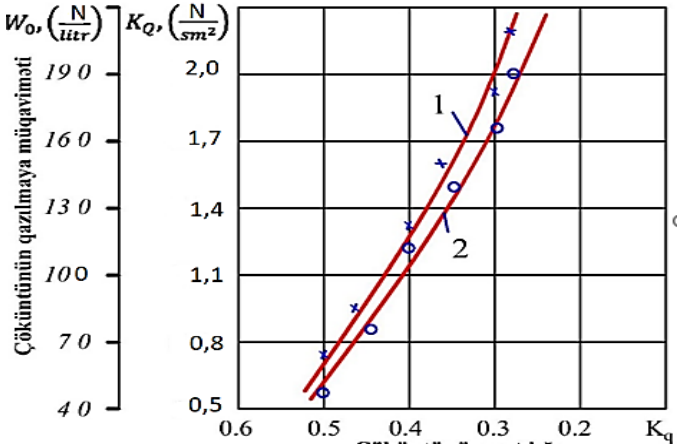


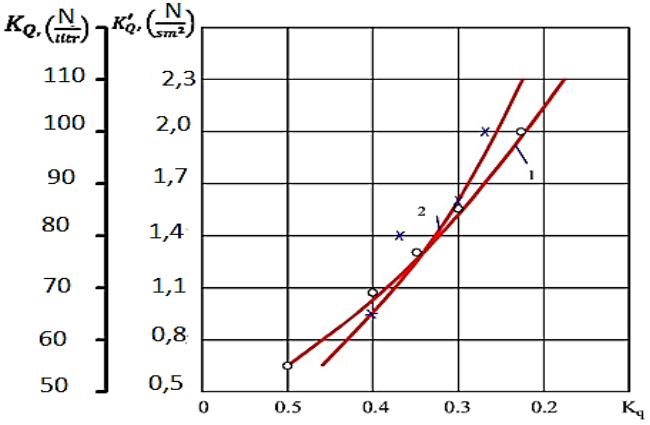
Figure 13. Measurement of gravity force on rollers (Gd) with membrane transmitters. 1 – roller, 2 – roller, 3 – cover, 4 – membrane sensor.

Since the resistance force at the beginning of the work process was small, it was not taken into account, and the resistance increases

observed in the characteristic places of the channel were accepted as reporting indicators in the os syllogogram. Based on the results of measurements and calculations, graphic dependences have been drawn up (Graphic 4).



Graphic 4. Dependence of sediment digging resistance (1) and specific resistance coefficient (2) on sediment density in underground channels



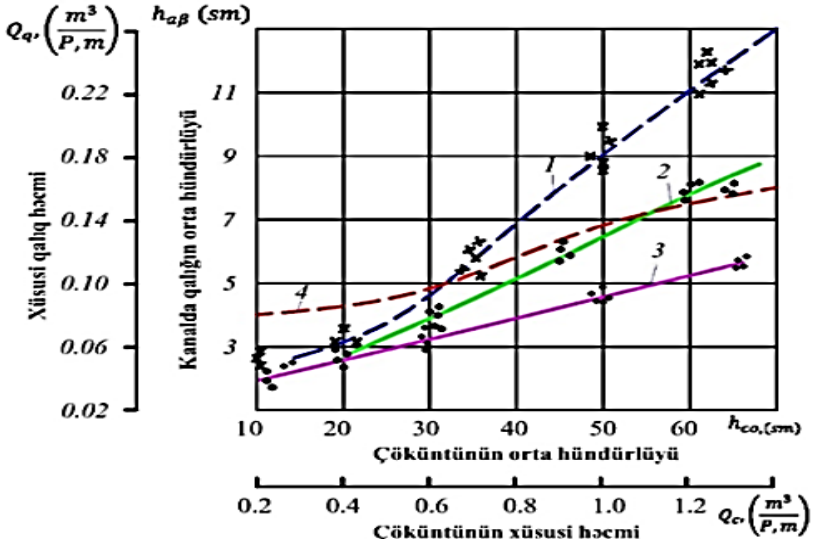
Graphic 5. Dependence of sediment digging resistance (1) and specific resistance coefficient (2) on sediment thickness in concrete-lined channels

Adequacy of theoretical and experimental research results was

checked in production conditions. Experiments (n=1...3) on the study of technological processes and quality indicators of the canal in low-water condition were conducted in field conditions in the part of the Absheron canal that passes through the Goredil-Mashtag area. In the experiments, the average depth of the sediments in the channel (in width and length), cross-sectional area and sediment volume were measured before and after cleaning.

Cleaning sediments with a new cleaning machine with a straight bucket - from the near slope to the opposite slope and with a reverse bucket - from the opposite slope to the near slope were considered.

As the sediment accumulation increases, the loss of sediment from the sides of the pile also increases, the productivity decreases and the quality decreases, and the normal stress in front of the pile increases intensively (Graphic 5).



Graphic 6. The dependence of the quality of channel cleaning on the number of repeated trips, the height and specific volume of sediment accumulation:

1- when u=1; u=2; u=3; u=4;

1,2,3 – cleaning with a flat backed;

4- cleaning with a backhoe

The results of the experiments show that a residue of 10-65 mm

thickness is obtained when cleaning with a new brush, and repeated runs are ineffective.

From the results obtained from the observation of the quality of cleaning with a new and basic backhoe excavator, it is known that it is possible to increase the quality indicators by 2-3 times with the use of a new excavator under the same conditions (Graphic 6).

Based on the results of the research, the application of the new bucket in canal cleaning has been shown to improve the quality of cleaning. The optimal height of residual sediment remaining in the canal after cleaning has been established as $h_{q0} = \frac{\sum h_q}{n} \approx 20 mm$ for small canals and approximately $h_{co} \approx 30\ mm$ for large canals.

Experimental research was conducted in three stages:

The conditions of the sediment mass were studied in natural environments within channels both with and without lining; the cohesion of the sediment was determined depending on factors such as accumulation time, thickness, water conditions, channel vegetation, and flow regime.

In the first test stand (scale M1:2), experiments were carried out in concrete-lined and unlined channels using sediments brought from the Absheron canal near the Goradil pumping station zone. The following issues were addressed:

The influence of sediment cohesion on excavation technological processes;

The effect of sediment cohesion on shear, digging, and dragging resistances;

The impact of sediment condition and environmental factors on cleaning quality.

The resistance forces during sediment excavation were measured using wire loop-type sensors attached to the arm of the scraper (scoop) and the overload rollers; the pressure forces exerted by the rollers on the ground were determined using membrane rollers, and oscillograms from complex strain gauge measurement devices were recorded.

As a result of studies conducted in laboratory conditions on semi-natural (scale *Ki=1:2*) and model test stands (scale *Ki=1:6*) in both lined and unlined channels, the following important scientific and practical issues have been resolved:

a) Depending on the sediment cohesion value (K_q), the shear, plastic deformation, and rolling boundaries of the sediment mass were determined. It was established that when the sediment cohesion is $K_q<0,28(0,3)$, the sediment mass is cut by the blade of the working tool, and after the sediment layer rises to a certain level along the surface of the scoop, it breaks apart.

b) It was determined that the excavation processes of dense sediment masses using a wide-gauge roller-equipped scoop are physically very similar to the excavation of light silty clay and sandy soils (Class II hardness, ω=20 ... 23%);

c) Semi-solid sediment masses with $K_q>0,32(0,35)$ fragment during excavation, and their accumulation and transport mainly occur by rolling.

At the model test stand (scale M1:6), the physical processes of sediment excavation were observed, and resistance forces and energy consumption during excavation were measured experimentally and analyzed.

Based on the research results, factors affecting the quality of the canal cleaning process and machine productivity include the cohesion of sediments, presence of lining, thickness of the sediment and cut layer, and other factors characterizing the interaction between the working tool and the environment, influencing excavation resistance, scoop filling degree, and excavation duration.

Field verification studies conducted with a natural scoop excavator measured and observed excavation cycle, scoop filling degree, sediment cohesion, work quality, and other indicators to determine the actual productivity of the machine.

In the fourth chapter, the economic justification for the application of the improved new working tool is presented. Economic efficiency is determined based on the cost of the work performed.

The economic benefit obtained from increasing the productivity and reducing the duration of work by applying the proposed canal cleaning machine and improved technology in the dissertation is determined according to the methodology outlined below.

The cost of the work performed using the machine is determined by the following expression:

$$C_{\partial} = C_{\partial_1} + C_{\partial_2} + C_{\partial_3} \quad (10)$$

where C_{∂_1} – the increase in productivity achieved by applying the new technology compared to the reference machine is;

C_{∂_2} – the income obtained from additional cultivated land due to the restoration of the canal's design capacity ahead of schedule (0.5 to 2.0 years);

C_{∂_3} – is the income gained from the earlier recovery of financial expenditures compared to the planned period.

The economic indicators were determined for the existing irrigation canals under the Sabirabad Irrigation Systems Directorate, selected as the research object by the Azerbaijan Melioration and Water Management JSC. Excavators of the ЭО-3321 and ЭО-3322 models ($q=0,5m^3$) from this organization's machinery fleet are used for canal cleaning, and with their application, farm canals up to 100 km in length have been cleaned.

Based on the comparison of economic indicators for cleaning sediment from concrete-lined and unlined inter-farm canals using the same base excavator (0.45–0.5 m³) equipped with existing backhoe and new straight bucket working tools, the economic benefit obtained from the application of the new working tool has been determined.

It has been determined that by applying the proposed machine and technology, it is possible to reduce the cost of the work performed by up to 50% compared to the existing machines and technologies in production.

Specifically, excluding additional income from the product, the annual income obtained from one machine amounts to 38.2 thousand manats per year.

The main results of the study:

1.Cleaning methods of irrigation canals have been systematized, according to the efficiency of the use of machines, the areas of application according to the state of sediments in the canals and operating conditions have been determined, and it has been justified that the most effective method of cleaning the canals is the machine with a wide range of rollers.

2.For the first time in the researches, the physical state of the sediments, the degree of hardness, depending on the collection period and the working mode of the channel (constant and intermittent flow), was studied, its effect on the parameters of the sediment excavation process was analyzed, and the "Theory of Soil Excavation" and V.V. Sokolovsky's "Statistics of Poured Soils" were studied. Based on the possibility of applying the main provisions of the "kası" theory to sediment drilling, the method of determination of resistance forces was developed.

3. As a result of the research conducted in the canals, the following issues of important scientific and practical importance were resolved:

a) depending on the amount of sediment density, the limits of sediment mass cutting, sawing and scalding are determined, when the density of sediment accumulation is $K_q < 0.28(0.3)$, the sediment mass is cut with the knife of the working body and the layer is covered with the surface of the slag up to a certain level it was determined that it disintegrated after rising.

b) The processes of digging a solid sediment mass with a wide roller auger are physically very close to the processes of digging light clay and sandy soils;

c) Semicircular sediment mass $K_q > 0.32(0.35)$ breaks up during digging, its collection and transportation is mainly carried out by spawning method.

4. The degree of adequacy of the results of theoretical and experimental studies was obtained with an accuracy of ±(8 – 10)%.

5. The law of change of the energy capacity of the sediment drill depending on the thickness of the sediment and the cutting depth was determined.

6. In the laboratory and in nature, the criterion for the evaluation of the quality of cleaning of the channel with the existing (cough) and new working body was determined, and the regression equation of the dependence of the quality of the work and the productivity of the machine on the density of the sediment mass was written.

7. For the first time, the "dancer" technological scheme has been developed in channel cleaning, which allows the machine to reduce the excavation

time by 30% and increase the productivity accordingly.
8. The economic benefit obtained from the application of the new working body in the cleaning of sediments of concrete-lined and unlined inter-farm canals has been assigned. It was determined that with the application of the proposed machine and technology, it is possible to reduce the cost of the work performed by up to 50% compared to the existing machine and technology in production.

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Personal contribution of the claimant in sealed cases:
(3, 5, 8, 9, 10, 12, 13, 14,15) works were performed by the author freely. In the scientific work No. (1, 2, 4,6, 7, 11,16), the author took part in formulating the problem and analyzing the obtained results.

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The dissertation work can be viewed in the library of the Azerbaijan University of Architecture and Construction.

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